Sacramento Valley Regional Water Management Plan

Draft

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Sacramento River Settlement Contractors

Jacobs

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Acronyms and Abbreviations

ACID	Anderson-Cottonwood Irrigation District
ac-ft	acre-feet
Ag WUE	Agricultural Water Use Efficiency Element
APEP	Advanced Pumping Efficiency Program
BMP	Best Management Practices
BWMP	Sacramento River Basinwide Water Management Plan
CALFED	Bay-Delta
CIMIS	California Irrigation Management Information System
CNRA	California Natural Resources Agency
CSQMP	Comprehensive Surface Water Quality Management Plan
CVO	Central Valley Operations
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act of 1992
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
ESA	Endangered Species Act
GCID	Glenn-Colusa Irrigation District
GSA	Groundwater Sustainability Agencies
GSP	Groundwater Sustainability Plan
GWMP	groundwater management plan
ILRP	Irrigated Lands Regulatory Program
ITRC	Irrigation Training and Research Center
KLOG	Knight's Landing Outfall Gate
M&I	municipal and industrial
maf	million acre-feet
MFWC	Meridian Farms Water Company
MPIPG	Management Practice Implementation and Performance Goal
MRP	Monitoring Reporting Program
MRPP	Monitoring and Reporting Program Plan
N/A	not applicable
NCMWC	Natomas Central Mutual Water Company
NCWA	Northern California Water Association
NRCS	Natural Resources Conservation Service

O&M	operation and maintenance
PCGID	Princeton-Codora-Glenn Irrigation District
PID	Provident Irrigation District
QO	Quantifiable Objectives
RAGB	Redding Area Groundwater Basin
Regional Criteria	*Bureau of Reclamation, Mid-Pacific Region, Regional Criteria for Evaluating Water Management Plans for the Sacramento River Contractors*
Regional Plan	2021 Regional Water Management Plan
RRA	Reclamation Reform Act of 1982
SCADA	supervisory control and data acquisition
SGMA	Sustainable Groundwater Management Act
SMWC	Sutter Mutual Water Company
SQMP	Surface Water Quality Management Plan
SRSC	Sacramento River Settlement Contractors
SVGB	Sacramento Valley Groundwater Basin
SVRWMP	Sacramento Valley Regional Water Management Plan
SVWMP	Sacramento Valley Water Management Program
SWP	State Water Project
SWRCB	State Water Resources Control Board
TB	Targeted Benefits
TCCA	Tehama-Colusa Canal Authority
USGS	United States Geological Survey
VFD	variable frequency drives
WDR	Waste Discharge Requirement
WMP	Water Management Planner
WQCP	Water Quality Control Plan

Section 1
Introduction and Regional Overview/Resources

1. Introduction and Regional Overview/Resources

According to the Reclamation Reform Act of 1982 (RRA) and the Central Valley Project Improvement Act of 1992 (CVPIA), all contractors that receive more than 2,000 acre-feet (ac-ft) of water from any federal project or provide water to more than 2,000 acres are required to prepare a water management plan. This 2021 Regional Water Management Plan (Regional Plan) was prepared jointly by the following participating Sacramento River Settlement Contractors (SRSCs):

- Anderson-Cottonwood Irrigation District (ACID)
- Glenn-Colusa Irrigation District (GCID)
- Provident Irrigation District (PID)
- Princeton-Codora-Glenn Irrigation District (PCGID)
- Reclamation District 108 (RD 108)
- Reclamation District 1004 (RD 1004)
- Meridian Farms Water Company (MFWC)
- Sutter Mutual Water Company (SMWC)
- Natomas Central Mutual Water Company (NCMWC)

The Regional Plan has been prepared in accordance with Bureau of Reclamation's (Reclamation's) 2020 Standard Criteria, which allows for multiple water districts/companies to prepare a joint plan given the historic and on-going high degree of coordination among the participants. The participating SRSCs have a long history of cooperative operations and actions and have chosen to prepare a regionally based plan to better promote basinwide water management and habitat benefits. This section provides a regional overview of the overall study area and identifies actions being taken by the SRSCs at the regional level including coordinated joint water diversions, water use, and restoration actions intended to improve overall surface and groundwater management and habitat conditions.

All participating SRSCs have contracts with the Reclamation and receive their contract supplies via the Sacramento River and federal Central Valley Project (CVP). Figure 1-1 depicts the study area, which includes five generally hydrologic subbasins originally identified as part of the original Sacramento River Basinwide Water Management Plan (BWMP) and SRSC service area boundaries. For this report, the downstream terminus of the Sacramento River basin is the confluence of the Sacramento and American Rivers.

The geographic area covered by this Regional Plan and served by the participating SRSCs is the portion of the Sacramento River Basin adjacent to the river from Shasta Dam to the Sacramento metropolitan area. The Sacramento River basin includes the northern third of the Central Valley and yields approximately 35 percent of the total outflow of all rivers in the state. The river flows generally south and meets the San Joaquin River at the Sacramento-San Joaquin Delta (Delta) where their combined flows continue west through Suisun, San Pablo, and San Francisco bays to the Pacific Ocean. The river and other valley tributaries provide important habitat for a variety of anadromous and resident fish species as well as terrestrial and plant species.

1.1 Ongoing Regional Actions

As watershed stewards, the SRSC group continues to be committed to optimized shared use of water resources throughout the Sacramento Valley. This group has historically and continually collaborates throughout the year to optimize delivery needs of the contractors while responding to real-time conditions of the Sacramento River. Working with Reclamation Central Valley Operations (CVO) staff, the SRSCs are able to adjust calls for water dynamically while meeting state and federal water flow requirements at Wilkins Slough. Prior to and throughout the Settlement Contract season, a group of SRSC (representing more than 90 percent of the total SRSCs contract amounts) provide Reclamation information on forecasted daily diversion rates and monthly volumes through the SRSC Web Portal and coordination meetings with CVO staff. The forecasted diversions are continually updated throughout the season as conditions change.

The SRSC have a history of leveraging this coordination and collaborative nature to benefit other water uses, including related to fisheries habitat. As an example, 2015 was designated a critically dry year by Reclamation per existing contract provisions. Such years are generally particularly difficult for water users and with respect to fisheries habitat and conditions. The SRSC voluntarily shifted a portion of their forecasted October diversions into November which provided a fisheries benefit and assisted in the overall operation of the CVP. The SRSC delayed approximately 60,000 ac-ft of desired diversions from October until later in the year and were able to maintain a relatively stable group diversion rate through careful management from September through December 10th. Reclamation completed an Environmental Assessment and a Finding of No Significant Impact to extend the Settlement Contracts 2015 season. The SRSC are developing similar creative options for the 2020 critically dry year.

1.1.1 Active Fisheries Habitat Restoration

As a group, the SRSCs are not only committed to salmonid habitat restoration but have helped to develop and drive the implementation of restoration of spawning and rearing habitat downstream of Shasta Dam. The first CVPIA restoration project that an SRSC entity undertook was in 2014 when GCID constructed Painter’s Riffle, in Redding, California (Shasta County). Since then, this group has undertaken CVPIA restoration projects, including to the following list of projects:

- Rockwad Habitat Structure Placement at Bonneyview Bridge – 2017 (Shasta County)
- Lake California Side Channel – 2017/2018 (Tehama County)
- Rio Vista Side Channel – 2019 (Tehama County)
- Market Street Gravel Injection – 2016 & 2019 (Shasta County)
- North Cypress Side Channel – 2017 (Shasta County)
- South Cypress Side Channel – 2020 (Shasta County)
- Wallace Weir Fish Rescue – 2016–2018 (Yolo County)
- Knight’s Landing Outfall Gates Fish Straying Barrier – 2016 (Yolo County)

Several of these projects were done without any reimbursement to the partners who used their own staff and resources to plan and execute the projects, adding up to more than $1 million in cost share or funding specifically by SRSC members (this does not include the CVPIA-provided funding). They added more than 20,000 cubic yards of spawning gravel and restored approximately 10 to 15 acres of instream habitat. Over the next 5 years, the Sacramento Valley Regional Water Management Plan (SVRWMP) group through GCID, RD 108, and the SRSC has committed to work with federal and state partners to implement approximately $20 million in salmonid habitat restoration projects on the Sacramento River. These 12 to 14 projects are consistent with Reclamation existing charters and proposed charters expected to be finalized in 2021. These projects will add more than 80,000 cubic yards of spawning gravel and restore more than 25 acres of instream habitat.

1.1.2 Floodplain Activation and Enhancement

In addition to the salmonid habitat restoration projects, the SVRWMP partners, within the context of the larger SRSCs, are part of a diverse team of landowners, scientists, water users, engineers, conservation organizations, and state and federal agencies working to reactivate the Lower Sacramento River Floodplains. Two pilot studies were carried out in 2018 and 2019 that demonstrated rice fields could be flooded to grow zooplankton, which is the food staple for migrating juvenile fish. The approach is to flood rice fields during winter when they are otherwise idle and then periodically drain the fields back into the

Sacramento River. This replicates historical patterns by slowing and spreading water onto the floodplains, resulting in more abundant fish food. The pilot studies have shown a direct correlation to the increased available food supplies and the condition and health of the salmon. Over the next 5 years, the SVRWMP partners, via RD 108, will be implementing $10 million in funding these and other landscape habitat projects, along with the other partners.

Supporting and improving the overall watershed health, a consistent and proven goal of this group, means supporting and improving the overall health and viability of the salmonid populations. Cutting-edge scientific research indicates that the health of a juvenile fish greatly influences it condition and survivability throughout its life cycle. As such, supporting the health and well-being of the juvenile fish through reactivated floodplains is not only innovative and feasible, but necessary.

1.2 Surface Water and Groundwater Resources

1.2.1 Surface Water Resources

Flow conditions on the Sacramento River are influenced by the operation of the CVP, tributary flow, and local municipal and irrigation district facilities. The most significant feature is Shasta Dam, which was completed in 1944 and is the largest reservoir in the CVP. Shasta Dam provides a storage capacity of 4,552,000 ac-ft. Keswick Dam, completed in 1950 as part of the CVP, provides a storage capacity of 23,800 ac-ft and serves as an afterbay for Shasta Dam. Since 1964, a portion of the flow from the Trinity River Basin has been imported to the Sacramento River Basin through CVP facilities. Water made available from the Trinity River system varies annually per specified fishery-related Trinity River flow requirements.

Prior to the construction of Shasta Dam, monthly flows reflected the runoff patterns associated with winter precipitation and spring snow melt. Peak flows generally occurred during the months of February, March, and April. Following the construction of Shasta Dam, average monthly flows during March and April were reduced, and average monthly flows during the summer irrigation months were increased. Following the construction of the Trinity River Division of the CVP in 1964, exports from the Trinity River Basin to the Sacramento River Basin increased the average annual releases from Keswick Dam.

The portion of the upper Sacramento River between Keswick Dam and Knights Landing (upstream of the confluence with the Feather River) is fed by several tributaries that drain the west slope of the Sierra Nevada Mountains and the east slope of the Coast Range. The lower Sacramento River extends from Knights Landing, above the confluence with the Feather River, to Freeport, below the point where the Sacramento River crosses the Delta boundary (defined by the Delta Protection Act and Section 12220 of the California Water Code). The flows in this portion of the Sacramento River are increased primarily by the addition of the Feather and American River flows (BWMP).

1.2.2 Groundwater Resources

The northern third of the Central Valley regional aquifer system is located in the Sacramento Valley (see Figure 1-2). The California Department of Water Resources (DWR) identifies this portion of the Central Valley as the Sacramento Valley and Redding Area Groundwater Basins (SVGB and RAGB, respectively), which cover over 5,500 square miles (DWR, 1978) (Figure 1-3). The RAGB and SVGB are subdivided into 5 and 16 subbasins, respectively, based on groundwater characteristics, surface water features, and political boundaries (DWR, 2016). From a hydrologic standpoint, these individual groundwater subbasins have a high degree of hydraulic interconnection because the rivers do not always act as barriers to groundwater flow. Therefore, the aquifer systems in the RAGB and SVGB function primarily as single laterally extensive alluvial aquifers, rather than numerous discrete, smaller groundwater subbasins.

Most of the RAGB is underlain by several hundred feet (up to 2,000 feet near the confluence of the Sacramento River and Cottonwood Creek [Pierce, 1983]) of unconsolidated freshwater-bearing materials. Groundwater is generally present under unconfined to semi-confined conditions. A majority of the groundwater development in the RAGB has occurred in the southern/central portion of the basin where the aquifer thickness is the greatest. Irrigation wells typically range between 100 and 500 feet deep, although in some places (particularly near surface streams) the static groundwater level may be within 10 feet of the ground surface (DWR, 1978).

Large amounts of groundwater are stored in unconsolidated deposits in the SVGB, which range in thickness from several hundred feet along the margins of the basin, to 3,000 feet in the southern portion (Page, 1986). Groundwater is used intensively in some areas but only slightly in areas where surface water supplies are abundant. Groundwater occurs in various degrees of confinement in the basin. Typically, unconfined conditions occur in the alluvial deposits, and partially confined to confined conditions occur at greater depths. Irrigation wells typically range from 100 to 600 feet deep; however, wells at depths greater than 1,000 feet exist in the southern portion of the basin. Groundwater levels associated with the SVGB have historically declined moderately during extended droughts, generally recovering to predrought levels because of subsequent wetter periods. Groundwater levels can be within 10 feet of the ground surface in low-lying portions of the basin (particularly near surface streams) and can increase to a depth of more than 100 feet toward the basin margins.

Groundwater in both the RAGB and SVGB is typically replenished through deep percolation of streamflow, precipitation, and applied irrigation water; recharge by subsurface inflow is relatively small in proportion. Surface water and groundwater systems are strongly connected throughout the groundwater basins and are highly variable spatially and temporally. Generally, the major trunk streams (the Sacramento and Feather Rivers) act as drains and are recharged by groundwater throughout most of the year. The exceptions are areas of depressed groundwater elevations attributable to groundwater pumping (inducing leakage from the rivers) and localized recharge to the groundwater system. In contrast, the upper reaches of tributary streams flowing into the Sacramento River from upland areas are almost all losing streams (they recharge the groundwater system). Some of these transition to gaining streams (they receive groundwater) farther downstream, closer to their confluences with the Sacramento River. Estimates of these surface water/groundwater exchange rates have been developed for specific reaches on a limited number of streams in the SVGB (USGS, 1985), but a comprehensive Valley-wide accounting has not been performed to date.

Attempts have been made in the past to estimate sustainable yields for different regions of the basin; however, these estimates can vary significantly depending on the methodology, water management, and land use assumptions, as discussed in DWR Bulletins 118, 118-6, 118-80, 160-93, and U.S. Geological Survey Water Resources Investigation 1401-A. Accepted "sustainable" groundwater use is currently being identified by basin and subbasin across the state in accordance with the Sustainable Groundwater Management Act (SGMA) discussed further below.

DWR has conducted several iterations of groundwater basin/subbasin prioritization (most recently in 2019) to identify and prioritize groundwater basins based on groundwater overdraft conditions. Parameters included in groundwater basin/subbasin prioritization include (DWR, 2020):

1) The population overlying the basin or subbasin.
2) The rate of current and projected growth of the population overlying the basin or subbasin.
3) The number of public supply wells that draw from the basin or subbasin.
4) The total number of wells that draw from the basin or subbasin.
5) The irrigated acreage overlying the basin or subbasin.

6) The degree to which persons overlying the basin or subbasin rely on groundwater as their primary source of water.
7) Any documented impacts on the groundwater within the basin or subbasin, including overdraft, subsidence, saline intrusion, and other water quality degradation.
8) Any other information determined to be relevant by the department, including adverse impacts on local habitat and local streamflows.[1]

The specified basin priority (very low, low, medium, and high) dictates what portions of SGMA apply to the basin as well as the schedule for development and implementation of required planning documents (discussed more below). Of the five groundwater subbasins in the RAGB, three are categorized as very low priority, and two are categorized as medium priority. Of the sixteen groundwater subbasins in the SVGB, one is categorized as very low, six are categorized as medium priority, and nine are categorized as high priority. None of the groundwater subbasins in the RAGB or SVGB have been identified as critically overdrafted. Figure 1-4 shows the groundwater subbasins in the Sacramento River Basin.

1.2.3 Groundwater Resources Management

1.2.3.1 Sustainable Groundwater Management Act

In 2014, the California Governor signed into law three bills (Assembly Bill [AB] 1739, Senate Bill [SB] 1168, and SB 1319), which are collectively known as the Sustainable Groundwater Management Act (SGMA). The intent of the legislation is to ensure sustainable, local and regional management of groundwater use and to address the issue of overdrafted groundwater basins across the state. SGMA calls for the development of new, local management entities—Groundwater Sustainability Agencies (GSAs) to manage basins sustainably, and requires those GSAs to adopt Groundwater Sustainability Plans (GSPs). The purpose of a GSP is to describe the approaches to achieve groundwater sustainability goals for a given groundwater basin/subbasin and to meet the GSP regulatory requirements. GSPs are intended to serve as the management plan for a given groundwater basin and describe current groundwater conditions, identify a sustainability goal for a given basin, set metrics to meet the sustainability goal within 20 years, and describe projects/management actions that will bring a given basin into sustainability (as applicable).

SGMA defines sustainable groundwater management as the "management and use of groundwater in a manner that can be maintained without causing undesirable results." Undesirable results are defined by SGMA as any of the following conditions occurring throughout a groundwater basin as a result of groundwater usage (DWR, 2018):

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

SGMA requires groundwater basins designated as high or medium priority to be managed under a GSP by January 31, 2022, and to achieve sustainability within 20 years, allowing until 2042. The state has

[1] Adverse impacts on local habitat and local streamflows, adjudicated areas, critically overdrafted basins, groundwater-related transfers.

prioritized 127 basins that must comply with SGMA; failure to locally implement SGMA will cause State Water Resources Control Board (SWRCB) intervention. Additional information on groundwater management and related district participation in local planning efforts is included in Section 2 for each district.

1.2.3.2 Groundwater Management Act (GMA)

The Groundwater Management Act encompasses a set of legislation (AB 3030 [1992], SB 1938 [2002], and AB 359 [2011]) intended to "encourage local agencies to work cooperatively to manage groundwater resources within their jurisdictions and to provide a methodology for developing a Groundwater Management Plan." AB 3030 provided the original framework for groundwater management plan (GWMP) development, SB 1938 set requirements for GWMP development and implementation for water purveyors to remain eligible for certain funding, and AB 359 set requirements for local agencies to identify/delineate groundwater recharge areas to remain eligible for certain funding. Existing GWMPs remain in effect until a GSP is adopted for a given subbasin. Settlement contractors have previously participated in various local plans as appropriate, which have in turn served as a basis to develop the local GSPs currently underway.

1.3 Typical District Facilities

Water diversion and conveyance facilities used by the participating SRSCs are generally similar in nature. Typical facilities are in-river diversion facilities, including pumps to lift water into conveyance canals and fish screens to ensure minimal impacts to the fishery. The diversion facilities also include measuring devices to track total diversion quantities.

Surface water diversions (primarily from the Sacramento River) to individual SRSC district/company service areas occur at points of diversion in accordance with existing water rights and Reclamation settlement contracts. The point(s) of diversion for each SRSC are identified on the facilities maps included within this SVRWMP. Diversions at all points of diversion are measured in compliance with the measurement regulations adopted by SWRCB pursuant to Senate Bill 88 and Reclamation contract provisions. The required accuracy under the measurement regulations varies between ±5 and ±15 percent, depending on when the measurement device was installed and the method of certification. Reclamation installs, maintains, and certifies the accuracy of measurement equipment at contract points of diversion. Reclamation has identified that the accuracy of the measurement equipment at contract points of diversion is within ±3 to 10 percent. At points of diversion not covered by the contracts, the SRSCs also install and maintain measurement equipment. These measurement devices are certified for accuracy by a qualified individual and meet the State's accuracy requirements of ±5 to 15 percent. Measurement devices used at the various points of diversion include propeller meters, acoustic meters, magnetic meters, and flumes.

In general, the majority of district canals move water via gravity flow, although some districts pump water where necessary to make deliveries. Some canals are lined, but the majority of canals in the valley are unlined due in part to the relatively high clay content of many districts' soils. Some districts have lined their canals with concrete or other relatively impermeable material. In many areas, canal lining has been determined to be unnecessary where losses are relatively small. The seepage quickly returns to the river or can be recovered from the groundwater. Some districts have also elected not to line canals due to concerns related to the removal of wildlife habitat in areas where such vegetation has been allowed to grow, as well as due to relatively high capital costs.

The degree of system automation varies by district and is influenced by such factors as topography and the size of a particular district. Distribution of water supplies to a given field or set of fields is accomplished via smaller lateral canals, which are designed, wherever possible, to allow for gravity flow. Pumping of water is limited to those areas where required.

The Sacramento River Basin is unique because water is reused extensively both within and between districts. Accordingly, some typical management measures can adversely affect downstream users. Districts generally maintain a series of tailwater drains to carry water away from fields, providing soil drainage and allowing productive use of the agricultural lands to continue. As much of this water is reused as possible, while some water is allowed to eventually return to the Sacramento River, seep to the groundwater table, or be pumped out and reused locally or by other downstream users. Many SRSCs, and other agricultural users in the Sacramento Basin incorporate reuse of this water into their overall water management plans, thereby decreasing their surface water diversions from the Sacramento River. In addition, reuse provides additional operational flexibility for water managers. Reliability, cost, and increasing soil salinity implications affect the level of reuse that may be effectively implemented at a sustainable level.

Greater detail on district-specific facilities and operations is provided in Section 2.

1.4 Topography and Soils

The SRSCs are situated within the Sacramento River Basin, within the Sacramento River watershed (see Figure 1-1). The basin is located in the northern portion of the Central Valley. Drainage is provided by the Sacramento River, which flows generally from north to south from its source near Mount Shasta to the Delta, and receives contributing flows from numerous major and minor streams and rivers that drain the east and west sides of the basin.

1.4.1 Topography

The Sacramento River Basin's principal geographic features include the Sacramento Valley, which is bounded on the northwest by the Klamath Mountains, the west by the Coast Range, the northeast by the southern extent of the Cascade Mountains, and the southeast by the northern extent of the Sierra Nevada Mountains. Elevations in the northern portion of the Sacramento River Basin range from approximately 3,600 feet above mean sea level (msl) in the headwaters of the Sacramento River in the city of Mount Shasta, to approximately 1,100 feet msl at Shasta Lake. The mountainous areas that border the valley reach elevations higher than 5,000 feet msl.

The floor of the Sacramento Valley, where the participating SRSCs are located, is relatively flat, with elevations ranging from approximately 60 to 300 feet msl. The topography of the basin lends itself to district water operations and management. The surface water supply naturally flows in a southerly direction to where the majority of the agricultural users are located. Even with this relatively flat topography, there is typically enough variation within the basin to allow for gravity/surface irrigation. The water can also be easily pressurized into sprinkler or micro-irrigation systems. The topography also forms a natural drain in the lower portion of the valley at the Yolo Bypass.

The west side of the Sacramento Valley contains a number of reservoirs, including Black Butte, Stony Gorge, East Park, and Indian Valley Reservoirs. From the east side of the valley come various tributary rivers and creeks, including Big Chico Creek, Butte Creek, and the Feather River. The Sacramento Valley also contains the Sutter Buttes (the "world's smallest mountain range"), located approximately 6 miles northwest of Yuba City; it is generally circular with a 10-mile diameter and covers an area of only 75 square miles.

1.4.2 Soils

The majority of the Sacramento Valley consists of soils that are fine textured with high clay content, mostly suitable for rice, tomatoes, and some cotton. Adjacent to the Sacramento River and the associated tributaries are coarser-textured soils suitable for a wide variety of crops.

The soil associations found within the Sacramento Valley are identified below. The descriptions include soil associations that are dominant in their respective region of the Sacramento Basin—northern, central, and southern. Complete descriptions of the soil associations and the corresponding acreage of each association in the valley are provided in the soil surveys for Shasta, Tehama, Butte, Glenn, Colusa, Sutter, Yuba, and Yolo Counties prepared by U.S. Department of Agriculture/Soil Conservation Service (now the Natural Resources Conservation Service [NRCS]).

1.4.2.1 Northern Region

Dominant soil associations in the northern region, represented by Tehama County, include the following (U.S. Department of Agriculture/Soil Conservation Service, 1967):

- **Toomes-Guenoc:** Shallow or moderately deep, rocky, gently sloping to steep soils, underlain by volcanic rock. Toomes soils are loams that are very rocky. Guenoc soils have a surface layer of loam and a subsoil of clay loam or clay.
- **Newville-Dibble:** Shallow to deep, moderately steep or steep, medium- to fine-textured soils underlain by soft sedimentary rock. Newville soils have a surface layer of gravelly loam and a subsoil of gravelly clay. Dibble soils consist of layers of silt loam or silty clay loam over dense compact siltstone.
- **Maywood-Tehama:** Very deep to moderately deep, nearly level to very gently sloping loams on floodplains and terraces along tributaries of the Sacramento River.

1.4.2.2 Central Region

Dominant soil associations in the central region, represented by Butte County, are as follows:

- **Stockton-Sacramento:** Very deep, nearly level, moderately well-drained to poorly drained soils occurring in nearly level basins or floodplains in the Sacramento Valley. Stockton soils have granular clay surface layers and massive clay subsoils. Sacramento soils have granular to blocky clay surface layers and hard, blocky clay subsoils.
- **Aiken-Cohassett:** Moderately deep to very deep, gently sloping to steep, well-drained soils. Aiken soils have soft, granular loam surface layers, and slightly hard, massive clay subsoils over weathered rock. Cohasset soils are soft, granular, cobbly, loam surface layers and hard, blocky clay loam subsoils resting on weathered basalt rock.
- **Goulding-Auburn:** Shallow to very shallow, gently sloping to very steep, well-drained soils. Goulding soils have soft, gravelly loam surface layers, and slightly hard, granular, very gravelly loam subsoils. Auburn soils have slightly hard, massive, cobbly, silt loam surface and hard, massive, silt loam subsurface layers that rest on metamorphic rock (U.S. Department of Agriculture/Soil Conservation Service, 1967).

1.4.2.3 Southern Region

Dominant soil associations in the southern region, represented by Colusa County, are as follows (Haradine, 1948):

- **Willows:** Nearly level, fine-textured soils with moderately dense subsoils. Willows soils are clays with sedimentary alluvium rock as the parent material.
- **Altamont-Contra Costa:** Steep, shallow, medium-textured soils. Altamont-Contra Costa soils are clay loams with sedimentary rock as the parent material.

Soil profile characteristics in the southern region, represented by Colusa County, are as follows:

- Older alluvial fans, alluvial plains, or terraces having moderately developed profiles with moderately dense subsoils.
- Soils of upland areas formed in place from underlying consolidated sedimentary bedrock.

Soils in Shasta, Tehama, Butte, Glenn, Colusa, Sutter, Yuba, and Yolo Counties are currently classified according to profile characteristics. Soil profile characteristics for these counties will be updated and grouped into soil association descriptions after publication of the new NRCS county soil surveys. Identification of the limitations on the participating SRSCs' agriculture resulting from soil problems is not applicable to the *Bureau of Reclamation, Mid-Pacific Region, Regional Criteria for Evaluating Water Management Plans for the Sacramento River Contractors* (Regional Criteria). Specific data regarding soil problems and related impacts to agriculture are available through the districts or individual farmers in the districts.

1.5 Climate

The total annual precipitation in the headwaters area of the Sacramento River averages between 60 and 70 inches per year. The Sierra Nevada and Cascade Mountains receive as much as 95 inches annual precipitation. Snow is prevalent in the mountains bordering the Sacramento Valley, and areas above 5,000 feet receive an average of 42 inches of precipitation per year.

The Sacramento Valley is characterized by hot, dry summers and cool, wet winters (see Table 1-1). Most of the precipitation in the valley occurs during November through April. Average annual rainfall in the area of the valley from Sacramento to Red Bluff was 19.51 inches, and ranged from a low of 16.22 inches to a high of 23.20 inches. During that same period, the average annual rainfall in the Redding area was 40.94 inches. Snowfall in the Sacramento Valley is rare, with the highest annual average of 4.8 inches measured in Redding.

Winds in the Sacramento Valley blow predominantly from the north and south because of the mountains bordering the valley. Annual average wind velocities range from 3.5 miles per hour in Mount Shasta to 8.2 miles per hour in Marysville. The average annual wind velocity for the valley is 6.6 miles per hour (Western Regional Climate Center, 2005).

Table 1-1. Average Temperature Range in the Sacramento Valley

Parameter*	Average High Temperature in °F	Average Low Temperature in °F	Precipitation in inches
Annual	74.9	48.7	19.51
January	54.1	37.3	3.90
February	59.8	40.54	3.35
March	65.4	43	2.60
April	72.5	46.4	1.33
May	81.2	52.5	0.72
June	89.4	58.3	0.29
July	95.7	61.4	0.04
August	94.1	59.6	0.09
September	89.3	56.3	0.33
October	78.6	49.78	1.10

Table 1-1. Average Temperature Range in the Sacramento Valley

Parameter*	Average High Temperature in °F	Average Low Temperature in °F	Precipitation in inches
November	64.3	42.1	2.35
December	54.7	37.6	3.42

*Averages derived from five selected areas within Sacramento Valley (Orland, Colusa, Red Bluff, Sacramento, and Marysville).

Note:

°F = degree(s) Fahrenheit

Source:

Period of record for each station: Orland (03/01/1903–06/10/2016), Colusa (10/01/1948–04/30/2016), Red Bluff (11/01/1933–06/09/2016), Sacramento (11/10/1941–06/09/2016), and Marysville (02/01/1897–10/31/2007).

Meteorological data were obtained from Western Regional Climate Center at the following monitoring stations: Orland, California (046506), Colusa 2 SSW, California (041948), Red Bluff Muni AP, California (047292), Sacramento executive AP, California (047630), and Marysville, California (045385).

1.6 Natural and Cultural Resources

1.6.1 Natural Resources

Historically, the Sacramento Valley contained a mosaic of riverine, wetland, and riparian habitat with surrounding terrestrial habitats consisting of perennial grassland and oak woodland. With settlement of the Sacramento Valley, agricultural and urban development converted land from native habitats to cultivated fields, pastures, residences, water impoundments, flood control structures, and other developments. The primary areas of concern are the Sacramento Valley portions of Shasta, Glenn, Colusa, Yolo, Solano, Butte, Sutter, Yuba, Nevada, Placer, and Sacramento Counties. Land uses in the Sacramento Valley are variable and include developed areas ranging in character from downtown Sacramento to smaller communities such as Willows and Colusa. Most of the valley, however, is rural in character and developed for agricultural use. As a result, native habitats generally are restricted in their distribution and size and are highly fragmented.

The Sacramento Valley supports the following seven primary vegetation and wildlife communities:

- Seasonally flooded agricultural land
- Orchard and vineyard
- Wetlands
- Valley foothill riparian forest
- Foothill pine-oak woodland
- Blue oak woodland
- Non-native grassland

A few other habitats (e.g., mixed conifer, montane hardwood, and chaparral) occur in areas of higher elevation.

Non-native grassland dominates the valley floor where there is no cultivation; otherwise, row and field crops and general agricultural land predominate, with rice, pasture, wheat, safflower, tomatoes, corn, and fruit and nut trees accounting for most of the crops. Rice fields are flooded in fall for rice stubble decomposition and the creation of wintertime waterfowl habitat. Agricultural drains and canals support wetland vegetation in some areas and provide habitat for wetland species; more extensive areas of freshwater marsh habitat are provided in several national wildlife refuges. Some vernal pool complexes persist in areas of non-native grassland throughout the Sacramento Valley. The area within Butte and Sutter Counties is a relatively flat area with several trapped depressions that result in large hydrologic sinks that have no outlets. These sinks support a large amount of freshwater marsh habitat.

Special-status species are species listed as Endangered, Threatened, or Candidate for listing under the Federal and State Endangered Species Acts. Table 1-2 lists the special-status species that might occur in the Sacramento Valley.

Table 1-2. Potential Federal- and State-listed and Proposed Species in the Sacramento Valley Area (2021)

Common Name	Scientific Name	Status
Wildlife		
American badger	*Taxidea taxus*	Federal – None State – CSC
American peregrine falcon	*Falco peregrinus anatum*	Federal – Delisted State – Delisted, FP
bald eagle	*Haliaeetus leucocephalus*	Federal – Delisted State – E, FP
bank swallow	*Riparia*	Federal – None State – T
burrowing owl	*Athene cunicularia*	Federal – None State – CSC
California black rail	*Laterallus jamaicensis coturniculus*	Federal – BCC State – T, FP
California clapper rail	*Rallus longirostris obsoletus*	Federal – E State – E
California freshwater shrimp	*Syncaris pacifica*	Federal – E State – E
California least tern	*Sterna antillarum browni*	Federal – E State – E, FP
California red-legged frog	*Rana aurora draytonii*	Federal – T State – CSC
coast horned lizard	*Phrynosoma blainvillii*	Federal – None State – CSC
conservancy fairy shrimp	*Branchinecta conservatio*	Federal – E State – None
crotch bumble bee	*Bombus crotchii*	Federal – None State – CE
delta green ground beetle	*Elaphrus viridis*	Federal – T State – None
foothill yellow-legged frog	*Rana boylii*	Federal – None State – E
giant garter snake	*Thamnophis gigas*	Federal – T State – T
grasshopper sparrow	*Ammodramus savannarum*	Federal – None State – CSC

Table 1-2. Potential Federal- and State-listed and Proposed Species in the Sacramento Valley Area (2021)

Common Name	Scientific Name	Status
greater sandhill crane	*Grus canadensis tabida*	Federal – None State – T, FP
loggerhead shrike	*Lanius ludovicianus*	Federal – None State – CSC
mountain plover	*Charadrius montanus*	Federal – None State – CSC
northern harrier	*Circus cyaneus*	Federal – None State – CSC
northern spotted owl	*Strix occidentalis caurina*	Federal – T State – None
pallid bat	*Antrozous pallidus*	Federal – None State – CSC
purple martin	*Progne subis*	Federal – None State – CSC
salt marsh harvest mouse	*Reithrodontomys raviventris*	Federal – E State – E, FP
Shasta salamander	*Hydromantes shastae*	Federal – None State – T
short-eared owl	*Asio flammeus*	Federal – None State – CSC
Swainson's hawk	*Buteo swainsoni*	Federal – BCC State – T
Townsend's big-eared bat	*Corynorhinus townsendii*	Federal – None State – CSC
tricolored blackbird	*Agelaius tricolor*	Federal – None State – T
valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	Federal – T State – None
vernal pool fairy shrimp	*Branchinecta lynchi*	Federal – T State – None
vernal pool tadpole shrimp	*Lepidurus packardi*	Federal – E State – None
western bumble bee	*Bombus occidentalis*	Federal – None State – CE
western mastiff bat	*Eumops perotis californicus*	Federal – None State – CSC
western pond turtle	*Emys marmorata*	Federal – None State – CSC
western red bat	*Lasiurus blossevillii*	Federal – None State – CSC
western snowy plover	*Charadrius alexandrinus nivosus*	Federal – T State – CSC

Table 1-2. Potential Federal- and State-listed and Proposed Species in the Sacramento Valley Area (2021)

Common Name	Scientific Name	Status
western spadefoot	*Spea hammondii*	Federal – None State – CSC
western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	Federal – T State – E
white-faced ibis	*Plegadis chihi*	Federal – None State – CSC
white-tailed kite	*Elanus leucurus*	Federal – None State – FP
yellow warbler	*Setophaga petechia*	Federal – None State – CSC
yellow-breasted chat	*Icteria virens*	Federal – None State – CSC
yellow-headed blackbird	*Xanthocephalus*	Federal – None State – CSC
Plants		
Boggs Lake hedge-hyssop	*Gratiola heterosepala*	Federal – None State – E
Butte County meadowfoam	*Limnanthes floccosa* ssp. *californica*	Federal – E State – E
Colusa grass	*Neostapfia colusana*	Federal – T State – E
Contra Costa goldfields	*Lasthenia conjugens*	Federal – E State – None
El Dorado bedstraw	*Galium californicum* ssp. *sierrae*	Federal – E State – Rare
few-flowered navarretia	*Navarretia leucocephala* ssp. *pauciflora*	Federal – E State – T
Greene's tuctoria	*Tuctoria greenei*	Federal – E State – Rare
Hartweg's golden sunburst	*Pseudobahia bahiifolia*	Federal – E State – E
hairy Orcutt grass	*Orcuttia pilosa*	Federal – E State – E
Hoover's spurge	*Chamaesyce hooveri*	Federal – T State – None
Indian Valley brodiaea	*Brodiaea coronaria* ssp. *rosea*	Federal – None State – E
Keck's checkerbloom	*Sidalcea keckii*	Federal – E State – None
Layne's ragwort	*Senecio layneae*	Federal – T State – Rare
Milo Baker's lupine	*Lupinus milo-bakeri*	Federal – None State – T

Table 1-2. Potential Federal- and State-listed and Proposed Species in the Sacramento Valley Area (2021)

Common Name	Scientific Name	Status
palmate-bracted bird's beak	*Cordylanthus palmatus*	Federal – E State – E
Pine Hill ceanothus	*Ceanothus roderickii*	Federal – E State – Rare
Pine Hill flannelbush	*Fremontodendron decumbens* ssp. *californicum*	Federal – E State – Rare
Sacramento Orcutt grass	*Orcuttia viscida*	Federal – E State – E
scadden flat checkerbloom	*Sidalcea stipularis*	Federal – None State – E
showy Indian clover	*Trifolium amoenum*	Federal – E State – None
slender Orcutt grass	*Orcuttia tenuis*	Federal – T State – E
Solano grass	*Tuctoria mucronata*	Federal – E State – E
Stebbin's morning-glory	*Calystegia stebbinsii*	Federal – E State – E
Suisun thistle	*Cirsium hydrophilum* var. *hydrophilum*	Federal – E State – None
two-fork clover	*Triolium amoenum*	Federal – E State – None

Notes:

E = Endangered under either the federal Endangered Species Act (ESA) or the California ESA
T = Threatened under either the federal ESA or California ESA
CE = Candidate for listing as Endangered under the California ESA
FP = California fully protected species
CSC = California species of special concern
BCC = U.S. Fish and Wildlife Service Birds of Conservation Concern
Rare = Classified as rare under Native Plant Protection Act

The Central Valley provides habitat for several species of native anadromous fish, including freshwater stages of Chinook salmon and steelhead. The Sacramento River provides a corridor to the ocean for anadromous salmonids that are spawned and reared in Central Valley rivers, streams, and hatcheries.

The Sacramento River is the largest river system in California and, along with the hatcheries on its tributaries, produces more than 90 percent of the Central Valley salmon and steelhead. The Sacramento River supports four runs of Chinook salmon—fall, late fall, winter, and spring—with fall Chinook being the most abundant. Most of the Central Valley fall steelhead are also found in the Sacramento River Basin. Native non-salmonid anadromous fish in the Central Valley include green sturgeon, white sturgeon, and Pacific lamprey.

Table 1-3 presents the special-status fish species that could occur in the Sacramento Valley, the regulatory status of each, and the water body where each species is anticipated to occur.

Table 1-3. Special-status Fish Species within the Sacramento Valley

Common Name	Scientific Name	Status	Location
Central Valley fall-run/late-fall-run Chinook salmon	*Oncorhynchus tshawytscha*	SC, CSC	Sacramento, Feather, Yuba, and lower American Rivers and the Delta
Central Valley spring-run Chinook salmon	*Oncorhynchus tshawytscha*	T, T	Sacramento, Feather, and Yuba Rivers and the Delta
Central Valley winter-run Chinook salmon	*Oncorhynchus tshawytscha*	E, E	Sacramento River and the Delta
Central Valley steelhead	*Oncorhynchus mykiss*	T, None	Sacramento, Feather, Yuba, and lower American Rivers and the Delta
delta smelt	*Hypomesus transpacificus*	T, E	Delta
green sturgeon southern DPS	*Acipenser medirostris*	T, CSC	Sacramento and Feather Rivers and the Delta
Hardhead	*Mylopharodon conocephalus*	CSC	Sacramento and Feather Rivers
longfin smelt	*Spirinchus thaleichthys*	C, T	Delta
river lamprey	*Lampetra ayresi*	CSC	Sacramento River and the Delta
Sacramento perch	*Archoplites interruptus*	CSC	Sacramento River and the Delta
Sacramento splittail	*Pogonichthys macrolepidotus*	CSC	Sacramento, Feather, and lower American Rivers and the Delta
San Joaquin roach	*Lavinia symmetricus* ssp.	CSC	Sacramento River

Notes:

E = Endangered – Federally listed as being in danger of extinction.
T = Threatened – Federally listed as likely to become endangered within the foreseeable future.
P = Proposed – Officially proposed for listing as endangered or threatened.
C = Candidate – Candidate to become a proposed species.
SC = Species of Concern – Species of Concern to the National Marine Fisheries Service.
ST = State Threatened – State listed as likely to become endangered.
CSC = California Species of Special Concern – Species of special concern to the California Department of Fish and Game.

1.6.2 Cultural Resources

Archaeological evidence of human occupation in the Sacramento Valley and nearby areas extends back several thousand years. The Sacramento Valley was home to several Native American groups, including the Wintu, Yana, Nomlaki, Konkow, Nisenan, Patwin, By Miwok, and Plains Miwok.

The northern Sacramento Valley saw the majority of white settlement following the California Gold Rush. Settlement was further stimulated by the 1862 Homestead Act and construction of railroads. Settlements included the establishment of farms, ranches, gold mines, and lumber and other extractive industries.

Through the late nineteenth and twentieth centuries, the expansion of riverboat and ferry transportation and later railroad and highway transportation infrastructure increased access to more distant markets. The northern end of the Sacramento Valley developed a growing population sustained by a mix of mineral and timber extraction industries and farm and ranch operations. Large-scale irrigation of farms and ranches was made possible in the mid-twentieth century by completion of Shasta Dam and other large water reservoirs and aqueduct projects. In recent decades, recreation and tourism have emerged as important components of the local economy.

Following the California Gold Rush, white settlers developed the farmland in the region and made use of its abundant water. Several agricultural developments were introduced. Today, the Sacramento Valley enjoys a diverse population and industry with vast stretches of rich farmland.

The southern region of the Sacramento Valley includes portions of Yolo, Glenn, Solano, and Colusa Counties. After the California Gold Rush, many miners became permanent settlers who raised cattle, sheep, wheat, and barley. Initially, the location of towns and settlements was influenced by access to water and water transportation routes. In the late nineteenth century, emphasis shifted from livestock grazing to growing grain and orchard crops.

In the 1870s, the railroad progressed northward and brought settlers who established towns such as Arbuckle, Williams, Maxwell, Willows, and Orland. With the advent of large-scale flood control and irrigation projects, the Colusa Subbasin has become noted for growing rice and tomatoes. Large-scale, diversified farming was introduced as new lands were irrigated and brought into production and as shipment of local products to domestic and international markets increased with improved railroad and highway transportation systems.

1.7 Operating Rules, Regulations, and Agreements that Affect Water Availability

The operating rules, policies, and regulations for the region other than regulatory requirements governing CVP and SWP operations vary from district to district. In general, operating rules and regulations include lead time for water orders and water shutoff, policies on water allocation, return flows and drainage, and policies related to water transfers into or out of each participating SRSC. The operating rules and regulations for each participating SRSC depends on how each was originally formed. For example, mutual water company policies and procedures are determined by a board of trustees; water districts formed under Chapter 11 of the California Water Code have policies and procedures that are determined by a board of directors who require the districts to hold a certain amount of money in reserve. For a more complete description of the operating rules and regulations for each participating SRSC, see Section 2. Copies of available district rules and regulations are included in Attachment B.

1.8 Measurement, Pricing, and Billing

Water measurement at the district level provides necessary information and monitoring data to make decisions and efficiently manage the water supply. Water measurement for a typical Sacramento Valley irrigation district can be considered in terms of four basic operations levels—supply, conveyance and distribution, turnout to individual fields or customers, and drainage. The methods used to measure water for these operations are driven largely by several key factors common to most of the SRSC districts. These include scheduled water delivery (as opposed to on-demand or rotation), unlined earthen canals and laterals on open-channel distribution systems, related irrigation methods within a given district, the predominance of particular crops, and the operation and maintenance (O&M) costs related to different measurement methods. There are also many local and site-specific factors that influence the choice of measurement methods, both between and within districts. The extent of water measurement, the methods used, and the level of recording and documentation vary greatly among individual SRSCs, from extensive measurement and reporting at all operational levels to only minimal measurement at key supply and distribution points.

To support a more standardized level of documentation related to current water measurement devices and approach, the participating SRSCs individually conducted an inventory of current water measurement devices used to measure flows at diversions, laterals, and turnouts. An agricultural measurement device inventory has been completed for each District/Company and is provided in Section 2 under the Water Measurement, Pricing, and Billing section for each SRSC.

1.8.1 Measurement Practices

The following discussion summarizes current practices among the SRSCs. In addition, Table 1-4 briefly describes measurement methods used by each participating SRSC. The potential benefits of improved water measurement, factors in selecting measurement methods, and water measurement for each operational level for both current practices and potential improvements are provided in Chapter 3.

Table 1-4. Existing Sacramento River Settlement Contractors Measurement Methods

SRSC	Measurement Method
ACID	Main river diversions have meters, which measure both flow rate and total flow volume. Flow rates are measured at major lateral headgates by weirs or gate head-flow tables. Flows at field turnouts are measured using canal headgate position tables. Total volumes pumped by drain pumps are estimated using power consumption and pump efficiency history.
GCID	Main canal flows are metered. Main laterals and sub-laterals serving field turnouts are metered. Drain pumps and groundwater wells are metered. Turnouts to fields are measured and totaled by service area using the measurements of the service lateral. Lateral spills are measured using lateral stage measurement and weir equations. Drain outflows are measured using weirs and meters.
PID	Main pump-station flows are measured using flowmeters. Wells and drain pumps are metered. Lateral headgate flows are measured using stage and gate position, or stage and weir geometry at flashboard turnouts.
PCGID	Main pump–station flows are measured using flowmeters. Wells and drain pumps are metered. Lateral headgate flows are measured using stage and gate position, or stage and weir geometry at flashboard turnouts.
RD 108	Pump-station flows are measured using flowmeters. Drain pumps and lift pump flows are estimated using power consumption and pump efficiency curves. Wells and drain pumps are metered. Drain flows discharged into the river are metered at pump stations. Flows in canals and laterals are calculated using head measurements at gates and weirs.
RD 1004	Pump stations at river diversions measure flow and quantity using flowmeters. Canal and lateral flows are measured using meters and totalizers. The well is metered. Drain-pump flows are estimated using power consumption and pump efficiency data.
MFWC	Pump-station flows are measured with flowmeters. Canal and lateral flow rates are measured using weir or gate head/flow curves. Wells are metered. Drain-pump flows are estimated using power consumption and pump efficiency data.
SMWC	Main pump-station flows are measured with flowmeters and pump flowcharts. Flows at lateral headgates are measured using headgate position. Drain lift-pump flows are measured using power consumption records and capacity information. Drainage leaving the company is measured using a DWR formula.
NCMWC	Main river-diversion pump stations measure flows using flowmeters. Drain-pump and secondary lift-pump volumes are estimated using power consumption and pump efficiency data. This method is also used to estimate outflow amounts from drainage pumps into the river.

1.8.1.1 Sacramento River Diversions – Current Practices

Diversions from the Sacramento River are the primary water source for each participating SRSC. These diversions are delivered via pump or gravity flow. Pumped diversions are measured and recorded using meters or calibrated pump curves. Gravity diversions are measured using either water level measurement at weirs or flumes, or by flowmeters (propeller type) installed in full-flow pipes such as road-crossing culverts. Measurement devices for river diversions are typically installed and maintained by Reclamation staff. Pursuant to diversion measurement requirements adopted by the SWRCB in 2016 to implement Senate Bill 88, all water right holders (including the SRSC) are required to measure diversions under their water rights. As described within Chapter 2 the SRSC hold water rights for diversions from the Sacramento River and other sources. These requirements for SRSC generally require that measurement accuracy is certified by a "qualified individual" for example, a CA registered Professional Engineer, measurements be recorded on at least an hourly basis, and at certain points of diversion data be telemetered and posted to a public website. All of the SRSC are in compliance with these requirements under their water rights, for both Sacramento River diversions and other source diversions. This compliance is achieved through extensive coordination with Reclamation.

1.8.1.2 Distribution Canals and Laterals – Current Practices

Flows in the canals and laterals are typically measured at major flow-control structures such as in-line gates (checks) and lateral turnouts (headgates). The most common type of measurement uses gate or weir geometry and position, and measured water level (head) in the canal. Typically, only the flow rate is recorded at these points. Some districts measure both flow rate and total flow using the average flow rate and duration of operation. This requires either very stable water level control or continuous water level measurement to provide good accuracy. In some cases, lateral turnouts are measured using propeller meters installed in short runs of full-flow pipes downstream of headgates, such as at road-crossing culverts. This method provides both flow rate and total quantity with good accuracy. In-line flumes and weirs with stage recorders are used in a few locations for main canal flows only.

1.8.1.3 Groundwater Wells – Current Practices

In most districts, wells are primarily privately owned. District-owned wells typically have flowmeters and totalizers. Many privately owned wells have flowmeters and totalizers, primarily those that participate in water transfers. In some cases, the total quantity of flow can be estimated through power use records and using pump efficiency curves. The SRSC also measure water level and water quality of groundwater wells on a regular basis, and more frequently during water transfers. Some SRSC wells have water level and quality sensors installed for continuous monitoring.

1.8.1.4 Drains – Current Practices

Drain flow measurement can be categorized within each district's service area in terms of total inflows and total outflows. Inflows include water coming into the service area from upstream districts, tailwater runoff from individual fields, and operational spills (intentional or otherwise) at the ends of laterals or overflow points. Outflows from drains include water pumped from drains back into the distribution system, gravity outflow as the drain leaves a district service area, and pumped outflow directly into the Sacramento River.

Most districts do not measure total inflows to drains, unless the drain flow is an authorized source of water under an SRSC's water right (in which case the total drain inflow diverted by the SRSC is measured). See section 1.8.1.1 for additional information on current measurement practices for these situations. In some cases, inflows from other districts are estimated by water stage at key drain diversion point check structures. Some districts measure operational spills and intentional turnouts to drains by recording the water level at overflow weirs on a daily basis. Inflows from field tailwater are generally not measured. Outflows from drains are generally measured by a combination of drain pump (relift to laterals) meters or power use records, reclamation drain pump meters or power use records, and recording of stage at key gravity outflow points from the district service area. See Chapter 3, specifically Exemptible BMP 8 for additional information on measurement of drain outflow.

1.8.1.5 Field Turnouts – Current Practices

Delivery of water to individual fields is measured and/or estimated by all SRSCs for flow rate and/or total quantity delivered. Districts measure/estimate flows using a combination of the following methods, although several SRSCs are currently in the process of implementing improved turnout measurement programs (described in Chapter 3):

- Standard canal gates (screw gates) at the upstream end of short culverts measure flow rate using differential head and gate position.
- Flash-board overshot or undershot weirs measure flow rate using head and weir or orifice geometry.
- Constant-head-orifice arrangements measure flow using differential head on upstream gate.
- Gated culverts or constant-head-orifice turnouts with open-channel propeller meters on the downstream end measure flow rate and total quantity.
- Ratings maintained for each delivery point based on velocity measurements taken with acoustic doppler equipment.

Measurement of total quantity requires recording flow rate and the total time of delivery with a relatively stable canal water surface, or use of a totalizer device. Several districts measure and record both flow rate and total delivered quantity without using meters, by having operators record both the set flow rate and the start-stop time of each daily delivery. See Chapter 3, specifically Critical BMP 1, for additional information, including details of the types of measurement used at field turnouts.

1.8.2 Pricing Structures and Billing

Water pricing is a fundamental agricultural water management tool. When used effectively, water pricing structures can provide a direct economic signal for the water user between the quantity of use and farm-level water management practices, crop types, and net financial results. As a district-level management option, water pricing structures can encourage more efficient use of existing water supplies or other specific targeted benefits. The mechanisms and influence of water pricing structures on Agricultural Water Use Efficiency Element (Ag WUE) and overall agricultural economics are complex. Detailed evaluation of the impacts of pricing structures on existing district practices requires sophisticated economic modeling to capture the multitude of influences that ultimately determine land use choices, irrigation practices, water use levels, crop prices, and net economic benefits or costs to growers and districts. The following sections provide a summary of existing pricing structures, a range of possible new pricing structures, and issues related to the evaluation and implementation of an incentive pricing program.

1.8.2.1 Existing Pricing Structures

Existing price structures are influenced by many factors, including the cost of water supplies, the water district or company incorporation charter and regulations, operating costs, crop types, and irrigation methods within a service area. Districts typically set a price structure that covers O&M costs and long-term capital replacement and improvement costs. Some of the current price structures include a direct or indirect quantity component.

Pricing structures generally include a basic annual maintenance charge (e.g., $10 per ac-ft per year or $10 per share of company stock per year) that is independent of water use. In addition to this annual charge, pricing structures typically include one of the following charges:

- **Per acre:** Dollar per acre per season. May vary by crop type or be the same for all crops.

- **Per irrigation:** Dollar per acre per irrigation event. Charged for each scheduled irrigation throughout the season. May vary by crop type, or be the same for all crops. May also vary by time of year, with the first irrigation of the season having the highest cost, subsequent regular irrigations a slightly lower cost, and post-harvest irrigations for weed control or rice decomposition another cost.
- **Per ac-ft:** Dollar per ac-ft delivered. Charged for the volume of irrigation water delivered.

1.8.2.2 Indirect Price Signals Related to Water Use

Water pricing is only one of several direct and indirect cost signals to which a grower might be subject. A farmer who pays a flat rate (the sum of the base charge and annual irrigation charge as referenced in Table 1-5) for water use as an SRSC customer may still have a monetary impact through such things as quantity and cost of fertilizers, pesticides, and herbicides. Increased water use may increase costs for these inputs. Poor water management by over irrigating may reduce yields and, thus, gross revenue. If the farmer operates a private well or drain pump, the electrical power costs are a direct cost related to water use. Districts must cover operating and capital expenses with revenue from customers. Excessive irrigation results in increased pumping costs from the Sacramento River, the drain system, and wells. These costs are ultimately passed directly back to the growers, albeit at an average rate for all district customers. Many SRSC operating staff have authority to shut off delivery to a customer whose field is observed to be poorly irrigated and allowed to have excessive tailwater runoff.

Table 1-5. Existing SRSC Pricing Structures

SRSC	Pricing Structure
ACID	Base charge of $87.00 per acre per year. Annual irrigation charge of $115.00 per parcel. Irrigation delivery is on rotation basis.
GCID	Base charge of $7.62 per acre per year. Annual irrigation charge of $41 per acre. Crop irrigation duty of $59/acre (rice).
PID	Base charge of $10.00 per acre per year. Annual irrigation charge of $110.00 per acre (rice).
PCGID	Base charge of $22.00 per acre per year. Annual irrigation charge of $185.00 per acre (rice). $10.00 to $15.00 per acre per irrigation for other crops.
RD 108	Base charge of $10.00 per acre and $15.00 per ac-ft for actual use.
RD 1004	Per-ac-ft charge of $17.00 per ac-ft, measured at customer turnout.
MFWC	Base charge of $27.00 per acre per year. Annual irrigation charge of $30.00 per ac-ft.
SMWC	Water rate is set at $30.00/ac-ft based on volume measured at the point of delivery.
NCMWC	Base charge and administration fee on all acres of $52.84 and $32.54 to cover fixed cost of the Company; plus a water toll on irrigated acres based on type of crop. Irrigation charge of $8.83 per ac-ft based on evapotranspiration of applied water and applied water demand. Rice decomposition flooding charge is an additional $17.66 per ac-ft.

Information specific to each participating SRSC's pricing structure, including the basis of the water charges and copies of current billing forms used by each, can be found in Section 2 and BMP section specifically Critical BMP 4 and Exemptible BMP 4.

1.9 Water Shortage Allocation Policies

1.9.1 CVP Sacramento River Contract Supply Requirements

The CVP supplies approximately 6 to 7 million ac-ft (maf) of water annually to water contractors in the Central Valley, Santa Clara Valley, and Contra Costa County. As identified above, total CVP contractual entitlements north of the Delta total approximately 4 maf. Contracts with various entities specify that full contractual water deliveries be made except during dry periods. During periods of reduced supplies, water deliveries are decreased according to the curtailment terms in the contracts.

1.9.2 Criteria for Defining Water Availability

Except in times of critical-year reductions and water shortages, the CVP makes available the amount of water specified in the terms of its water right settlement and CVP water service contracts. Conditions for determining the quantity of water available to the SRSC during water shortage years are based on the Shasta Criteria. The Shasta Criteria are used by Reclamation to determine when a water year is considered to be critical, based on inflow to Shasta Lake. If a water year is determined to be critical, deliveries of Base and Project Supplies to SRSCs are reduced to 75 percent of the contract amount. A critical year is any year when on, or before, February 15 the forecast full natural inflow to Shasta Lake for the current water year (October of the preceding calendar year through September 30 of the current calendar year) is equal to or less than 3.2 maf. A year is also critical when the total accumulated actual deficiencies are below 4 maf in the previous water year or series of successive previous water years, each of which had inflows of less than 4 maf, together with the forecast deficiency for the current water year, exceed 800,000 ac-ft.

Water availability for delivery to CVP water service contractors during periods of insufficient water supply is determined at the discretion of Reclamation according to a combination of operational objectives, hydrologic conditions, and reservoir storage conditions. In years of shortage, Reclamation has historically allocated shortages equally among water service contractors within the same general area (e.g., north of the Delta). There is no limit on the shortage that Reclamation can declare for CVP agricultural water service contractors, and Reclamation can reduce their water supplies to zero. Some CVP municipal and industrial (M&I) water service contracts provide for a minimum allocation of 75 percent, or less, of the contract supply; and in drought years, Reclamation has applied such standards to M&I water service contracts.

The CVP contractors along the Sacramento River are grouped into the following three major categories.

1.9.2.1 Sacramento River Settlement Contractors

Most of these SRSCs claimed water rights in the Sacramento Basin prior to the construction of Shasta Dam. Contract provisions specify potential reductions of no more than 25 percent of contracted amounts during dry conditions (as determined by the Shasta Inflow Index). Approximately 2.2 maf of water (1.8 maf being designated as Base Supply) is allocated annually for delivery to the SRSCs. This total represents approximately 55 percent of the total quantity of water Reclamation must provide for agricultural, M&I, and wildlife refuge uses north of the Delta. The SRSC entitlements represent the majority of CVP water that is used north of the Delta. Additionally, SRSC supplies are the most reliable among contract holders because the SRSC entitlements are subject to the least severe curtailments.

1.9.2.2 CVP Water Service Contractors

These agricultural and M&I water service contractors entered into agreements with Reclamation for delivery of CVP water as a supplemental supply. Water deliveries to agricultural water service contractors can be reduced up to 100 percent in particularly dry years. Maximum curtailment levels are not specified for most M&I water service contractors. Water availability for delivery to CVP water service contractors during periods of insufficient supply is determined by a combination of operational objectives, hydrologic conditions, and reservoir storage conditions. Given the curtailment provisions, water service contractors holding these contracts have a relatively less reliable supply than the SRSCs. Examples of this type of water service contractor within the Sacramento River Basin include those associated with the TCCA.

Approximately 1 maf of water is allocated annually for delivery to CVP water service contractors (approximately 0.5 maf is allocated to both agricultural and M&I water service contractors) in the basin. This represents approximately 25 percent of the total quantity of water Reclamation must provide for agricultural, M&I, and wildlife refuge uses north of the Delta.

1.9.2.3 Colusa Drain Mutual Water Company

This company was chartered in 1988, to serve as a vehicle for entering into a contract with Reclamation. Although not an SRSC, the company is composed of diverters from the Colusa Basin Drain who are not within previously existing water districts. The company's service area includes approximately 57,500 acres, extending over 80 miles of the Colusa Drain from Glenn to Yolo Counties. The Reclamation contract with the company has no provisions for a physical supply of water. The company pays Reclamation for project releases, which are required to offset the impacts to senior water rights holders downstream of the company diverters, caused by calculated consumptive use within the company's service area. The company has historically required approximately 25,000 to 30,000 ac-ft of replacement water that has been met with Project Supply provided under its contract with Reclamation or has been met with water transfers from SRSCs.

1.10 Water Quality

1.10.1 Surface Water Quality

Water from the Sacramento River and its major tributaries is generally of good quality. Total dissolved solids in the Sacramento River and its major tributaries (Yuba, Feather, and American Rivers) are typically low, while higher median concentrations of dissolved solids occur at agricultural sites such as the Sacramento Slough and Colusa Basin Drain, but are diluted upon mixing with Sacramento River water. Nutrient concentrations such as nitrate are low (below drinking water standards) throughout the Sacramento River Basin. At limited locations, algae attached to streambed material is abundant, indicating that further investigation of nutrient dynamics and their consequences to the streams of this watershed is warranted. Excess algal growth, which is usually related to higher-than-normal nutrient inputs to streams, is a water quality concern when the algae affect the aquatic community (because of dissolved oxygen depletion).

Some stream segments are listed as impaired by various contaminants. Impairment means that a standard of water quality for beneficial uses (for example, as a source of drinking water or for recreation or industrial use) is not being met. Pursuant to Section 303(d) of the Clean Water Act, states are required to periodically review water quality data and develop lists of water bodies that do not meet their designated beneficial uses.

On the basis of California's 2002 list of impaired water bodies, the segment of the Sacramento River from Keswick Dam to Knight's Landing is listed as impaired because of toxicity of unknown origin, and the segment from Knight's Landing to the Delta is listed as impaired due to diazinon, mercury, and toxicity of unknown origin. Diazinon is attributable to agricultural runoff, while mercury is primarily attributable to discharges from abandoned mines such as those located upstream of Keswick and from the Feather River Basin.

1.10.1.1 Mineral Water Quality

The segment of the Sacramento River between Keswick Dam and Red Bluff has excellent to good mineral quality; therefore, the water is suitable for most M&I uses.[2] Most of the water can be classified as calcium-

[2] For drinking water purposes, mineral quality has been defined using the following hardness levels: calcium carbonate less than 75 milligrams per liter (mg/L) – soft (excellent mineral quality); calcium carbonate between 75 and 150 mg/L – moderately hard (good

magnesium bicarbonate; it is slightly hard but does not require softening. Many tributaries drain to the upper Sacramento River without deteriorating mineral quality, indicating the excellent mineral quality of the tributaries.

From Red Bluff to the Delta, the Sacramento River is generally of good mineral quality, although water quality is periodically degraded because of the discharge of toxins, untreated sewage, and other nonpoint-source contaminants. In the lower Sacramento River, agricultural drainage influences water quality by contributing to increased turbidity and mineral, nutrient, and herbicide loads. The state agencies and agricultural entities continue to promote management practices to ensure that discharges from agricultural lands do not exceed performance goals established by the Central Valley Regional Water Quality Control Board (Water Board).

1.10.1.2 Sediment

Turbidity levels are generally excellent but become seasonally elevated because of high flows in Cottonwood Creek, which is highly susceptible to sediment loading during high runoff.[3] Sediment levels in the Sacramento River and Feather River are typically low when compared to tributary contributions comprised primarily of agricultural return flows.

1.10.1.3 Dissolved Oxygen

The Sacramento River downstream of Keswick Dam is a designated spawning area for anadromous fish and has a minimum allowable dissolved oxygen level of 7 milligrams per liter (mg/L). At the Red Bluff Diversion Dam, the river maintains oxygen levels near saturation, with concentrations that have ranged from slightly below 10 mg/L to over 12 mg/L.

1.10.1.4 Salinity

The two primary parameters for characterizing irrigation water are salinity hazard and sodium hazard. Salinity hazard is classified as low if specific conductance is less than 250 micromhos per centimeter at 25 degrees Celsius. The maximum specific conductivity at any of the Sacramento River locations did not exceed 250 micromhos per centimeter at 25 degrees Celsius during 1997. The sodium hazard is classified as low if the sodium adsorption ratio is less than 10.

1.10.1.5 Heavy Metals

Acid mine drainage has been a serious environmental problem in the northern portion of the Sacramento River Basin. Several Sacramento River tributaries are listed as impaired due to high concentrations of metals such as cadmium, copper, lead, and zinc. Detected metals concentrations have been toxic to fish in the upper Sacramento River near, and downstream of, Redding.

1.10.1.6 Pesticides

The agricultural use of herbicides, insecticides, and fungicides (collectively referred to as pesticides) can result in seasonal aquatic toxicity, sediment toxicity, or exceedance of drinking water quality standards. Water quality regulations enacted in the 1980s resulted in changes in rice water management practices that significantly reduced the levels of rice herbicides present in drainage water.

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mineral quality); $CaCO_3$ between 150 and 300 mg/L – hard (fair mineral quality); and calcium carbonate greater than 300 mg/L – very hard (marginal to unacceptable mineral quality).

[3] For drinking water purposes, source-water turbidity levels have been defined accordingly: turbidity less than 5 nephelometric turbidity units (NTU) – excellent; turbidity between 5 and 50 NTUs – good; turbidity between 50 and 100 NTUs – fair; and turbidity greater than 100 NTUs – impaired.

Pursuant to the Water Board's "Conditional Waiver of Waste Discharge Requirements for Irrigated Lands," water quality monitoring for specific classes of pesticides, including organophosphates, carbamates, and pyrethroids is being undertaken in the Sacramento River and the Delta. Monitoring continues to provide data to help manage the timing, magnitude, and duration of potential pesticide water quality concerns.

1.10.1.7 Organic Carbon

Organic carbon is a concern to municipal drinking water agencies. During the disinfection process, organic carbon reacts with chlorine to form disinfection by-products. Organic carbon can be present in dissolved and particulate forms. Dissolved organic carbon can pass through a 0.45-micrometer filter; particulate organic carbon is retained by the filter. Collectively, dissolved organic carbon and particulate organic carbon are referred to as total organic carbon. The specific types of organic molecules that may be present in natural water range from small compounds, such as formic or acetic acid, to large macromolecules such as proteins.

Dissolved organic carbon comprises the majority of the total organic carbon load in the Sacramento River. During the irrigation season, dissolved organic carbon levels in the Sacramento River at Colusa typically range from 1 to 2 mg/L, while dissolved organic carbon levels in the Sacramento River at Verona typically range from about 2 to 3 mg/L. During the irrigation season, levels in tributaries dominated by agricultural return flows can range from 3 to 9 mg/L.

1.10.1.8 Water Quality Monitoring

Water quality monitoring is undertaken by a number of agencies and organizations in the Sacramento Valley. DWR's Northern and Central Districts maintain a network of water quality monitoring and surface water sampling stations in the Redding Subbasin and in counties throughout the Sacramento Valley. The agency operates electronic continuous recorders for field monitoring of water quality parameters. Periodically, agency personnel conduct field analyses and collect water quality samples for laboratory analysis from rivers, lakes, reservoirs, and certain drains in the Sacramento Valley. The agency also conducts studies to determine the physical, chemical, and biological characteristics of streams, lakes, and reservoirs in the districts. The studies, in part, are conducted to evaluate factors contributing to enrichment (eutrophication), factors affecting drinking water quality, and the influence of watershed development. The DWR also maintains a database of current and historical water quality data.

Agricultural water users in the Sacramento Valley began implementation of water quality monitoring programs in 2004. Monitoring locations are at mainstem and tributary sites, including agricultural drains. The parameters monitored include conventional water quality parameters (pH, temperature, dissolved oxygen, turbidity, and salinity), and aquatic and sediment toxicity. Monitoring is being undertaken by the Sacramento Valley Water Quality Coalition (Coalition) and by the California Rice Commission. The Coalition includes members throughout the Sacramento Valley, while the California Rice Commission includes commercial rice acres within the Sacramento Valley. Additional information on water quality monitoring can be found in Chapter 4.

1.10.2 Groundwater Quality

Groundwater quality is generally excellent throughout the Redding and Sacramento Valley Basins and is suitable for most uses. Concentration of total dissolved solids is normally less than 300 mg/L, although water in some areas may contain total dissolved solids to 1,500 mg/L (such as those observed in shallow groundwater, locally known as connate water, in areas south of Sutter Buttes) (DWR, 1978). However, concerns over water quality are on the increase, as evidenced by recent actions taken by the Water Board with respect to the proposed extension of the *Conditional Waiver of Water Discharge Requirements for Discharges from Irrigated Lands*, commonly called the Agricultural Waiver. In response to these concerns, the Coalition was formed in 2002 and includes approximately 200 agricultural and wetlands entities and local governments. The Coalition has developed and continues to implement a regional water quality monitoring and reporting program to ensure that water quality levels are maintained in the Sacramento Valley.

In a few places in the Sacramento Valley, shallow, high-salinity water makes the groundwater unusable. In other areas, elevated levels of naturally occurring boron restrict the type of crops that can be irrigated with groundwater. In some areas, nitrates and other introduced chemicals make the groundwater unfit for domestic use. DWR's Northern and Central Districts currently monitor groundwater quality in over 300 wells in Northern California and about 400 wells in Central California to identify areas of poor quality and to track changes in overall groundwater quality (DWR, 2005). Groundwater quality analyses typically include field measurements (temperature, pH, and conductivity), minerals (calcium, magnesium, and chloride), nutrients (phosphorus and nitrate), minor elements (arsenic, cadmium, and iron), organic compounds (pesticides and petroleum derivatives), and pathogens (bacteria). The districts' groundwater quality data extend back to the early 1950s.

1.11 History and Subbasin Description

Six groundwater basins/subbasins were identified to review current and future water requirements, water supplies, and possible options to maximize management activities. The boundaries of each subbasin were derived from existing DWR study boundaries where appropriate, accounting for the boundaries of each of the participating SRSC districts. In general, the subbasin boundaries were developed according to the following considerations:

- Encompass participating SRSC boundaries
- Possess common hydrologic, land, and water use characteristics
- Consistency with DWR planning boundaries
- The six groundwater basins/subbasins identified as part of this process include the following:
- RAGB
- Colusa Subbasin
- Butte Subbasin
- Sutter Subbasin
- North American Subbasin
- Yolo Subbasin

The Colusa, Butte, Yolo, and Sutter Subbasins are dominated by agricultural uses; municipal and industrial (M&I) uses are generally insignificant. The vast majority of total water requirements in the Sacramento Basin come from the agricultural sector. The RAGB and North American Subbasin have extensive agricultural requirements as well as substantial M&I requirements related to the Redding and Sacramento urban areas, respectively. Environmental uses within the basins/subbasins include wildlife refuges, native vegetation and associated wildlife use, streams and the Sacramento River and associated aquatic and wildlife use, wetlands, duck clubs, mitigation lands, and habitat incidental to agricultural production (e.g., rice fields) and water conveyance (e.g., drain canals).

The majority of the districts, other than the most northerly (ACID) and southerly (NCMWC), are generally rural and are surrounded by agricultural uses. Rice is the predominant crop for most of the districts given the clay soils that are prevalent; many of the growers within those districts have acquired equipment and expertise specific to rice. Other key crops include nut and fruit orchards, tomatoes, vine seed, corn, pasture, and alfalfa where suitable soils are present. The following provides a brief summary of the location and general characteristics of each subbasin. Additional details are provided in Section 2.

1.11.1 Redding Area Groundwater Basin

The RAGB is located at the northern extent of the Sacramento Valley. The basin encompasses the Sacramento River from Shasta Dam to north of Red Bluff and consists of significant urban areas, including the cities of Redding, Anderson, Shasta Lake, and the community of Cottonwood. ACID is the participating SRSC within the RAGB.

Relative to the subbasins in the central and southern end of the study area, the RAGB receives approximately twice as much rainfall annually; the rainy season may extend further into the spring months and delay the demand for irrigation water. Inflows to the basin are dominated by natural runoff from tributaries to the Sacramento River and regulated Sacramento River flows released from Shasta Dam. Water is also imported from the Trinity River Basin via the CVP. Outflows from the basin consist primarily of the Sacramento River flows.

Numerous water users along the Sacramento River divert water for agricultural and municipal uses. Many diversions are controlled by contracts with Reclamation between April 1 and October 31. There are also numerous water users with riparian and appropriative rights to Sacramento River water and associated tributaries in the basin.

No California State Water Project (SWP) contractors are located in the basin. A portion of most diversions returns to the basin as a result of system leakage or deep percolation, which enters the groundwater system. In the groundwater system, a portion of this water remains in storage, and the remainder becomes subsurface flow to the Sacramento River or another part of the surface water system. A small percentage of these flows may be rediverted for irrigation purposes before reaching the river. See Figure 1-5 for a map of the RAGB and participating SRSCs.

1.11.2 Colusa Subbasin

The Colusa Subbasin drains a portion of the west side of the Sacramento Valley and is bounded on the west by the Coast Ranges, on the north by Stony Creek, on the east by the Sacramento River (from the GCID diversion facility to the Knights Landing outfall gates), and on the south by the Colusa County line (DWR, 2018a). Participating SRSCs within this subbasin include the following:

- GCID
- PID
- PCGID
- RD 108 (northern half; southern half is located in the Yolo Subbasin which is not discussed in this Plan)

Water users in the basin include other CVP contractors, such as the Tehama-Colusa Canal Authority (TCCA), Sacramento River riparian diverters, and groundwater users. There are no SWP contractors in the subbasin.

Inflows to the subbasin include diversions from the west bank of the Sacramento River and imports through the Tehama-Colusa Canal. Outflows occur through the Colusa Basin Drain into the Yolo Subbasin and ultimately to the Sacramento River. Surplus water from precipitation and return flows from irrigation typically flow to the Colusa Basin Drain. This surplus water is rediverted (several times in some cases) for irrigation before leaving the basin as outflow.

Rice is the predominant crop grown by irrigators in the subbasin (CNRA, 2020). For example, irrigated lands in GCID, the largest water purveyor in the area, typically consist of over 75 percent rice. This percentage is generally less toward the southern end of the subbasin. See Figure 1-6 for a map of the Colusa Subbasin and participating SRSCs.

1.11.3 Butte Subbasin

The Butte Subbasin is located on the east side of the Sacramento Valley and is bounded on the west by the Sacramento River, on the north/northeast by the boundary with the Vina Subbasin, on the east by the Feather River, and the south by the Sutter County line. The participating SRSC within this subbasin is RD 1004.

Inflows to the subbasin include diversions from the Sacramento River, Butte Creek, and Big Chico Creek. Outflows occur either through Butte Slough to Sutter Bypass or through RD 1004 pumping plants to the Sacramento River. Surplus water from precipitation and return flows from irrigation flow to Butte Slough. This surplus water can be rediverted for irrigation before leaving the basin as outflow.

Other water users in the subbasin include the SRSCs Lewis Ranch and M&T Ranch. Western Canal Water District, which is a State Water Contractor, is located within the subbasin. See Figure 1-7 for a map of the Butte subbasin and participating SRSCs.

1.11.4 Sutter Subbasin

The Sutter Subbasin is south of Butte Subbasin and is located on the east side of the Sacramento Valley. This subbasin was modified in 2018 to generally coincide with the Sutter County boundary.[4] The subbasin is bounded on the west and south by the Sacramento River, on the north and northeast by the Sutter/Butte County line, and on the east by the Feather River. Participating SRSCs within this subbasin include the following:

- Meridian Farms Water Company (MFWC)
- Sutter Mutual Water Company (SMWC)

Inflows to the subbasin include diversions from the Sacramento River, Butte Slough, and Sutter Bypass West Borrow Channel. Outflows occur through pumping plants operated by RD 70, RD 1500, and RD 1660. Surplus water from precipitation and return flows from irrigation are rediverted in portions of the subbasin for crop irrigation. In particular, drain flows from landowners located outside water company boundaries (rim landers), along the western edge of the southern portion of the subbasin, are reused by adjacent companies before being pumped out of the subbasin.

In addition to the participating SRSCs, there are numerous short-form SRSCs, riparian diverters, groundwater users, and other irrigation companies with water rights on Butte Creek and Butte Slough. There are no SWP contractors in the subbasin. See Figure 1-8 for a map of the Sutter subbasin and participating SRSCs.

1.11.5 North American Subbasin

The North American Subbasin is bounded on the west by the Sacramento and Feather Rivers, on the north by the Bear River, and on the south and southeast by the American River. The eastern boundary is defined as the edge of the Sacramento Valley floor (DWR, 2018c). Like the RAGB, this subbasin is unique in that a large proportion of municipal users are present throughout the area, including parts of the city and County of Sacramento and urban centers in Placer County, such as the city of Roseville. Most of the area is served with surface water or a combination of surface water and groundwater.

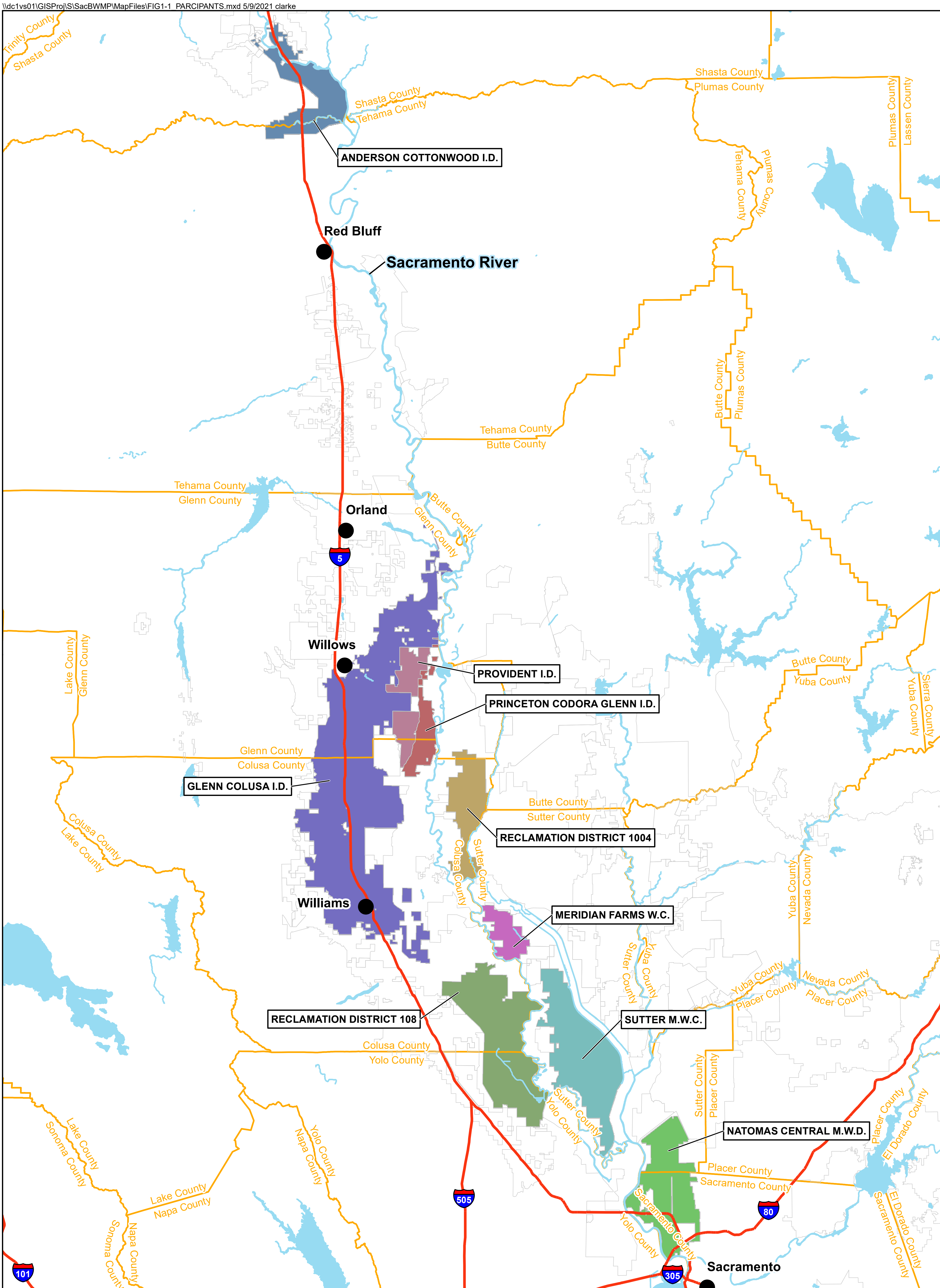
NCMWC is the only SRSC in the North American Subbasin that is participating in this Regional Plan. Nonparticipating SRSCs include Pleasant Grove-Verona Mutual Water Company and numerous short-form

[4] https://www.suttercounty.org/doc/government/depts/ds/pw/wr/sgma/sgmahome

SRSCs. Other major water users in the subbasin include various CVP contractors associated with the American River; South Sutter Water District; Nevada Irrigation District; riparian diverters associated with the Sacramento, American, Feather, and Bear Rivers; and groundwater users. There are no SWP contractors in the subbasin.

Inflows to the subbasin include diversions from the Sacramento, Feather, Bear, and American Rivers and imported water from canals and tributaries originating in the foothills to the east. Outflows occur through four RD 1000 pumping plants to the Sacramento River, and through an RD 1001 pumping plant to the Natomas Cross Canal. Surplus precipitation and return flows from irrigators is rediverted in portions of the subbasin for further crop irrigation. See Figure 1-9 for a map of the North American subbasin and participating SRSCs.

\\dc1vs01\GISProj\S\SacBWMP\MapFiles\FIG1-1_PARCIPANTS.mxd 5/9/2021 clarke



N

0 5 10 20 Miles

1 inch = 10 miles

FIGURE 1-1
PARTICIPATING SACRAMENTO RIVER SETTLEMENT CONTRACTORS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

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LEGEND

Sacramento River Watershed

Sacramento River Basin

N

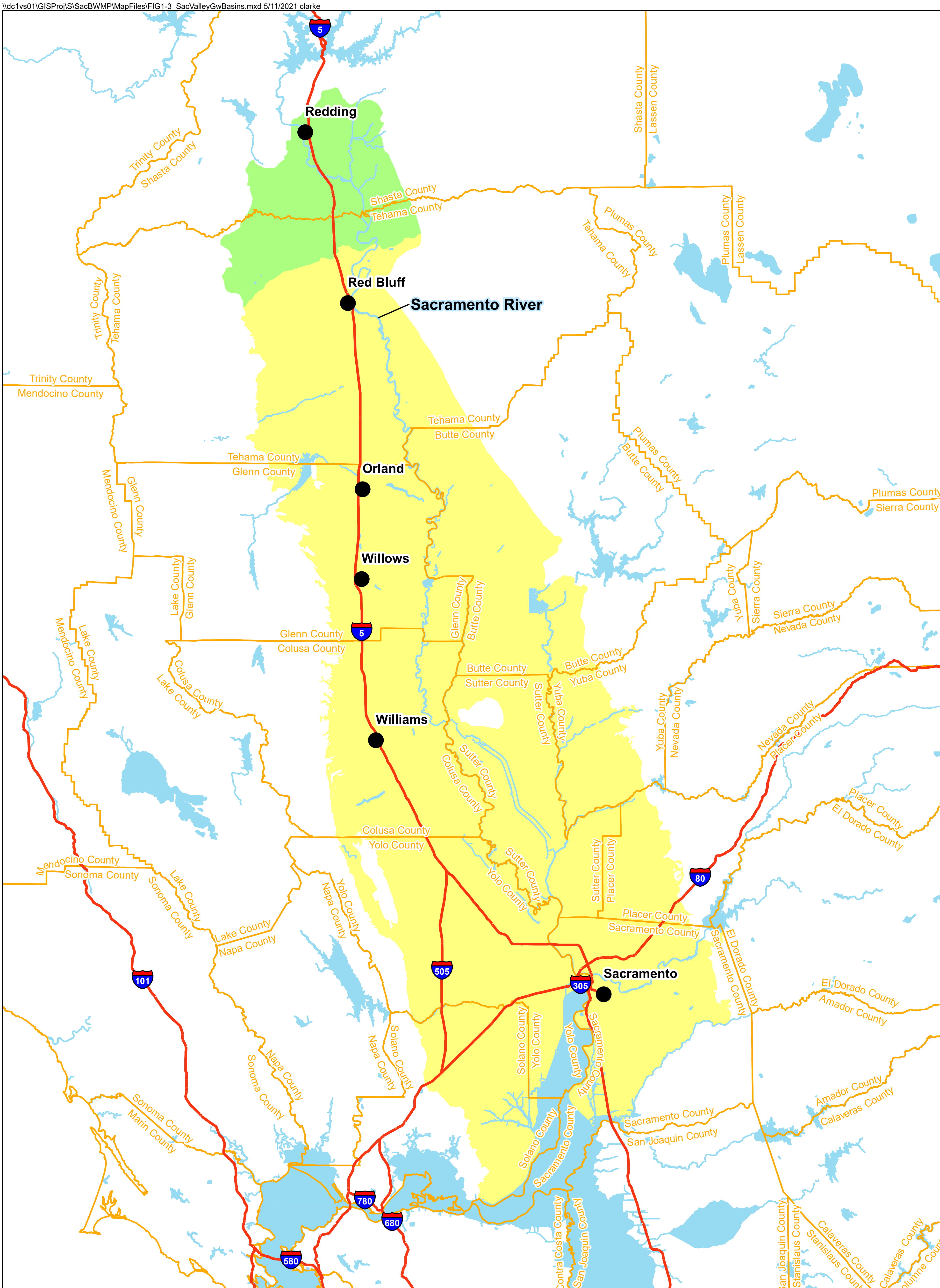
0 15 30 60 Miles

1 inch = 30 miles

FIGURE 1-2
SACRAMENTO RIVER BASIN
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

Jacobs

\\dc1vs01\GISProj\S\SacBWMP\MapFiles\FIG1-3_SacValleyGwBasins.mxd 5/11/2021 clarke



LEGEND

AREA OF ANALYSIS

REDDING AREA GROUNDWATER BASIN

SACRAMENTO VALLEY GROUNDWATER BASIN

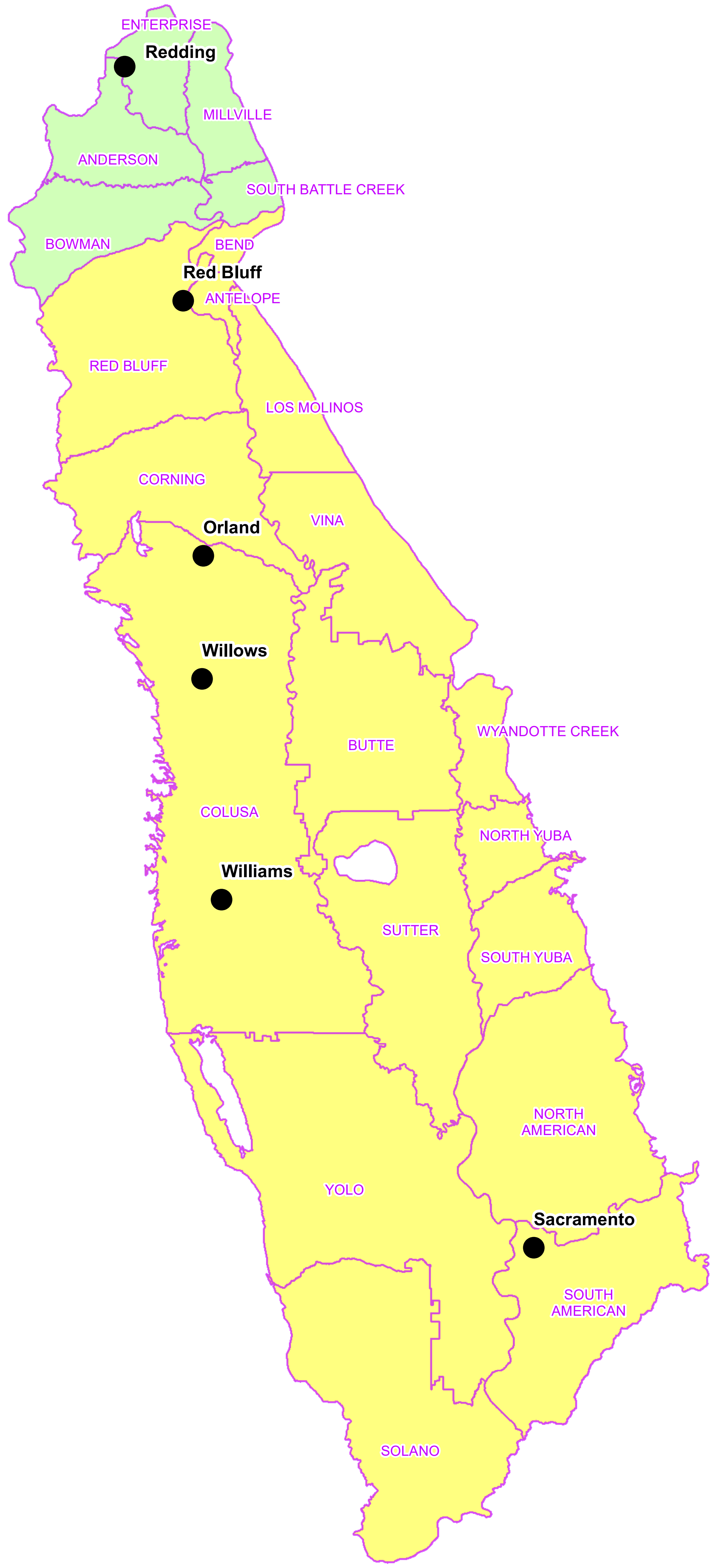
N

0 7.5 15 30 Miles

1 inch = 15 miles

FIGURE 1-3
SACRAMENTO VALLEY GROUNDWATER BASINS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs



LEGEND

- REDDING AREA GROUNDWATER BASIN
- SACRAMENTO VALLEY GROUNDWATER BASIN
- GROUNDWATER SUBBASIN

N

0 7.5 15 30 Miles

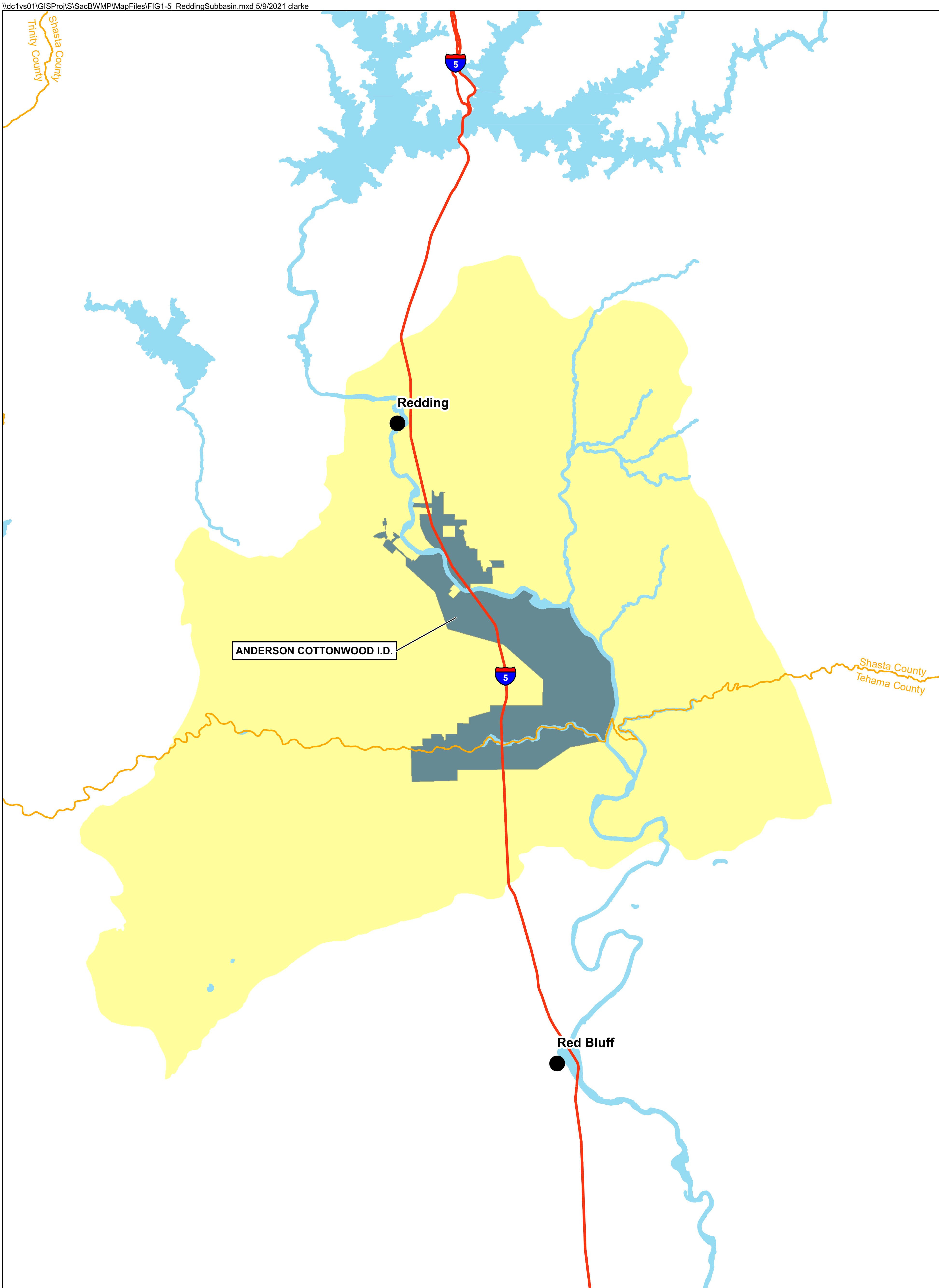
1 inch = 15 miles

FIGURE 1-4
GROUNDWATER SUBBASINS IN SACRAMENTO RIVER BASIN
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

\\dc1vs01\GISProj\S\SacBWMP\MapFiles\FIG1-4_GwSubbasinsSacRiver.mxd 5/11/2021 clarke

\\dc1vs01\GISProj\S\SacBWMP\MapFiles\FIG1-5_ReddingSubbasin.mxd 5/9/2021 clarke



LEGEND

Redding Area Subbasin Boundary

N

0 2 4 8 Miles

1 inch = 4 miles

FIGURE 1-5
REDDING SUBBASIN AND PARTICIPATING SACRAMENTO RIVER SETTLEMENT CONTRACTORS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

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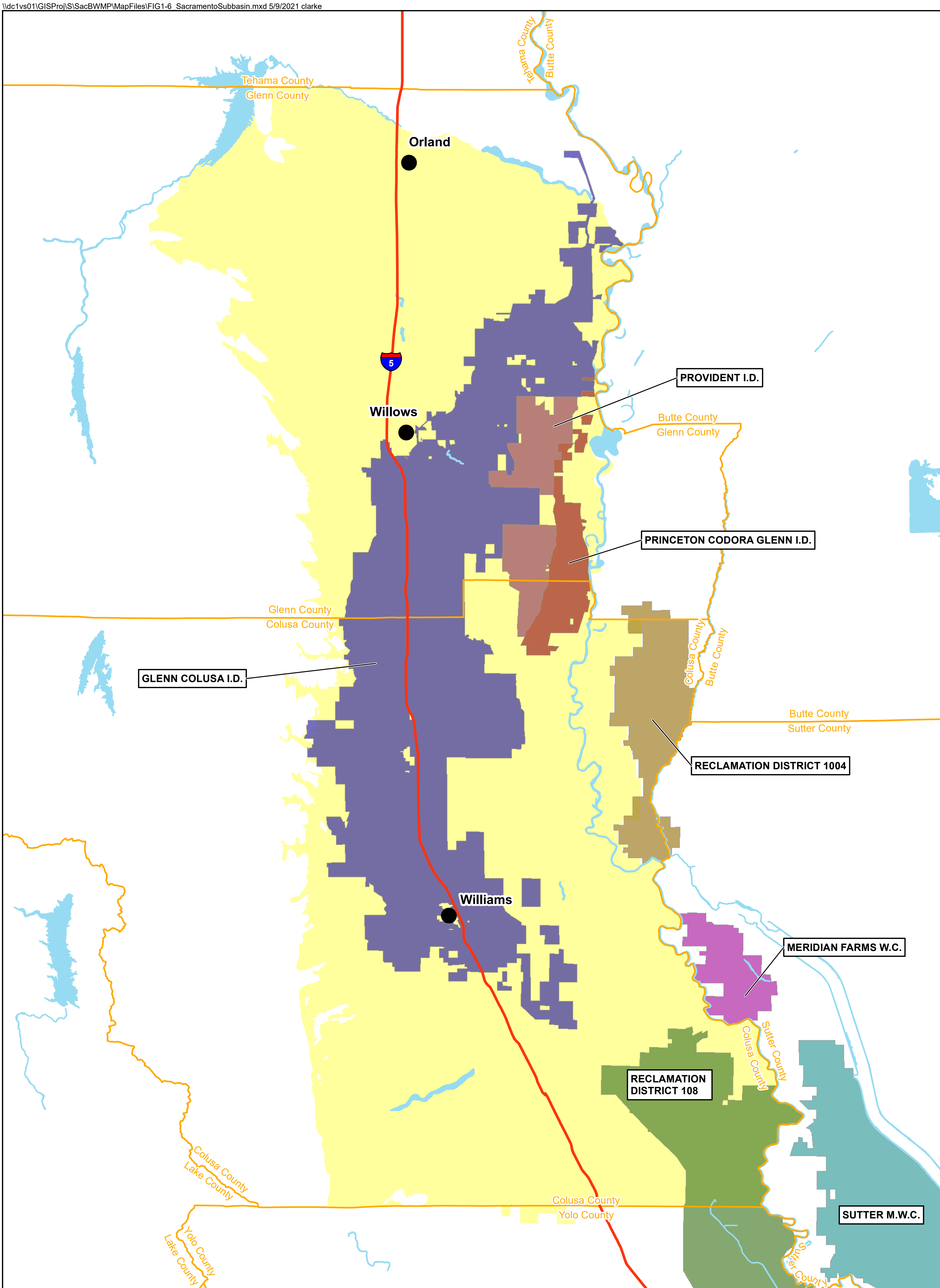

LEGEND

Sacramento Valley - Colusa Subbasin Boundary

N

0 2.5 5 10 Miles

1 inch = 5 miles

FIGURE 1-6
SACRAMENTO VALLEY - COLUSA SUBBASIN AND PARTICIPATING SACRAMENTO RIVER SETTLEMENT CONTRACTORS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

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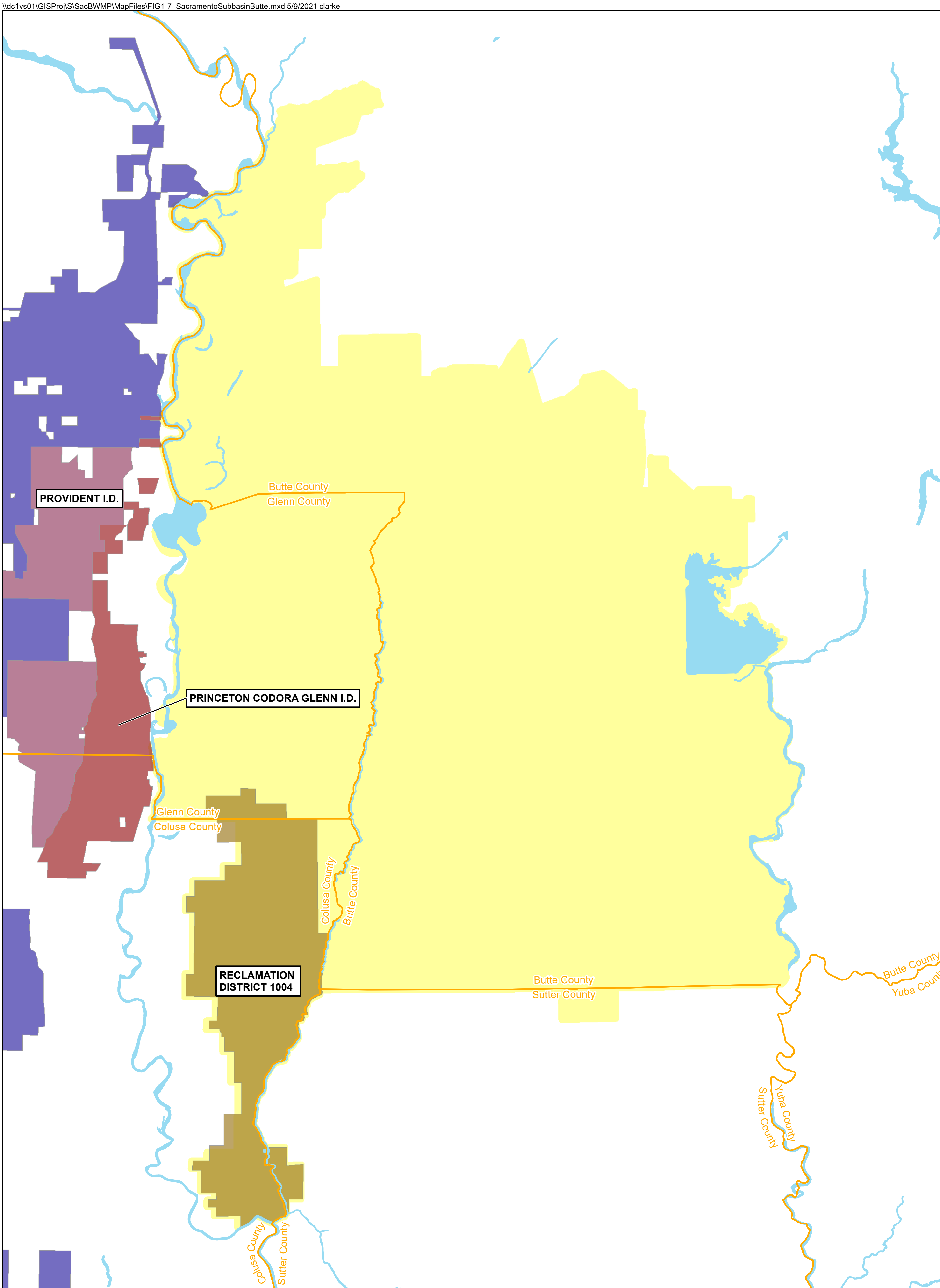


LEGEND

Sacramento Valley - Butte Subbasin Boundary

N

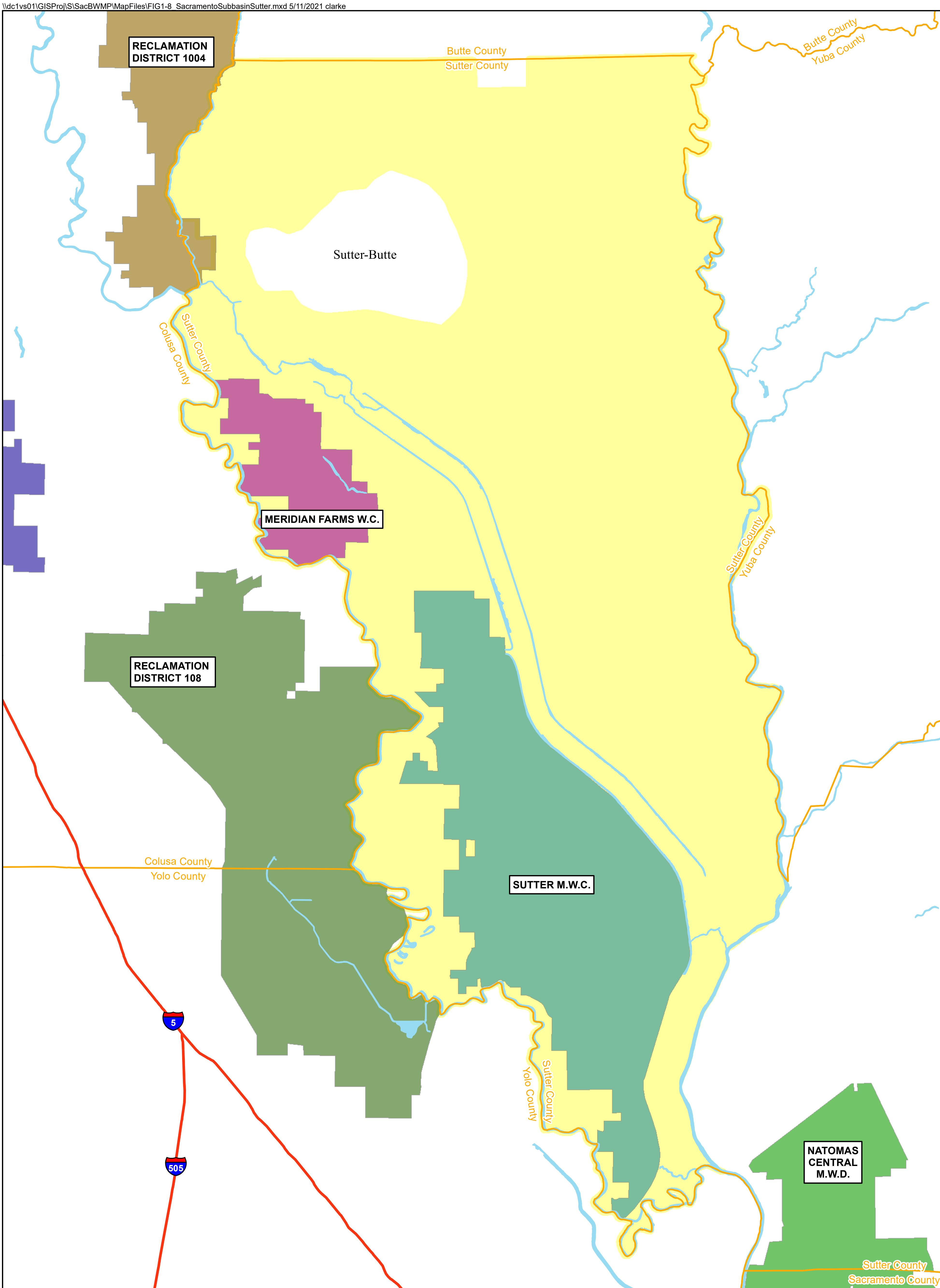
0 1.5 3 6 Miles

1 inch = 3 miles

FIGURE 1-7
SACRAMENTO VALLEY - BUTTE SUBBASIN AND PARTICIPATING SACRAMENTO RIVER SETTLEMENT CONTRACTORS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

\\dc1vs01\GISProj\S\SacBWMP\MapFiles\FIG1-8_SacramentoSubbasinSutter.mxd 5/11/2021 clarke



LEGEND

Sacramento Valley - Sutter Subbasin Boundary

N

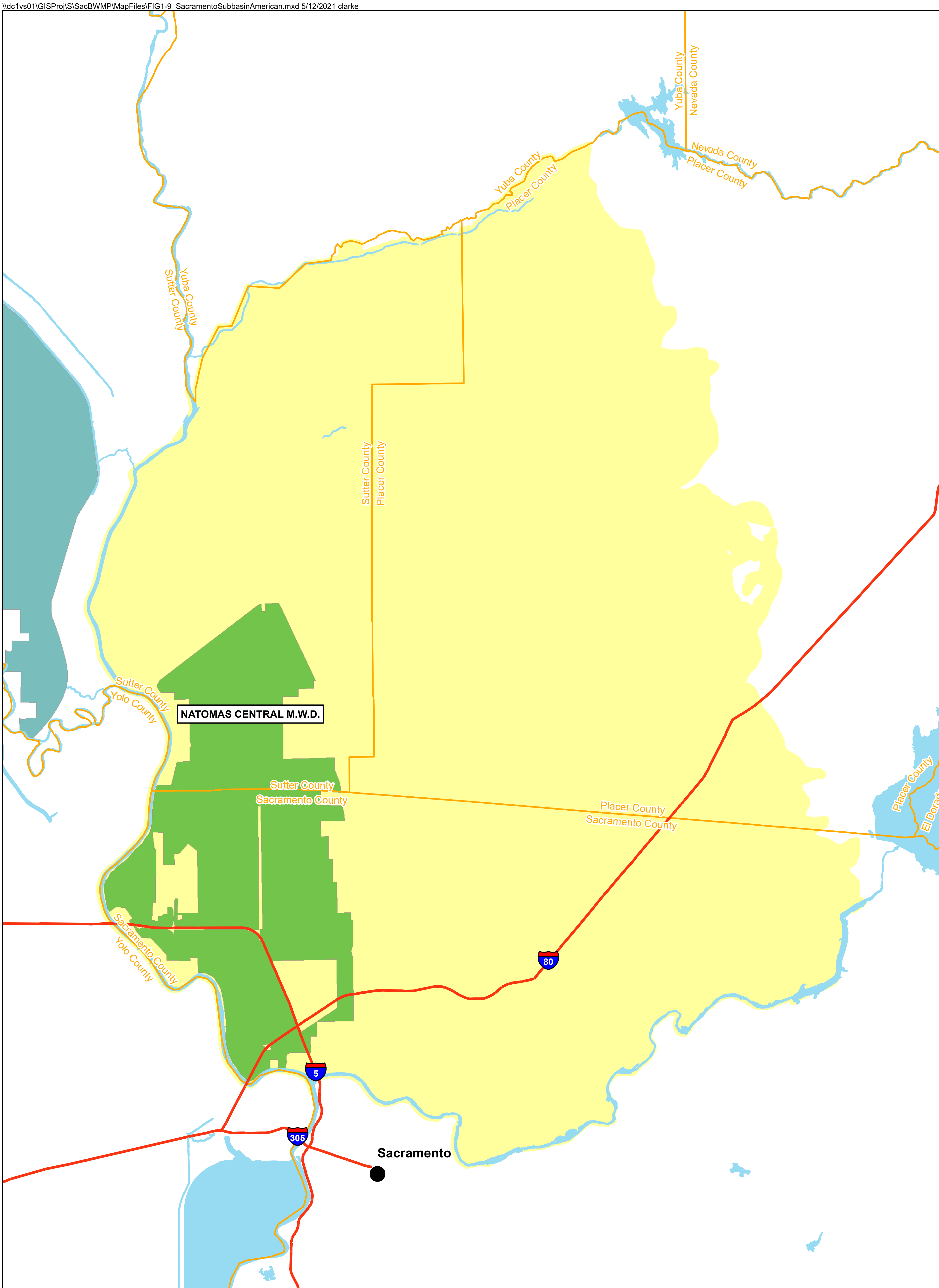
0 1.5 3 6 Miles

1 inch = 3 miles

FIGURE 1-8
SACRAMENTO VALLEY - SUTTER SUBBASIN AND PARTICIPATING SACRAMENTO RIVER SETTLEMENT CONTRACTORS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

\\dc1vs01\GISProj\S\SacBWMP\MapFiles\FIG1-9_SacramentoSubbasinAmerican.mxd 5/12/2021 clarke



LEGEND

Sacramento Valley - North American Subbasin Boundary

N

0 1.5 3 6 Miles

1 inch = 3 miles

FIGURE 1-9
SACRAMENTO VALLEY - NORTH AMERICAN SUBBASIN AND PARTICIPATING SACRAMENTO RIVER SETTLEMENT CONTRACTORS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN

Jacobs

Section 2
District Descriptions

2. District Descriptions

This section provides district-specific summary information including district size and customers base, diversions, key conveyance facilities, water management activities, and water use/customer demand in accordance with Reclamation's Standard Criteria reporting requirements. Use and management of tailwater across districts is also discussed given the high degree of coordination among districts.

Anderson-Cottonwood Irrigation District (ACID)

2.1 Anderson-Cottonwood Irrigation District

ACID average Project Water diversions during the last 5 years are less than 2,000 ac-ft (copies of these records are available within Reclamation's files). Therefore, ACID is exempt from federal requirements to prepare a water management plan. ACID has voluntarily elected to continue its participation in the regional SRSC efforts and be included within this plan.

2.1.1 History

Anderson-Cottonwood Irrigation District (ACID or the District) was formed under Division 11 of the State Water Code and is the oldest such district in the Sacramento Valley, originally encompassing 32,000 acres. On November 24, 1914, McCoy Fitzgerald posted a "Notice of Appropriation of Water" on the west bank of the Sacramento River in Redding. In December of that same year, title to this appropriation was deeded to ACID. The State Division of Water Rights issued a certificate in June 1918, prescribing the time to complete application of water to the proposed place of use. ACID subsequently made beneficial use of the water and established a pre-1914 water right. In June 1967, ACID entered into a negotiated agreement with Reclamation quantifying the amount of water ACID could divert from the Sacramento River. The District and Reclamation subsequently negotiated a revised amount recognizing ACID's annual entitlement to a Base Supply of 121,000 ac-ft/yr of flows from the Sacramento River and also provided for a 4,000 ac-ft allocation of Project Supply, resulting in a total contract entitlement of 125,000 ac-ft/yr. Historic irrigation methods including flood irrigation for alfalfa and pasture are still used but now include more focused drip irrigation for some orchards. Many of the same facilities originally constructed by the District are in use today.

2.1.2 Service Area and Distribution System

ACID's service area encompasses approximately 32,000 acres and extends south from the city of Redding within Shasta County to northern Tehama County, encompassing the city of Anderson and the town of Cottonwood; 10,000 acres are irrigated. Although ACID overlaps the service area boundaries of these water purveyors, the District does not currently provide water for M&I uses in these communities. Approximately 90 percent of ACID's customers irrigate pasture for haying or livestock; however, some orchard and other food crops are also grown. In total, ACID's service area accounts for about two thirds of irrigated pasture in the Redding Subbasin.

2.1.3 Water Supply

2.1.3.1 Surface Water

ACID holds a water right, under pre-1914 postings, to divert water from the natural flow of the Sacramento River. The ACID surface water supply entitlement is currently addressed in a contract renewed with Reclamation in 2005, Contract No. 14-06-200-3346A (Contract No. 3346A). This contract provides for an agreement between ACID and the United States on the diversion of water from the Sacramento River during the period April 1 through October 31 of each year. This contract will remain in effect until March 31, 2045. There are no water quality concerns or restrictions on the District's water sources.

The current contract No. 3346A provides for a maximum total of 125,000 ac-ft/yr, of which 121,000 ac-ft is considered to be Base Supply and 4,000 ac-ft is Project Supply, as shown in Table 2.1-1. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.1-1. ACID: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	44,000	4,000
Non-critical Months	77,000	0
Total Annual	**121,000**	**4,000**

The contract specifies the total quantity of water that may be diverted by ACID each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 8,000 ac-ft in April to a maximum of 22,000 ac-ft in June, July, and August. Project Supply is available during the months of July and August, with entitlements of 2,000 ac-ft in each. The contract identifies July and August as the critical months. For the critical months, the total Base Supply is 44,000 ac-ft, and the total Project Supply is 4,000 ac-ft, as shown in Table 2.1-1.

Non-contract Period (November – March)

Contract No. 3346A does not limit ACID from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. However, the existing land use within ACID's service area does not require non-contract-period diversions.

Other Surface Water Sources

Other than Sacramento River water rights/contract entitlements, ACID does not hold water rights to any other surface water sources, as shown in Table 2.1-1.

2.1.3.2 Groundwater/Conjunctive Use

Approximately 12 privately owned wells are located within the District's boundaries. Very little groundwater is used within the District for agricultural purposes, except occasionally during drought years. Additional information about wells and groundwater conditions in this area can be found online at the DWR Water Data Library; see http://well.water.ca.gov/. The District owns and operates two production wells that are managed as part of a conjunctive use plan. The District currently owns 13 monitoring wells and plans to expand this network as funds become available. Annual District well groundwater pumping amounts range from 2,247 ac-ft to 3,785 ac-ft depending on year type.

Intentional groundwater recharge is not currently practiced in the District given generally stable groundwater levels. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from water conveyance (particularly via recharge from the Main Canal) and irrigation application practices. The District is not involved in any active groundwater banking program.

Groundwater Subbasin Conditions

Most of the ACID service area overlies the Redding Groundwater Basin, within the Anderson Subbasin. The Redding Groundwater Basin is in the northernmost portion of the Sacramento Valley. Underlying Tehama and Shasta Counties, it is bordered by the Klamath Mountains to the north, the Coast Range to the west, and the Cascade Mountains to the east. The Red Bluff Arch, between Cottonwood and Red Bluff, separates the Redding Groundwater Basin from the Sacramento Valley Groundwater Basin to the south. DWR Bulletin 118 subdivides the Redding Groundwater Basin into six subbasins: Anderson, Enterprise, Millville, Rosewood, Bowman, and South Battle Creek (DWR, 2003c).

The Redding Groundwater Basin consists of a sediment-filled, southward-plunging symmetrical trough (DWR, 2003a). Simultaneous deposition of material from the Coast Range and the Cascade Mountains resulted in two different geologic formations, which are the principal freshwater-bearing formations in the basin. The Tuscan Formation in the east is derived from Cascade Mountains volcanic sediments, and the Tehama Formation in the western and northwest portion of the basin is derived from Coast Range and Klamath Mountain sediments. These formations are up to 2,000 feet thick near the confluence of the Sacramento River and Cottonwood Creek, and the Tuscan Formation is generally more permeable and productive than the Tehama Formation (Pierce, 1983). Groundwater recharge occurs at the higher elevations by stream leakage and direct infiltration of precipitation. Rivers and streams transition to gaining streams at lower elevations and receive groundwater discharge. Areas of riparian vegetation occur along surface water features throughout the basin.

Above the Tuscan-Tehama Formation lies the discontinuous Quaternary Red Bluff Formation, which consists of coarse gravel, commonly with large boulders, in a red sandy-clay matrix. The Red Bluff Formation is of low to moderate permeability and, at a local scale, can contain perched water (Pierce, 1983). Overlying the Red Bluff and/or the Tuscan-Tehama Formation are Quaternary terrace and alluvial deposits located in the Sacramento River floodplain and its tributaries. These materials are moderately to highly permeable (Pierce, 1983).

Based on the hydrogeologic setting, the groundwater system in the Redding Basin can be thought of as a single unconfined to a semi-confined (leaky) aquifer system with groundwater levels in the heart of the basin typically within 100 feet below ground surface (bgs).

The water budget of the Redding Groundwater Basin is dominated by a large annual influx of water falling as precipitation on the surrounding mountains and on the valley floor. A large portion of recharge to the Redding Groundwater Basin is from precipitation and snowmelt from higher elevations. Average annual precipitation in the Redding Groundwater Basin ranges from 22 to as much as 40 inches in the higher elevations (California Spatial Information Library/DWR Statewide isohyet map). As is typical throughout the Central Valley, 80 to 90 percent of the area's precipitation occurs from November to April. In the surrounding mountain ranges, precipitation ranges from 40 to 75 inches. A portion of this water is consumed by ET by native vegetation, and the remainder occurs as runoff and groundwater recharge.

It has been estimated that the Redding Groundwater Basin yields an average of 850,000 ac-ft of annual runoff (CH2M HILL, 2003). Much of this water is potentially available to recharge the Redding Groundwater Basin and replenish groundwater levels that have been temporarily depressed because of groundwater pumping. Applied water totals approximately 270,000 ac-ft in the Redding Groundwater Basin (CH2M HILL, 1997). The exact quantity of groundwater that is pumped from the basin is not known; however, it has been estimated that approximately 55,000 ac-ft of water is pumped annually from municipal, industrial, and agricultural production wells (CH2M HILL, 2003). This magnitude of pumping represents approximately 6 percent of the average annual runoff into the basin. ACID's facilities and irrigation are significant contributors to groundwater recharge in the Redding Groundwater Basin. Annual leakage from the ACID Main Canal is estimated to be approximately 44,000 ac-ft.

Past pumping and drought conditions have not historically adversely affected the overall long-term groundwater level trends in ACID. Based on hydrograph data from DWR monitoring wells located within ACID, it is evident that groundwater levels have not substantially increased or decreased over the last 45 years (DWR, 2003b). Water levels are also consistently within 100 feet bgs in the District. Temporary fluctuations in groundwater levels are evident from seasonal climatic variations and drought conditions. Groundwater level declines did occur temporarily during the 1976–1977 and 1987–1992 drought periods. However, groundwater levels recovered to pre-drought levels after the drought period (DWR, 1996a).

Groundwater Planning/SGMA

The District participates in the Enterprise Anderson Groundwater Sustainability Agency and is in the process of drafting a GSP that will be completed by January 31, 2022.

2.1.3.3 Other Water Supplies

No tailwater from outside of the service area is available for use by ACID. However, the District does operate five pumping plants to recapture some return flows from lands within the District's boundaries. ACID reuses approximately 5,000 ac-ft annually.

2.1.4 Water Use

Water use within the District is predominantly agricultural as the District does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2020 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the Water Management Planner (WMP) (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.1.4.1 Agricultural

Land use within ACID's service area is primarily pasture, in addition to alfalfa and some deciduous orchard crops. Pasture use is typically in the range of 75 percent of the total crop mix served by the District (DWR, Northern District). Water requirements are typically highest during the summer months (June, July, and August) due to the area's hot, dry climate. Little groundwater is used across the District; the small portion used is limited primarily to deciduous crops. Annual cropping patterns have not varied a great deal since the mid-1970s. Associated on-field crop water requirement needs and diversions, therefore, have been more a function of water-year type and climate than changes in cropping.

Future irrigation season cropping patterns and associated water requirements are anticipated to remain relatively the same as current needs in terms of crop mix; however, the District anticipates an overall decrease in irrigated acreage associated with continued urban encroachment.

2.1.4.2 Urban

ACID's service area overlays several municipal water purveyors, many of whom are projecting increased demands to the year 2030. A majority of the increase is assumed to be met by surface water taken from the Sacramento River. The District has implemented some programs and is actively negotiating others that would increase supply to these purveyors.

Examples of programs include direct supply to water treatment facilities, direct supply for municipal irrigation, provision of water for cooling buildings and industrial developments, water marketing, and assisting with the fulfillment of area of origin needs. The District has implemented the following three long-term water transfer agreements (2006, 2008, and 2009) for the provision of Project Water for general M&I use:

- City of Shasta Lake: Transfer of 2,000 ac-ft/yr of Project Water through 2045.
- Shasta Community Services District: Transfer of 200 ac-ft/yr of Project Water through 2045. This transfer has been approved and will result in additional diversions by Shasta Community Services District from Whiskeytown Lake for general M&I purposes within its service area.

- Bella Vista Water District: Transfer of 1,536 ac-ft/yr of Project Water through 2045. This transfer has been approved by Reclamation and will result in additional diversions by Bella Vista Water District at their Wintu Pumping Plant, immediately downstream from ACID's flashboard dam and screened gravity diversion on the Sacramento River.

The District entered into an agreement with the City of Redding in 2011 that introduces the City of Redding as a customer of ACID for the provision of Base Supply for M&I purposes to overlapping areas with the agencies' service areas. The agreement provides for a maximum annual diversion of 1,000 ac-ft. The District is also currently providing Anderson Union High School water for cooling operations.

2.1.4.3 Environmental/Natural and Cultural Resources

There are no managed designated environmental or wetlands areas within the District. Approximately 3,000 acres of riparian vegetation are estimated to be incidentally supplied by irrigation associated with delivery laterals or adjacent lands (CH2M HILL, 1997). The application of water to pasture lands (historically ranging from 10,000 to 12,000 acres) and associated vegetation provides habitat to common and special-status terrestrial and avian species that use such habitat. Additionally, pasture provides habitat for a number of species of small mammals, ground-dwelling birds, and reptiles and amphibians, all of which provide a prey base for predatory birds. Dryland pasture in the region often supports a vernal pool ecosystem that is occupied by a number of special-status plant and animal species.

2.1.4.4 Topography and Soils

The District's topography generally consists of nearly level to gently sloping terrain. Because the District is relatively flat, the impact of the area's terrain on water management practices is negligible. There are no agricultural limitations resulting from soil problems or impacts of any microclimates on water management within the District.

Complete descriptions of the soil associations and the corresponding acreage of each association in the District are provided in the NRCS Soil Surveys for Shasta and Tehama Counties (see Attachment I) The soil associations that are found within the District are as follows:

- **Newtown-Red Bluff:** Nearly level to steep, well-drained and moderately well-drained clays and clay loams formed in old alluvium on high terraces.
- **Churn Perkins-Tehama:** Nearly level to moderately steep, well-drained and moderately well-drained clay loams and silty clay loams formed in recent alluvium on low terraces.
- **Tuscan-Igo:** Nearly level to gently sloping, well-drained cobbly clay loams and gravely loams that contain a hardpan and were formed in old basic alluvium on high terraces.
- **Reiff cobbly alluvial land association:** Nearly level to gently sloping, moderately well-drained to excessively drained loamy fine sands to loams and frequently flooded cobbly land on valley bottoms and floodplains.
- **Maywood-Tehama:** Very deep to moderately deep silt loam, nearly level to very gently sloping soils on floodplains and terraces along tributaries of the Sacramento River.
- **Corning-Redding:** Nearly level to sloping, gravely, medium-textured soils that are moderately deep to shallow to claypan or hardpan on terraces west of the Sacramento River and along its tributaries.
- **Newville-Dibble:** Shallow to deep gravely loam and silt loam, moderately steep or steep, medium- to fine-textured soils underlain by soft sedimentary rock.

2.1.4.5 Transfers and Exchanges

ACID is one of 34 SRSCs that currently participate in the Pool Program. The Pool Program was curtailed in 2009 because most SRSCs have elected to market and transfer their excess water through negotiated individual or group-based agreements.

Currently, all of ACID's Project Supply has been committed for transfer to local purveyors each year through 2045. However, due to restrictions on the transfer amount available to the City of Shasta Lake resulting from potential coldwater pool impacts, up to 1,860 ac-ft may remain available during most water-year types.

2.1.4.6 Other Uses

There are no other uses other than those discussed above within ACID.

2.1.5 District Facilities

2.1.5.1 Diversion Facilities

ACID's primary water source is surface water diversion from the Sacramento River. Water pools behind the District's seasonal dam (creating Lake Redding) and flows by gravity through an intake screen, tunnel, and ultimately into the Main Canal. In 1999, ACID completed the improvements to the fish ladder and screen facilities as part of a CALFED-funded effort to enhance the Sacramento River anadromous fishery. ACID also has one pump station diversion on the Sacramento River, which is located approximately 4 miles downstream of the District's diversion dam and is used to supply water to its Churn Creek Lateral. The District has two production wells with a combined output of 13.2 cfs. The District service area does overlay portions of the Redding Groundwater Basin. Table 2.1-2 summarizes ACID's surface water supply facilities. See Attachment A for a map of ACID's major conveyance facilities.

Table 2.1-2. ACID Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
ACID Diversion Dam	Sacramento River	Gravity	450	114,700[a]
Churn Creek Lateral Pump Station	Sacramento River	Pump	75	19,400[a]

[a] Estimated proportion of total diversions based on pump station capacity.

2.1.5.2 Conveyance System

ACID's distribution system includes approximately 30 miles of unlined canals and main laterals. Approximately 5 miles of the 35 mile? Main Canal are concrete lined. The Main Canal flows through several inverted siphons for conveying the canal flows under cross drainage channels such as Clear Creek. The District has an ongoing program for replacement of open-channel farm laterals with pipeline laterals. Several wasteways are located along the canal route at creek crossings and natural drains. These wasteways return water to the river or local streams when flow exceeds the capacity of the canal, which typically occurs in the winter months during storm runoff. Table 2.1-3 summarizes ACID's Main Canal and irrigation lateral features.

Table 2.1-3. ACID Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
ACID Canal	ACID Diversion Dam	450	Partial (5 miles)	Cottonwood Creek	25
Churn Creek Lateral Canal	Churn Creek Pump Station	75	Partial (0.25 mile)	None	25

2.1.5.3 Storage Facilities

ACID currently has no storage facilities.

2.1.5.4 Spill Recovery/Outflow

ACID has a network of unlined drainage ditches for conveying irrigation return flows. The drains generally empty into the Sacramento River or one of the local tributary creeks. Most of the soils in the District's service area are well drained; therefore, the field-applied water generally percolates directly to the underlying groundwater basin, which minimizes the need for extensive drainage facilities. Drainage flows out of the District by gravity. However, the District operates five drain pump stations for recapture of drain flows. Table 2.1-4 summarizes these drain recapture facilities.

Table 2.1-4. ACID Drain Pump Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping Total (ac-ft/yr)
Simpson	Anderson Creek	Lateral	10	1,400
Jesson	Anderson Creek	Lateral	5	700
Supan	Anderson Creek	Lateral	10	1,400
Perry's Pond	Perry's Pond	Lateral	5	700
Dymesich's Pond	Dymesich's Pond	Lateral	5	700

2.1.5.5 Proposed O&M and Capital Improvements

To be completed.

2.1.6 ACID Operating Rules and Regulations

According to the Rules and Regulations of ACID:

> *The Anderson-Cottonwood Irrigation District is [the] government agency acting under and by virtue of Division 11 of the California Water Code. It is governed by a Board of Directors that is elected by the voters of the District. The District operates for the sole benefit of the lands and the people situated within the District boundaries. The benefits people within the District derive from the District will be measured by the extent to which the people*

> *within the District and the District's employees and Board of Directors cooperate to make the District a success.*
>
> *The rules and regulations are adopted pursuant to California Water Code Section 22257 to effect an orderly and equitable distribution of water within the District, and a procedure for operation, maintenance, repair and replacement of District facilities.*

Water rotation, apportionment, and shortage allocation: Under normal conditions, water schedule is based on assigned hours and schedule; irrigators typically receive a 24-hour notice when water will be available.

> *Water will be furnished in rotation to each irrigator. Ditchtenders will endeavor to give advance notice, personally or through others, to irrigators of the approximate time their rotation will start. Any irrigator not taking water when his turn arrives may forfeit his right during that rotation. In the event of shortages, the District will endeavor to equitably apportion the available water supply.*

Use of drainage waters:

> *All water introduced into the District by the District facilities remains District water and is subject to rediversion and reuse by the District for the benefit of its customers. All such water, whether drainage or seepage water, intercepted and put to beneficial use will be charged for at the rates established by the District.*

Policies for wasteful use of water:

> *Water must be used continuously by the irrigator throughout the period of delivery. If water is wasted, or inefficiently or improperly used the General Manager may refuse further delivery of water until the cause of waste or inefficient or improper use is removed. The General Manager may also levy appropriate monetary penalties for waste or inefficient or improper use.*

2.1.7 Water Measurement, Pricing, and Billing

ACID's main river diversions (Lake Redding and Churn Creek) have meters installed and are operated by Reclamation; they provide both flow rate and total volume of flow. At major lateral headgates, the District measures flow rates manually using weir or gate head-flow tables. Flows at field turnouts are measured using canal headgate position tables. Drain pump flows are not metered, but the total volume pumped is estimated using power consumption and pump efficiency history. Increases in conveyance efficiency may be achieved with a program of water measurement that includes installation of intermediate measurement points along the Main Canal, improved lateral flow measurement, and installation of flowmeters and totalizers on drain pumps.

Information on turnout measurement can be found in Attachment M. Estimates of flow rate are made based on canal headgate position relationships that were established by a one-time measurement of customer turnout flows using weir flow tables or a handheld propeller meter. ACID's on-farm efficiency is relatively low (45 percent based on 1982 NRCS study). Field metering in combination with modifying the delivery arrangement from a rotation basis to arranged, an appropriate incentive pricing structure, and on-field improvements such as land leveling may increase the average on-farm efficiency, with some savings in water use. However, the effective implementation of such a program would depend on the correct combination of the above factors, in addition to basic economic considerations such as the return on investment to the District and landowners. Additionally, the installation, maintenance, and reading of the meters (950) would represent a major up-front capital cost to the District as well as an ongoing labor and capital expense. Table 2.1-5 presents an inventory of the District's water measurement devices.

Table 2.1-5. Agricultural Measurement Device Inventory for ACID

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Propeller	1	±2%	Daily	Yearly	Yearly
Sonic Flowmeters	1	±2%	Daily	Yearly	Yearly
Weirs	20	±10%	Weekly	N/A	Yearly
U.S. Geological Survey Stage Recorder	1	±5%	Daily	Monthly	Yearly
SCADA Pressure Transducers	4	±1%	Twice daily	Yearly	Yearly
IRTC Mobile Weir Stick	1	±10%	Approximately every other month	N/A	N/A
Mobile Global Flow Probe	2	±5%	As needed	Yearly	Yearly
Total	**32**				

Note:

SCADA = supervisory control and data acquisition

ACID customers pay on a per-acre basis of irrigated land and are billed upon submittal of an application for water each spring prior to the irrigation season. An administrative application fee of $115 per parcel is also imposed.

Rates from for 2020 and 2021 remained unchanged at $87 per irrigated acre.

Glenn-Colusa Irrigation District

2.2 Glenn-Colusa Irrigation District

2.2.1 History

Glenn-Colusa Irrigation District (GCID or the District) has a water right, under pre-1914 postings, to divert water from the natural flow of the Sacramento River. The water right dates back to 1883, when Will S. Green posted notices for the appropriation and diversion of irrigation water on the west bank of the Sacramento River, at the upstream end of the Oxbow Channel near the current diversion at the main pump station. GCID also has adjudicated pre-1914 water rights under the Angle Decree, issued in 1930 by the Federal District Court, Northern District of California, to divert water from the natural flow of Stony Creek, a tributary to the Sacramento River.

GCID was originally organized in 1920, after several private companies failed financially, and a group of landowners reorganized and refinanced the irrigation district, retaining claim to Green's historic water right. The District was originally 103,000 acres, and subsequently sold some land to the federal government which would later become the Sacramento, Delevan, and Colusa federal refuges totaling approximately 20,000 acres. Historic irrigation methods are similar to what are currently implemented with many of the same facilities in use today to supply farms that employ methods ranging from flood (e.g., rice) to drip (e.g., some orchards) irrigation.

GCID entered into a negotiated settlement contract agreement with Reclamation in 1964 quantifying the amount of water GCID could divert from the Sacramento River and Stony Creek from April 1 through October 31 of each year. Contract No. 14-06-200-0855A (Contract No. 0855A) was renewed in 2005 through March 31, 2045. The contract acknowledges GCID's annual entitlement of a Base Supply of 720,000 ac-ft/yr of flows from the Sacramento River and also provided for a 105,000 ac-ft allocation of Project Supply, resulting in a total contract entitlement of 825,000 ac-ft/yr. The 825,000-ac-ft/yr entitlement recognized under contract for GCID is inclusive of their entitlement recognized under their Angle Decree rights, which, on average, yield about 15,000 to 18,000 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply to the Settlement Contract are identified in Table 2.2-1.

Table 2.2-1. Schedule of Monthly Water Diversions – GCID

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	100,000	0	100,000
May	140,000	0	140,000
June	150,000	0	150,000
July	130,000	55,000	185,000
August	90,000	50,000	140,000
September	65,000	0	65,000
October	45,000	0	45,000
Total	**720,000**	**105,000**	**825,000**

Notes:

Contract No. 14-06-200-855A-R-1
Points of Diversion: 154.7R, 154.8R

2.2.2 Service Area and Distribution System

GCID is located in the central portion of the Sacramento Valley on the west side of the Sacramento River and is the largest irrigation district in the Sacramento Valley, encompassing approximately 175,000 acres, 135,000 of which are irrigated, and serving approximately 1,700 parcels of land. The service area extends from northeastern Glenn County near Hamilton City to south of Williams in Colusa County. District boundaries also encompass the communities of Willows and Maxwell. GCID does not currently supply M&I water to any of the regions that overlie its service area. Rice is the predominant crop, accounting for approximately 85 percent of the District's irrigated acreage. Other important crops include tomatoes, orchards, vineseeds, cotton, alfalfa, and irrigated pasture.

2.2.3 Water Supply

2.2.3.1 Surface Water

GCID holds both pre- and post-1914 appropriative water rights to divert water from the natural flow of the Sacramento River. GCID also has adjudicated pre-1914 water rights under the Angle Decree, issued in 1930 by the Federal District Court, Northern District of California, to divert water from the natural flow of Stony Creek, a tributary to the Sacramento River. In addition, as the successor in interest to Central Canal and Irrigation Company, GCID may have, under a May 9, 1906, Act of Congress, "the right to divert, at all seasons of the year, from the Sacramento River…an amount of water which…shall not exceed nine hundred cubic feet per second, to be used for irrigating the lands of the Sacramento Valley, on the west side of the Sacramento River…" (Public Law 151, Ch. 439). These water rights are shown in Table 2.2-2 with associated dates and quantities. There are currently no water quality concerns within the District or restrictions on the District's water sources.

Table 2.2-2. GCID: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	A000018 (3/3/15)	000029 (10/20/15)	002871 (5/14/47)	Mar 1 to Nov 1	110 cfs
Sacramento River	A001554 (12/3/19)	000796 (12/14/20)	007208 (3/20/65)	Apr 15 to Oct 1	83.27 cfs
Sacramento River	A001624 (1/14/20)	000797 (12/14/20)	007209 (3/30/65)	Apr 15 to Nov 1	32.0 cfs
Hunters Creek	A008688 (5/28/36)	004795 (8/17/36)	005387 (1/14/59)	Apr 15 to Oct 1	2 cfs
Stone Corral Creek	A012125 (10/8/47)	008272 (12/20/50)	004340 (4/24/56)	Apr 20 to Sep 30	11 cfs
Unnamed stream tributary to Funks Creek	A023005 (3/12/68)	015687 (9/10/68)	010635 (4/23/76)	Primary: Apr 1 to Jun 30 Secondary: Sep 1 to Dec 31	2 cfs 415 ac-ft/yr
Sacramento River	A030838 (2/19/1999)	21101 (5/16/2001)	Pending	Nov 1 to Mar 31	1,200 cfs 182,900 ac-ft/yr

Table 2.2-2. GCID: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	S007367 (N/A)	N/A	N/A	Apr 1 to Oct 31	2,700 cfs
Colusa Basin Drain	S007368 (N/A)	N/A	N/A	Apr 1 to Aug 31	134 cfs

[a] Source – SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b] N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c] The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d] The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e] The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

The GCID surface water supply entitlement is currently addressed in a contract entered into with Reclamation in 1964, Contract No. 14-06-200-0855A (Contract No. 0855A). This contract provides for an agreement between GCID and the United States on the diversion of water from both the Sacramento River and Stony Creek from April 1 through October 31 of each year. The existing contract term is through March 31, 2045.

Pursuant to provisions of the contract, Reclamation can require GCID to divert from the Sacramento River water quantities equal to and in lieu of its entitlement under the Angle Decree. Such water, along with Sacramento River water, is made available to GCID under Contract No. 0855A for diversion at its main pump station. In 1998, GCID executed a new agreement with Reclamation (Agreement No. 1425-98-FC-20-17620) for the conveyance of wildlife refuge water and other related purposes. Under the terms of this separate wheeling agreement with Reclamation, GCID can request to receive a portion of its entitlement water via two points on interconnections with the Tehama-Colusa Canal: the Cross-Tie, a 48-inch-diameter pipe at Canal Mile 56, and the Inter-Tie, a 1,000-cfs flume, at Canal Mile 37. The use of the Tehama-Colusa Canal for delivery of entitlement water is subject to available capacity as determined by Reclamation, in accordance with the terms and conditions of the wheeling agreement. However, GCID has agreed to pay TCCA the O&M costs associated with wheeling a minimum of 25,000 ac-ft annually of Sacramento River water to GCID from the Tehama-Colusa Canal whether GCID uses the water or not.

Contract No. 0855A provides for a maximum total of 825,000 ac-ft/yr, of which 720,000 ac-ft is considered to be Base Supply and 105,000 ac-ft is CVP water (Project Supply). The contract also provides that additional Project Supply can be purchased if surplus water is available. Water from Stony Creek and water diverted from the Sacramento River at the main pump station is accounted for as water diverted under Contract No. 0855A. For purposes of the contract, it was determined that GCID's Angle Decree rights yielded, on a long-term average, about 15,000 ac-ft/yr. This yield was included in the 720,000 ac-ft of Base Supply entitlement recognized under Contract No. 855A.

The contract specifies the total quantity of water that may be diverted each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 45,000 ac-ft in October to a maximum of 150,000 ac-ft in June. CVP Supply water is available during the months of July and August, with entitlements of 55,000 and 50,000 ac-ft, respectively. The contract identifies July and August as the critical months. For the critical months, the total Base Supply is 220,000 ac-ft and the total Project Supply is 105,000 ac-ft, as shown in Table 2.2-3.

Table 2.2-3. GCID: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	220,000	105,000
Non-critical Months	500,000	0
Total Annual	**720,000**	**105,000**

Non-contract Period (November – March)

Contract No. 0855A does not limit GCID from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. GCID has a water right permit for non-contract-period diversions for the amount of 182,900 ac-ft (up to 1,200 cfs), as shown in Table 2.2-2. Although some pre-irrigation occurs within the District, non-contract-period diversions are predominantly used for rice straw decomposition and to support associated waterfowl habitat. Approximately 35,000 acres are typically flooded annually.

GCID has an agreement with Reclamation to convey water to approximately 22,500 acres of wildlife refuges year-round. GCID is strictly a water conveyor for Reclamation in this agreement and is paid on an ac-ft basis. The water delivered to the refuges by GCID is not counted toward GCID's water right entitlement. Approximately 60,000 to 80,000 ac-ft/yr of supply is conveyed by GCID to the refuges. However, the District must be prepared, if necessary, to convey up to 105,000 ac-ft to meet Level 4 requirements. In addition, as noted above, GCID may hold a right to divert up to 900 cfs from the Sacramento River during "all seasons of the year," pursuant to the May 9, 1906, Act of Congress (Pub. L. No. 151, Ch. 2439).

Other Surface Water Sources

As discussed above, GCID has entitlements to water from Stony Creek, which can be diverted from Stony Creek, or equivalent quantities can be diverted from the Sacramento River. The GCID service area is relatively large and contains a number of small tributaries to the Sacramento River. GCID holds water rights to pump from Hunters Creek, Funks Creek, and Colusa Basin Drain, as shown in Table 2.2-2.

2.2.3.2 Groundwater/Conjunctive Use

Groundwater use within GCID is generally limited because of the availability of surface water supplies and is driven primarily by climatic conditions. In the past, GCID has managed and operated a voluntary groundwater conjunctive water management program to increase capacity when water supply does not meet demand. Up to 100 landowners have participated in the groundwater program, representing a combined capacity of approximately 500 cfs. Pumping has ranged from 20,000 ac-ft/yr during years of high surface water supply to as much as 77,000 ac-ft in critically dry years. Seasonal fluctuations in groundwater levels are generally less than 10 feet, but can be up to 30 feet in drought years. Historical trends show that groundwater levels in the GCID area are generally stable over the long term, although short-term fluctuations in groundwater levels are observed that can be correlated with precipitation trends. The stability of the groundwater level is due in part to GCID's average groundwater recharge of 126,000 ac-ft to the basin during the contract period (April through October). The source of this recharge is approximately 88,000 ac-ft due to deep percolation from agricultural land and 38,000 ac-ft of seepage water percolation from GCID's unlined conveyance system.

Groundwater Subbasin Conditions

The GCID boundary lies within the Sacramento Groundwater Basin. The area is located on alluvium and flood basin sediments, as well as alluvial fan deposits. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities. Alluvial fan sediments are deposited in higher energy, continental environments. Because they are coarser grained, alluvial fan deposits generally have high permeabilities. These recent sediments are underlain by older deposits of the Tehama and Tuscan Formations (DWR, 1978).

In the northern portion of GCID, the Tehama Formation contains extensive deposits of interbedded gravel from the ancestral Stony Creek (the Stony Creek Member). The Stony Creek Member of the Tehama Formation is typically very productive, yielding large quantities of water to wells. In the south-central portion of GCID, between Willows and Williams, the Tehama Formation is predominately clayey, and wells in this area are generally less productive than those in the northern portion of GCID (DWR, 1978).

The Tuscan Formation is an important water-bearing unit in the northeastern portion of the Sacramento Valley (DWR, 2003a). In the Colusa Subbasin, the Tuscan Formation interfingers with the Tehama Formation at depths of 300 to 1,000 feet bgs. Coarse-grained deposits within the Tuscan Formation can provide high well yields; however, the unit is generally too deep to be tapped by domestic and most agricultural wells west of Chico (DWR, 1978).

Groundwater quality in the Sacramento Groundwater Basin is generally good and is sufficient for agricultural, domestic, and M&I uses. The total depth of freshwater aquifer in the GCID area is estimated as 900 to 1,500 feet bgs. The freshwater is underlain by saline water found in older marine units.

In the northern portion of GCID, between the towns of Artois and Glenn, groundwater movement is generally to the southeast, toward the Sacramento River, at a gradient of between 4 and 15 feet per mile (DWR, 2003a). In the middle of GCID, near the town of Maxwell, the flow changes to a more easterly direction with a gradient of approximately 4 to 10 feet per mile. At the southern end of GCID, near the town of Williams, groundwater flows east to slightly northeast, toward the Sacramento River, with the gradient ranging from 7 to 10 feet per mile. The steeper gradients exist at the southwest and northwest edges of GCID. Groundwater throughout the Sacramento Groundwater Basin, and therefore within GCID, occurs in a broad alluvial basin and is therefore not confined to any well-defined subsurface stream channels.

Groundwater Planning/Sustainable Groundwater Management Act

The District is a member of three GSAs: Colusa Groundwater Authority, Glenn Groundwater Authority, and the Corning Subbasin GSA. As part of the Sustainable Groundwater Management Act (SGMA), all three GSAs are developing compliant GSPs for completion and submittal to DWR in January 2022. The three GSAs are part of two groundwater subbasins: Colusa Subbasin and Corning Subbasin. The District does not participate in groundwater banking.

2.2.3.3 Other Water Supplies

An aggressive recapture program, which captures both subsurface flows (from system leakage and deep percolation recovered by open surface drains) and tailwater runoff from cultivated fields from within GCID's service area, is a part of GCID's overall water management program. GCID recaptures this water with both gravity and pump systems. This captured water is delivered to either laterals or the main canal for reuse. Currently, GCID recycles approximately 175,000 ac-ft annually. Relatively small quantities of tailwater are available to GCID from areas outside of the District's boundaries.

Much of GCID's surplus water is captured for use by downstream districts such as the PID, PCGID, and MID. GCID is one of the irrigation districts that signed the Five-Party Agreement of June 2, 1956. This agreement represents a cooperative effort by GCID, PID, PCGID, MID, and two entities that have since dissolved (Compton-Delevan Irrigation District and Jacinto Irrigation District) to share O&M of the drains within their respective service areas and to share the right to recirculate the water in those drains. In addition, Colusa Basin Drain Mutual Water Company members rely on tailwater from GCID and other upstream water users.

The Colusa Subbasin irrigation systems' ability to extensively recapture and recirculate irrigation water on an inter-district basis has resulted in a basinwide traditional irrigation efficiency of over 80 percent and an "effective efficiency" of more than 91 percent (see Table A-2, Efficient Water Management for Regional Sustainability in the Sacramento Valley, prepared for NCWA by CH2M HILL, Davids Engineering, and MBK Engineers, final draft).

GCID adopted a Water Transfer Policy in 1995, which was updated in 2015. This policy identifies agricultural water users within the Sacramento Valley as the highest priority and environmental purposes as the second highest priority for future water transfers. An in-basin water transfer program was introduced in 1997 and has been used annually except for critically dry years.

2.2.4 Water Use

Water use within the District is predominantly agricultural as the District does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.2.4.1 Agricultural

Land use within GCID's service area is primarily rice, due to the presence of fine-textured and poorly drained soils within the majority of the District. Other key crops include orchards, alfalfa, tomatoes, and cotton. Rice accounts for approximately 80 to 85 percent of the District's irrigated acreage on an annual basis (DWR, Northern District). Water requirements are typically highest during the summer months (July and August) due to the requirements of rice and the area's hot, dry climate. Cultural practice water needs for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields. Although surface water is the primary source of irrigation water, groundwater is used in drought years on an individual grower basis, as well as per agreements with the District.

Annual cropping patterns have remained fairly constant over the last few decades, other than in response to farm programs in the early 1980s. Associated water requirement needs and associated diversions, therefore, have been more a function of water-year type and climate than changes in cropping.

Future irrigation season cropping patterns, associated water requirements, and land use are anticipated to remain relatively the same as current conditions.

2.2.4.2 Urban

Although GCID overlays the agricultural communities of Willows, Maxwell, and Williams, the District currently does not serve these or other major M&I users. The District has been involved in water transfer programs with municipalities in the past where growers within GCID are given incentives to pump groundwater so that Sacramento River surface water can in turn be transferred to eligible candidates. Future transfers will be dependent on water availability and overall economics. M&I water demand within the vicinity of the District is anticipated to increase only slightly, with additional annual water requirements in the year 2020 expected to increase by less than 10,000 ac-ft compared to 1995 estimated levels (DWR, Northern District). This water (in addition to current demands) is assumed to be groundwater. Although lands that are incorporated within a municipality are currently uncoupled from the District, GCID could serve at least a portion of the current and/or future M&I water requirement given a mutual agreement.

2.2.4.3 Environmental/Natural and Cultural Resources

GCID conveys water to three National Wildlife Refuges (Sacramento, Delevan, and Colusa), encompassing approximately 22,500 acres. Level 4 (total quantity of water identified for each refuge to optimize management identified by the CVPIA) water requirements for these three refuges total 105,000 ac-ft. The District upgraded its conveyance system to better supply the refuges and provide year-round service in 2000. Additionally, the District serves approximately 700 acres of privately owned duck clubs. Approximately 8,350 acres of riparian vegetation are estimated to be incidentally supplied by irrigation, including vegetation directly adjacent to delivery laterals or influenced by leakage from the delivery system. Such vegetation includes elderberry shrubs, which provide habitat for the federally listed valley elderberry longhorn beetle, and habitat used by the giant garter snake.

Approximately 35,000 acres of rice stubble are typically flooded each year, with associated winter habitat benefits to migratory waterfowl that use the area as part of the Pacific Flyway. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas.

Other than what is mentioned above, there are no recreational and/or cultural resources located within the District.

2.2.4.4 Groundwater Recharge

Intentional groundwater recharge is not currently practiced in the District. However, the District is helping to facilitate recharge programs between non-governmental organizations and water users. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from conveyance losses and irrigation application practices.

2.2.4.5 Topography and Soils

The District's topography consists of nearly level to gently sloping terrain. Because the District is relatively flat, the impact of the area's terrain on District water management practices is negligible. There are no impacts on water management within the District from microclimates.

Soil associations for the Glenn County area and soil profile characteristics for the Colusa County area of the District are listed below. The total acreage for the individual soil associations and soil profiles within the District is shown in the General Soils Map and Profile Characteristic Map provided in the NRCS Soil Survey for Glenn and Colusa Counties. There are currently no known agricultural limitations resulting from soil problems within the District.

Soil associations in the Glenn County area of GCID are as follows (Attachment I):

- **Arbuckle-Kimball-Hillgate:** Sandy loam, well-drained, moderately permeable to very slowly permeable soils on low terraces.
- **Tehama-Plaza:** Silt loam, deep, well-drained to somewhat poorly drained soils mainly on alluvial fans.
- **Myers-Hillgate:** Clay loam well-drained, slowly and very slowly permeable soils mainly on alluvial fans.

- **Willows-Capay:** Clay, somewhat poorly drained and poorly drained, fine-textured soils.
- **Willows-Plaza-Castro:** Clay loam, somewhat poorly drained and poorly drained, medium- to fine-textured soils.
- **Wyo-Jacinto:** Sandy loam, well-drained to somewhat excessively drained, medium-textured and moderately coarse-textured soils on young alluvial fans or on wind-deposited material.
- **Cortina-Orland:** Gravely sandy loam, shallow to deep, well-drained to excessively drained soils on recent alluvial fans and on floodplains.

Soil profile characteristics in the Colusa County area of GCID are as follows (Attachment I):

- Young alluvial fan and basin soils with moderately compacted subsoils.
- Older alluvial fan and basin soils with moderately compacted subsoils.
- Older plain or terrace soils with dense clay subsoils.
- Upland soils formed in place from the underlying softly consolidated sedimentary materials.

2.2.4.6 Transfers and Exchanges

GCID makes conserved water available for its annual in-basin base supply transfer program and to Colusa Drain Mutual Water Company.

There are no other transfers and exchanges into or out of the service area.

2.2.4.7 Other Uses

No other significant water uses other than those discussed above occur within GCID.

2.2.5 District Facilities

GCID's main facilities within its service area include a 3,000-cfs pumping plant and fish screen structure, a 65-mile main canal, and approximately 900 miles of lateral canals and drains that serve its approximate 175,000-acre service area (Attachment A). The pump station is situated on an oxbow off the main stem of the Sacramento River. Diversion flow passes through a 1,100-foot fish screen structure where it is pumped into GCID's main irrigation canal. The remaining flow in the oxbow passes by the screens and then back into the main stem of the Sacramento River. The construction of a large siphon at Stony Creek in 1998, and various other siphons and cross-drainage structures in 1999/2000, eliminated the need for a seasonal dam in Stony Creek and allows for winter deliveries.

2.2.5.1 Diversion Facilities

GCID's primary diversion supply facility is the Hamilton City Pump Station located on the Sacramento River. The existing pump station was constructed in 1984. In 2001, GCID completed the improvement and enlargement of the fish screen, including the construction of a gradient control facility along a segment of the main stem of the Sacramento River and a water control structure for the Oxbow Channel where the pump station is located. GCID receives its Stony Creek water supply through diversion from the Sacramento River or via Reclamation's Tehama-Colusa Canal facilities. GCID can convey refuge water and some of the Settlement Contract water through TCCA via two points of interconnection with the GCID Main Canal: the Inter-Tie, a 1,000-cfs flume near the Glenn and Colusa County boundary line (Main Canal Mile Post 37), and the Cross-Tie, a 48-inch-diameter pipe west of Williams (at Main Canal Mile Post 56).

Table 2.2-4 summarizes GCID's surface water supply facilities. See Attachment A for a map of GCID's major conveyance facilities.

Table 2.2-4. GCID Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
Hamilton City Pump Station (Mile 1.4)	Sacramento River	Pump	3,000	659,900
Tehama-Colusa Canal Inter-Tie (Mile 37.2)	Tehama-Colusa Canal	Gravity	1,000	25,400
Tehama-Colusa Canal Cross-Tie (Lateral 56-1G)	Tehama-Colusa Canal	Gravity	130	23,400

2.2.5.2 Conveyance System

GCID has approximately 65 miles of main canal and 900 miles of laterals, canals, and drains. The main canal is the primary conveyance facility for the District. The main canal generally runs along the west side of the District and supplies the various laterals for delivery to field turnouts. GCID has made many major main canal improvements during the past 10 years and will continue to modernize facilities to accommodate its canal supervisory control and data acquisition (SCADA) and automation projects.

Table 2.2-5 summarizes GCID's main canal and the major irrigation lateral features. GCID does not currently have any lined canals. Estimation of the leakage losses from the GCID main canal indicates that losses are minimal due to the low permeability of the clay soils that are common in the area. A relatively minor quantity of water could be saved by lining some portion of the main canal, but the preliminary analysis shows this to be a prohibitively expensive water management option. Most seepage from District canals returns to surface drains adjacent to the canals or recharges the underlying groundwater basin, making net regional water savings from canal lining minimal.

Table 2.2-5. GCID Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
GCID Main Canal	Hamilton City Pump Station	3,000	No	N/A	13
River Branch Canal (Lateral 12-4)	GCID Main Canal at MCM 12.8/12.9	200	No	Lower part of PCGID	15
Bondurant Slough (Drain A) (Laterals 17-1 and 17-2)	GCID Main Canal (48-inch sluice gate)	200	No	Colusa Basin Drain	12
Quint Canal (Lateral 21-2)	GCID Main Canal	160	No	Colusa Basin Drain (20-47 Drain)	12
Willow Creek (Drain B)	GCID Main Canal	100	No	Quint Canal	12
Lateral 25-1	GCID Main Canal	200	No	Western Canal	12

Table 2.2-5. GCID Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Lateral 26-2	GCID Main Canal	130	No	Sacramento National Wildlife Refuge	10
Lateral 35-1	GCID Main Canal	80	No	Sacramento National Wildlife Refuge	10
Hunter Creek (Drain D) (a.k.a. Willits Slough)	GCID Main Canal (sluice gate at MCM 40.3)	75	No	Logan Creek and Colusa Basin Drain, MID	10 (clay)
Lateral 41-1	GCID Main Canal	160	No	Delevan National Wildlife Refuge, MID	10 (clay)
Stone Corral Creek (Drain E)	GCID Main Canal	50	No	Delevan, Maxwell, and Colusa Basin Drain	<10
Lateral 45-1 (Drain F3 System)	GCID Main Canal	43	No	Kulh Weir-MID	11
Lateral 48-1 (Lurline Creek System)	GCID Main Canal	100 (Lurline Creek)	No	CDMWC and MID	12
Lateral 49-2 (Lurline Creek System)	GCID Main Canal	100 (Lurline Creek)	No	CDMWC and MID	12
Lateral 51-1 (Freshwater Creek System	GCID Main Canal	100	No	CDMWC Colusa Drain	12
Salt Creek System (including Spring Creek)	GCID Main Canal	50	No	Joins Freshwater Creek and goes into Colusa Drain (Davis Weir)	10 (can gain water)
Lateral 64-1 (at Milepost 64.95)	GCID Main Canal	80	No	Colusa National Wildlife Refuge	10
Lateral 56-1	Tehama-Colusa Canal Cross-Tie	100	No	Spring Creek/Salt Creek System	10

Notes:

CDMWC = Colusa Drain Mutual Water Company
N/A = not applicable

GCID continues to modernize its facilities to improve its canal system with automated control and monitoring, including motor-operated radial and slide gates, water level and flow measurement at key points in the system, and integrated SCADA to match supplies and demands throughout the system. The District also has an ongoing program to increase the coverage of the SCADA system and to automate remaining major flow control structures. Only three major main canal check structures require replacement and modernization. The District's operational spills are minimal based on the standard performance and requirements of an open-channel distribution system, and it is not likely that significant reductions in the quantity of operational spills can be achieved.

2.2.5.3 Storage Facilities

GCID currently has no significant storage facilities. The proposed Sites Reservoir is being evaluated west of the town of Maxwell. There is potential benefit to the reintroduction of water from Sites Reservoir, through the District's Main Canal, to the Colusa Basin Drain and then to the Sacramento River. For example, the water from Sites Reservoir could be used by the District in-lieu of some proportion of current Sacramento River diversions and/or blended with drain flow from the District to improve water quality released to the downstream system.

2.2.5.4 Spill Recovery/Outflow

An aggressive recapture program, which includes groundwater seepage and tailwater runoff from cultivated fields, is part of the District's overall water management program. GCID has a network of unlined drainage ditches for conveying irrigation return flows and regional surface runoff. The drainage ditches generally empty into regional sloughs and creeks, which in turn drain into the Colusa Basin Drain. The District operates 18 drain recapture pump stations to divert for reuse. These pump stations have a total combined capacity of 800 cfs and recapture an average of 90,000 ac-ft/season. The District also has 17 gravity surface diversions for recapturing, which recapture an average of 90,000 ac-ft/season.

2.2.5.5 Proposed O&M and Capital Improvements

The District has an adopted a Capital Improvement Program that focuses on the improvement of infrastructure reliability. Furthermore, the District is implementing turnout level measurement in accordance with federal and state mandates. No significant changes in operations are expected as a result of these efforts.

2.2.6 District Operating Rules and Regulations

GCID was formed under Division 11 of the California Water Code. As such, the District is subject to the rules and regulations of this code including governing its actions through an elected Board of Directors and is required to keep a minimum amount in financial reserves.

GCID operates its system year round except for a 6-week maintenance period in January and February. Winter water is generally used for rice straw decomposition, waterfowl and shorebird habitat, and frost protection. The irrigation season is considered to generally occur from April to October annually. Water orders are to be placed before 1:30 p.m. the day before the adjustment is to be made. Water rotation, apportionment, and shortage allocation:

> According to GCID Water Management and Conservation Policy: *All consumer requests for water must be received at the District's office, or by the responsible water operations worker, at least three days before the water is needed by the consumer.*
>
> According to Rule 6 of GCID Rules and Regulations: *In the event of water shortage or water delivery constraints, the District will endeavor to equitably apportion the available District water to the District land entitled thereto.*
>
> *In years in which the Board concludes that the District's water supply will be inadequate to serve all lands entitled to service from the District, the District will estimate the total water supply available for the irrigation season, and after deducting estimated canal losses,*

> *apportion the balance to each District landowner in accordance with California Water Code section 22250 and 22251. To accomplish this apportionment, the District will accept primary applications for acreages of crops for which the landowner's apportioned water share will bring appurtenant crops to maturity. All additional acreage applied for will be placed on a secondary application list. On expiration of the time to submit primary water applications, if the total estimated water required to serve the primary application is less than the total estimated water available, the excess shall be equitably allocated to secondary applications at the discretion of the Board.*

Use of drainage waters:

> According to Rule 7 of GCID Rules and Regulations: *District landowner(s) are advised that drain water in the District is considered water supplied by the District, and any such water recaptured by the landowner(s) or user(s) may not be used to increase irrigated acreage.*

Policies for wasteful use of water:

> *According to Rule 19 of GCID Rules and Regulations: If, in the opinion of the General Manager, a consumer is wasting water, either willfully, carelessly, negligently or on account of defective private conduits, the District may refuse the delivery of water until the wasteful conditions are remedied, or the District may reduce the water inflow into the consumer's fields to a flow that would be reasonable if such wasteful conditions were remedied. Wasteful water use practices include, but are not limited to, (1) using water on roads, vacant land, or land previously irrigated, (2) flooding any portions of a consumer's land to an unreasonable depth or using an unreasonable amount of water in order to irrigate other portions of such land, (3) using water on land that has been improperly prepared for the economical use of water, and (4) allowing an unnecessary amount of water to escape from any tailgate.*
>
> *The District reserves the right to refuse delivery of water when, in the opinion of the District Manager, the proposed use, or method of use, will require excessive quantities of water which constitute waste.*

2.2.7 Water Measurement, Pricing, and Billing

Main canal flows are measured using meters at key points, including an acoustic measuring device at the Stony Creek siphon. Main lateral measurements are partially automated via the SCADA system. The remainder are measured with Remote Tracker. Sub-laterals and field turnouts are measured by staff with velocity probes. District pumps, drain pumps, and groundwater wells and landowner pumps have in-pipe flow devices that collect gallon-per-minute flows. The District is divided into 10 areas. Each area's water budget continues to be refined as better water measurement methods are implemented, allowing the District to build from the field level to lateral reach and then overall area totals. Lateral and field spills, if they occur, are measured and totalized using lateral stage measurement and weir equations. Drain outflows from the District are measured and recorded using a combination of weirs and meters.

GCID currently serves approximately 1,660 parcels and has approximately 2,470 delivery points, with 45 delivery points serving more than 1 farm. GCID has focused on modernizing the main canal, lateral headgates, and laterals in a first-phase effort. To date, two main canal check structures have been replaced and automated. A third is under current construction, and the final structure is scheduled for water year 2024. GCID has modernized and metered 254 lateral headgates and lateral check structures. GCID has implemented manual turnout-level measurement in accordance with federal and State requirements. The District has achieved automated turnout-level measurement of 30 to 50 sites per year the past 3 years, with the goal to increase to 100+ sites per year over the next 5 years. Total deliveries per service lateral are recorded. The average on-farm efficiency for the District is approximately 65 percent, which is near the practical upper limit of around 70 percent. Farm-level measuring in combination with incentive pricing and on-farm improvements may potentially increase the average on-farm efficiency and provide a quantity of conserved water. Table 2.2-6 presents an inventory of the District's water measurement devices.

Table 2.2-6. Agricultural Measurement Device Inventory for GCID

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Pump meters (Private & GCID)	10	± %	Daily	Yearly	N/A
Velocity Probe (Turnouts)	Variable[a]	±4%	Daily[b]	Yearly	Yearly
Weirs	116	±5%	Daily	N/A	Every 5 years
Flumes	5	±2%	Daily	Every 5 years	Every 5 years
Metered Gates	254	±5%	Twice Daily	Yearly	Every 10 years
Total	**Variable**				

[a] Depends on Reclamation's water delivery forecast and number of irrigated fields.

[b] Minimum readings are at the start of a delivery, before delivery is turned off, any changes made during the delivery, and every 3 days during the delivery.

Provident Irrigation District

2.3 Provident Irrigation District

2.3.1 History

Provident Irrigation District (PID or the District) was formed on April 27, 1918 and included 16,557 acres. A small part of the land in what is now PID was once within the old Central Irrigation District. In 1931, when PID was reorganized and refinanced, certain lands were excluded. Some of the lands that were excluded were later organized into the Willow Creek Mutual Water Company. In 1964, PID and Reclamation entered into a negotiated agreement quantifying the amount of water PID could divert from the Sacramento River. The negotiated agreement recognized PID's annual entitlement to a Base Supply of 49,730 ac-ft/yr from the Sacramento River and also provided for a 5,000 ac-ft allocation of Project Supply, resulting in a total contract entitlement for 54,730 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract for PID and is included in Table 2.3-1. PID subsequently worked with Reclamation and counsel to finalize a new 40-year contract in 2005, maintaining the District's 49,730 ac-ft of Base Supply and 5,000 ac-ft of Project Supply.

Table 2.3-1. Schedule of Monthly Water Diversions – PID

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	7,210	0	7,210
May	10,830	0	10,830
June	12,920	0	12,920
July	6,300	3,500	9,800
August	2,500	1,000	3,500
September	7,400	500	7,900
October	2,570	0	2,570
Total	**49,730**	**5,000**	**54,730**

Notes:

Contract No. 14-06-200-856A-R-1
Points of Diversion: 123.9R, 154.8R

2.3.2 Service Area and Distribution System

PID lies to the west of the Sacramento River in the Colusa Basin in the Counties of Glenn and Colusa, approximately 7 miles east of the city of Willows. The District encompasses approximately 15,965 acres (including 800 acres recently annexed into the District), 15,332 of which are irrigated, and serves 72 landowners. Rice is the predominant crop, accounting for approximately 98 percent of irrigated acreage in the District. Many of PID's operations are coordinated with PCGID, located directly adjacent and east of the District.

2.3.3 Water Supply

The Sacramento River serves as the principal water source for the District, although the District also uses tailwater from both inside and outside of the District and from the Colusa Basin Drain. The District has water rights to the Sacramento River and several other surface water sources as shown in Table 2.3-2. The following discussion describes these sources and their historical use.

Table 2.3-2. PID: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River, Colusa Basin Drain, Willow Creek, Unnamed Drain[d]	A000462 (9/15/16)	000303 (7/12/17)	007205 (3/30/65)	About Apr 1 to about Oct 1	250 cfs
Sacramento River, Colusa Basin Drain, Willow Creek, Unnamed Drains[d]	A000640 (4/9/17)	000304 (7/12/17)	007206 (3/30/65)	About Apr 1 to about Oct 1	100 cfs
Sacramento River, Colusa Basin Drain, Drain 13, Drain 55, Unnamed Drain, Willow Creek	A000892 (1/18/18)	000416 (3/28/18)	007207 (3/30/65)	About Apr 1 to about Oct 1	110 cfs
Colusa Basin Drain	A001422 (9/2/19)	000847 (3/4/21)	001109 (9/15/31)	About Apr 15 to about Oct 1	10 cfs
Colusa Basin Drain	A010595 (1/27/43)	6210	4331 (4/24/56)	About Apr 15 to about Oct 1	10 cfs
Colusa Basin Drain	A011819 (4/9/47)	008238 (12/20/50)	004231 (3/21/56)	About Apr 1 to about Oct 15	7 cfs
Colusa Basin Drain	A013452 (11/9/49)	008290 (12/20/50)	004364 (5/21/56)	About Apr 1 to about Oct 1	3.25 cfs
Sacramento River, Colusa Basin Drain, Willow Creek, Unnamed Drain[d]	A030813 (11/9/1949)	21133 (6/13/02)	N/A	Oct 1 to Mar 31	483.25 cfs 26,747 ac-ft/yr
Sacramento River	S020960 (1903)	N/A	N/A		

[a] Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b] N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c] The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d] The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e] The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

2.3.3.1 Surface Water

As identified above, PID holds water rights to divert water from the natural flow of the Sacramento River. The PID surface water supply entitlement was addressed in a contract entered into with Reclamation in 1964, Contract No. 14-16-200-0856A (Contract No. 0856A). This contract provides for an agreement between PID and the United States on PID's diversion of water from the Sacramento River during the period April 1 through October 31 of each year. The District's current contract No. 0856A provides for a maximum total of 54,730 ac-ft/yr, of which 49,730 ac-ft is considered to be Base Supply and 5,000 ac-ft is CVP water (Project Supply), as shown in Table 2.3-3. The contract also provides that additional Project Supply can be purchased if surplus water is available. There are no restrictions on District water sources.

Table 2.3-3. PID: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	16,200	5,000
Non-critical Months	33,530	0
Total Annual	**49,730**	**5,000**

The contract specifies the total quantity of water that may be diverted by PID each month during the period April through October[5] each year. The monthly Base Supply ranges from a minimum of 2,500 ac-ft in August to a maximum of 12,920 ac-ft in June. CVP water (Project Supply) is available during the months of July, August, and September with entitlements of 3,500, 1,000, and 500 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 16,200 ac-ft, and the total Project Supply is 5,000 ac-ft, as shown in Table 2.3-3.

Non-contract Period (November – March)

Contract No. 0856A does not limit PID from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. PID has filed for, and was granted, a water right permit for diversions in the amount of approximately 26,700 ac-ft from October through March, as shown in Table 2.3-2. Relatively little pre-irrigation occurs within the District; therefore, non-contract-period diversions are predominantly used for rice straw decomposition. In response to increasingly stringent limitations on burning, many of the District's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. Approximately 4,000 to 8,500 acres have been flooded in the past; however, acreage is expected to increase over the next few years.

Other Surface Water Sources

PID has water rights to several surface water sources within or bordering the District's service area. As shown in Table 2.3-2, PID holds water rights to Willow Creek, Colusa Basin Drain, Drain 13, Drain 55, and several other unnamed drains. PID is also party to the Five-Party Agreement, which recognizes the shared operation of drains in the entities' service areas and the shared right to recirculation and reuse of drain water.

2.3.3.2 Groundwater/Conjunctive Use

The PID boundary overlies the Colusa Subbasin (DWR groundwater basin number 5-21.52) of the Sacramento Valley Groundwater Basin. Groundwater throughout the Sacramento Groundwater Basin, and therefore within PID, occurs in a broad alluvial basin and is therefore not confined to any well-defined subsurface stream channels.

[5] Article 3(b) allows a contractor to divert water under an after-acquired water right (such as Permit 21133) without paying a rescheduling fee under Article 3(c)(1) and also allows a contractor to divert water under an after-acquired water right before paying for Project Water.

Intentional groundwater recharge is not currently conducted in the District. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from conveyance losses and irrigation application practices.

Past pumping and drought conditions have not historically negatively affected the overall long-term groundwater level trends in PID. Based on the spring to spring water level information of DWR monitoring wells in the PID area that date back to the 1940s, there has been little significant change in groundwater levels over time (DWR, 2003b). Groundwater level data since 1980 from over 2,300 wells in the Sacramento Valley were reviewed, and the historical trends show that groundwater levels in the PID area are generally stable over the long term, although short-term fluctuations in groundwater levels are observed that can be correlated with precipitation trends.

Approximately 15 to 20 privately owned wells and four District-owned wells are located within the District's boundaries. During the drought years of 1976 to 1977, PID installed three agricultural groundwater wells to supplement its water supply. An additional well was installed in 1991. During the drought of 1986 to 1993, several private groundwater wells were installed. The total capacity of the District-owned wells is approximately 3,000 to 4,000 ac-ft/yr. Groundwater is used to help with initial flooding of the rice fields and to increase flexibility during the peak demand periods (DWR, 1978). During the drought years of 2014 and 2015, PID participated in groundwater substitution transfers.

Groundwater Subbasin Conditions

PID lies within the northeastern portion of the Colusa Subbasin. The area is located on recent alluvial sediments: channel, floodplain, basin, and alluvial deposits. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities. Stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeabilities. Underlying these recent fluvial deposits are the Tehama and Tuscan Formations (DWR 1978; DWR, 2003c).

Beneath the alluvial fan deposits are the deposits of the Tehama Formation. Although the Tehama Formation is mostly fine-grained, it contains sufficient sand and gravel zones in many areas to provide large quantities of groundwater. In the northern portion of the Colusa Subbasin, the Tehama Formation contains extensive deposits of interbedded gravel from the ancestral Stony Creek (the Stony Creek Member). The Stony Creek Member of the Tehama Formation is typically very productive, yielding a large quantity of water to wells. In the central and southern portion of the Colusa Subbasin, between Willows and Williams, the Tehama Formation is predominately clayey, and wells in this area are generally less productive than those in the northern portion of the subbasin (DWR, 1978).

The Tuscan Formation is an important water-bearing unit in the northeastern portion of the Sacramento Valley (DWR, 2003a). Deposited during the same period as the Tehama Formation, the Tuscan Formation consists of interbedded volcanic deposits (DWR, 1978). The unit grades from tuff breccias along the eastern margin of the Sacramento Valley to volcanic sands, gravels, and clays to the west. In the Colusa Subbasin, the Tuscan Formation is found at depths of 300 to 1,000 feet bgs, where it interfingers with the Tehama Formation (DWR, 2003a). Volcanic sands and gravels can provide high yields to domestic and irrigation wells; however, the unit is generally too deep to be tapped by wells west of Chico (DWR, 1978).

Groundwater quality in the Sacramento Groundwater Basin is generally good and sufficient for agricultural, domestic, and M&I uses. In general, natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada Mountains is generally of higher quality than runoff from the Coast Ranges because of the presence of marine sediments in the Coast Range. The total depth of fresh water in PID is approximately 1,200 feet bgs (Berkstresser, 1973). The fresh water is underlain by saline water.

In the northern portion of PID, near the town of Glenn, groundwater movement is generally to the southeast, toward the Sacramento River, at a gradient of 5 feet per mile (DWR, 2003c). In the southern portion of the District, the flow changes to a more southerly direction with a gradient of about 2.5 feet per mile. Seasonal fluctuations in groundwater level are generally less than about 5 feet, but can be up to 10 feet in drought years (DWR, 2003b). Wells located near recharge sources typically show less of an annual change in groundwater levels.

Groundwater Planning/Sustainable Groundwater Management Act

PID and PCGID originally filed as a GSA but later agreed to become members of both the Colusa and Glenn County GSAs and actively participate in both efforts. Both Plans are still in process and will be completed by Jan 31, 2022.

The District does not participate in any groundwater banking.

2.3.3.3 Other Water Supplies

In recent years, PID has relied heavily on tailwater, approximately 45,000 to 55,000 ac-ft/yr, from both inside and outside of the District's service area to supplement its Sacramento River entitlement. PID operates two gravity surface diversions on Drain 13 and Drain 55. These two drains primarily convey tailwater from GCID. In addition, Colusa Basin Drain, Quint Canal, and Willow Creek also convey tailwater from GCID and other sources. Approximately 25,000 to 30,000 ac-ft annually have been used in the past from these sources. PID meters water pumped from these drains.

In the past, PID has recycled internally about 20,000 to 25,000 ac-ft annually. Water recirculated within PID is metered. Continued reuse and recycling efforts are expected to be influenced by an increasing need to manage salinity and other constituents that affect crop productivity and sustainability.

2.3.4 Water Use

Water use within the District is predominantly agricultural as the District does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.3.4.1 Agricultural

Rice is the overwhelmingly predominant crop grown within PID's service area due to the presence of clayey soils within the majority of the District. Other crops include a small amount of pasture, orchard, and grains. Rice accounts for more than 98 percent of the District's irrigated acreage on an annual basis (DWR, Northern District). Historic irrigation methods, including flood irrigation for rice, are still used but now include more focused drip irrigation for some orchards. Many of the same facilities originally constructed by the District are in use today.

As is the case with most of the other districts, water requirements are typically highest during the summer months (June, July, and August) due to the requirements of rice and the area's hot, dry climate. Cultural practice water needs for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields. The vast majority of irrigation water requirements are met through the contract surface water supply, although groundwater is used in drought years on an individual grower basis and as per agreements with the District.

Annual cropping patterns have remained fairly constant over the last few decades, other than in response to farm programs in the early 1980s. Associated water requirement needs and associated diversions have therefore been more a function of water-year type and climate than changes in cropping.

Many of the District's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. This practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture.

Future irrigation season cropping patterns and associated water requirements and land use are anticipated to remain relatively the same as current conditions.

2.3.4.2 Urban

PID does not overlay any municipal or industrial centers and does not currently have plans to provide water for these uses other than continuing to pump and deliver water to the Willow Creek Mutual Water Company, which is an agricultural user. M&I water demand within the vicinity of the District is anticipated to increase only slightly, with additional annual water requirements in the year 2020 expected to increase by less than 5,000 ac-ft compared to 1995 estimated levels (DWR, Northern District). Future M&I requirements are assumed to be met by groundwater supplies. Although M&I requirements are not currently being served, the District does not preclude the possibility of serving such needs in the future.

2.3.4.3 Environmental/Natural and Cultural Resources

Approximately 50 acres of riparian vegetation are estimated to be incidentally supplied by irrigation, including vegetation directly adjacent to delivery laterals or influenced by leakage from the delivery system. Such vegetation includes habitat used by the federally listed giant garter snake. PID can contribute varying levels of flow depending on year type to the Delevan National Wildlife Refuge through Willow Creek during the irrigation season. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas.

Up to 8,500 acres of rice stubble have been flooded in the past, with associated winter habitat benefits to migratory waterfowl that use the area as part of the Pacific Flyway. Additionally, the District serves approximately 1,000 acres of privately owned duck clubs. No managed designated environmental or wetlands areas are within the District.

There are currently no known cultural resources or historic structures identified within the District. There are many winter wildlife hunting opportunities within the District.

2.3.4.4 Topography and Soils

The District's topography generally consists of nearly level to gently sloping terrain. Because the District is relatively flat, the impact of the area's terrain on District water management practices is negligible. There are no impacts from any microclimates on water management within the District.

Soil associations for the Glenn County area and soil profile characteristics for the Colusa County area of the District are listed below. The total acreage of each individual soil association and soil profile within the District is shown in the General Soils Map and Profile Characteristic Map provided in the NRCS Soil Survey for Glenn and Colusa Counties. Agricultural limitations resulting from soil problems are nonexistent or unknown at this time.

Soil associations in the Glenn County area of PID are as follows (Attachment I):

- **Zamora-Marvin:** Silt to silty clay loam, well-drained to somewhat poorly drained, moderately fine-textured and fine-textured soils on floodplains.
- **Tehama-Plaza:** Silt loam, deep, well-drained to somewhat poorly drained soils mainly on alluvial fans.
- **Willows-Plaza-Castro:** Clay loam, somewhat poorly drained and poorly drained, medium- to fine-textured soils.

Soil profile characteristics in the Colusa County area of PID are as follows (Attachment I):

- Older alluvial fan and basin soils with moderately compacted subsoils.

2.3.4.5 Transfers and Exchanges

PID is involved with several water transfer agreements. Several of the irrigation and reclamation districts adjacent to the Colusa Basin Drain have agreed to provide additional flow, when possible, to the drain for use by the Colusa Basin Drain Mutual Water Company. The districts are compensated by Colusa Basin Drain Mutual Water Company for this water. In addition, PID is one of the irrigation districts that signed the Five-Party Agreement of June 2, 1956. This agreement represents a cooperative effort by GCID, PID, PCGID, MID, and two entities that have since dissolved (Compton-Delevan Irrigation District and Jaciento Irrigation District) to share O&M of the drains within their respective service areas and to share the right to recirculate the water in those drains. PID also diverts water to Willow Creek Mutual Water Company via a transfer agreement.

There are no other trades, wheeling, wet/dry exchanges or other transactions into or out of District.

2.3.4.6 Other Uses

No other significant water uses other than those discussed above occur within PID.

2.3.5 District Facilities

2.3.5.1 Diversion Facilities

PID's primary water supply facility is a surface water diversion on the Sacramento River at Sidds Landing Pump Station. The District operates Sidds Landing Pump Station in cooperation with PCGID. The District also operates two gravity surface diversions on adjacent drainage channels that convey return flows from GCID lands to the west of PID. Table 2.3-4 summarizes PID's surface water supply facilities. See Attachment A for a map of PID's major conveyance facilities.

Table 2.3-4. PID Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
Sidds Landing Pump Station	Sacramento River	Pump	605	58,000
Drain 13 Gravity Surface Diversion	Drain 13	Gravity	100	9,500
Drain 55 Gravity Surface Diversion	Drain 55	Gravity	100	30,000

During the 1976 to 1977 drought, PID installed three groundwater wells to supplement its water supply. An additional well was installed in 1991. Table 2.3-5 summarizes the District's groundwater well data. During the drought of 1986 to 1993, several private groundwater wells were installed. There is no formal agreement between the District and the landowners regarding pumping of private wells. Approximately 7,200 ac-ft/yr can currently be pumped from the groundwater wells within the District.

Table 2.3-5. PID Groundwater Wells

Map ID	Capacity (cfs)	Historical Pumping (ac-ft/yr)	Water Quality
AG Well No. 1	4.5	534	Good
AG Well No. 2	10.7	280	Good
AG Well No. 3	12.9	207	Good
AG Well No. 4	11.1	302	Good

2.3.5.2 Conveyance System

PID's distribution and conveyance system includes approximately 58 miles of unlined canals and main laterals. The Main Canal runs from Sidds Landing Pump Station through the northern portion of the District. The PID main canal also supplies other canals in the Willow Creek Mutual Water Company to the west of PID's southern service area. Table 2.3-6 summarizes PID's distribution facilities.

Table 2.3-6. PID Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Provident Main Canal	Sidds Pump Station	400	No	Not applicable	15
Quint Canal	GCID Main Canal	80	No	Colusa Drain	15
Wylie Canal	Provident Main Canal	60	No	Quint Canal	15
Unnamed Lateral	Provident Main Canal and possibly groundwater pump No. 1	100	No	Unnamed Creek to Colusa Drain	15
North Lateral	Provident Main Canal	300	No	Colusa Basin Drain	15

2.3.5.3 Storage Facilities

PID currently has no storage facilities.

2.3.5.4 Spill Recovery/Outflow

PID has a network of unlined drainage ditches for conveying irrigation return flows. The drains generally empty into the Colusa Basin Drain. The District operates six pumping plants that recapture return flows. Table 2.3-7 summarizes the drain recapture facilities, and Table 2.3-8 summarizes the main drain laterals.

Table 2.3-7. PID Drain Pump Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping Total (ac-ft/yr)
Colusa Drain Pump	Colusa Basin Drain	Provident Main Canal	53	5,700
Sprague Drain Pump	Unnamed Creek	Booster Ditch	18	2,100
Willow Creek Drain Pump	Willow Creek	Quint Canal/Provident Main Canal	40	2,200
Green Camp Pump	Unnamed Creek	Provident Main Canal	16	680
57 Pumps	Colusa Drain	N Lateral	39	8,300
Drain 13 Booster Pump	Drain 13	Booster Ditch	48	10,400

Table 2.3-8. PID Drainage Laterals

Name	End Spill	Downstream Diverters/Recapture
Colusa Basin Drain	Sacramento River	Downstream diversions outside District
Willow Creek Drain	Colusa Basin Drain	Downstream diversions outside District
Drain 55	Colusa Basin Drain	Downstream diversions outside District
Drain 13	Colusa Basin Drain	Downstream diversions outside District

2.3.5.5 Proposed O&M and Capital Improvements

The District has completed installation of meters on all District-owned groundwater wells and drain recapture facilities. The District recently installed individual field measuring devices at all turnouts. The cost to implement this turnout measurement program was $362,400.

2.3.6 District Operating Rules and Regulations

PID was formed under Chapter 11 of the California Water Code. As such, the District is subject to the rules and regulations of this code, including governing its actions through an elected Board of Directors, and is required to keep a minimum amount in financial reserves.

Water rotation, apportionment, and shortage allocation: Water orders must be made 24 hours in advance. Shutoff is also 24 hours in advance.

> According to Rule 5 of PID Rules and Regulations: *All requests for water service must be made in writing and must be delivered at the District's office at least three days before the water is needed. Effort will be made to make delivery in less than three days, and where possible, delivery will be made within twenty-four hours.*
>
> According to Rule 13 of PID Rules and Regulations: *When, through lack of water, lack of ditch capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof, the full supply of water required by the water users, such supply as can be delivered will be pro rated until such time as delivery of a full supply can be given.*

On 75 percent supply years, every landowner receives his or her share of water from all sources based on their total assessed acres as a percent of the total. Landowners are then able to trade or sell their allocation to another farmer within the District.

Use of drainage waters:

> *District landowner(s) are advised that drain water in the District is considered water supplied by the District, and any such water recaptured by the landowner(s) or user(s) may not be used to increase irrigated acreage.*

Policies for wasteful use of water:

> According to Rule 12 of PID Rules and Regulations: *Any consumer wasting water on roads, or vacant land, or land previously irrigated either willfully, carelessly, or on account of defective ditches, or who shall flood certain portions or the land to an unreasonable depth, or use an unreasonable amount of water in order to properly irrigate other portions or whose land has been improperly checked for the economical use of water or allows an unnecessary amount of water to escape from any tailgate, will be refused the use of water until such conditions are remedied.*

2.3.7 Water Measurement, Pricing, and Billing

PID currently serves 72 farms and has approximately 228 delivery points, with 0 serving more than 1 farm. The District measures flows at the main pump stations with flowmeters. District wells and drain pumps are metered. Lateral headgate flows are measured using stage and gate position, or stage and weir geometry at flashboard turnouts. Minor increases in conveyance efficiency could be achieved by improved operations measurement, installation of measuring facilities at intermediate points along the main canal, and improved measuring at the heads of laterals. These new measurement facilities would be integrated with the operations automation program described above to increase overall distribution system efficiency.

As of December 2022, PID measures field turnouts. The District measures flow rate at turnouts using methods listed below. Flow rates are set to match the field demand based on the irrigation method and field conditions. The total quantity of water delivered to each turnout is determined using volume flow rate calculation via spot flow measurement with acoustic velocimeter. Accuracy testing will begin when water use begins during the next irrigation season, anticipated April 2023. While the accuracy testing occurs, PID will investigate volumetric pricing options and coordinate with legal counsel. PID intends to implement volumetric pricing by 2024. There are 228 measured delivery points, and 100 percent of delivered water is measured at the delivery point. Table 2.3-9 presents an inventory of the District's water measurement devices, including the total number of turnouts that are measured using the Acoustic Doppler Velocimeter method.

Table 2.3-9. Agricultural Measurement Device Inventory for PID

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Propeller	12	±5%	Daily	Yearly	Yearly
Magnetic Flowmeter	4	±5%	Continuously	Calibrated at installation	Yearly
Doppler Flow Meter	1	±15%	Continuously	Yearly	Yearly
Acoustic Doppler Velocimeter	228	To be determined	Daily	Calibrated at installation	Yearly
Weirs	1	±15%	Daily	N/A	Yearly
Total	**246**				

Princeton-Codora-Glenn Irrigation District

2.4 Princeton-Codora-Glenn Irrigation District

2.4.1 History

Princeton-Codora-Glenn Irrigation District (PCGID or District) was organized on December 9, 1916, under the California Irrigation District Act of 1897 and was 12,133 acres. The District was organized to take over from the receiver of the Sacramento Valley West Side Canal Company a portion of the River Branch canal system.

In 1964, the District entered into a negotiated agreement with Reclamation quantifying the amount of water PCGID could divert from the Sacramento River. The resulting negotiated agreement recognized PCGID's annual entitlement to a Base Supply of 52,810 ac-ft/yr of flows from the Sacramento River and also provided for a 15,000 ac-ft allocation of Project Supply, resulting in a total contract entitlement of 67,810 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract for PCGID and is included in Table 2.4-1. PCGID subsequently worked with Reclamation and counsel to finalize a new 40-year contract in 2005, maintaining the District's 52,810 ac-ft of Base Supply and 15,000 ac-ft of Project Supply.

Table 2.4-1. Schedule of Monthly Water Diversions – PCGID

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	10,800	0	10,800
May	13,500	0	13,500
June	12,790	400	13,190
July	6,740	6,000	12,740
August	2,780	8,400	11,180
September	480	200	5,000
October	1,400	0	1,400
Total	**52,810**	**15,000**	**67,810**

Notes:

Contract No. 14-06-200-849A-R-1
Points of Diversion: 123.9R, 154.8R

2.4.2 Service Area and Distribution System

PCGID is located west of the Sacramento Valley adjacent to the Sacramento River, in Glenn and Colusa Counties. The Colusa Basin Drain runs along most of PCGID's western boundary, beyond which lies PID. The community of Princeton lies within PCGID's boundaries. The District encompasses approximately 11,700 acres, 10,793 of which are irrigated, and serves 130 landowners. Rice is the primary crop grown within the District. The balance of irrigable acreage consists of orchards and row crops. PCGID does not supply M&I water to any entity. District operations are coordinated with PID, located directly adjacent and west of the District.

2.4.3 Water Supply

PCGID holds water rights to divert water from the natural flow of the Sacramento River as well as the Colusa Basin Drain. These diversions differ in the quantity and timing in which they can be used, as indicated in Table 2.4-2. The District also uses tailwater from both inside and outside of the District.

Table 2.4-2. PCGID: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	A000244 (2/3/16)	00463 (8/15/18)	002646 (4/10/44)	About Apr 1 to about Oct 31	120 cfs
Sacramento River	A000770 (9/5/17)	000464 (8/15/18)	004161 (12/30/55)	About Apr 1 to about Oct 31	120 cfs
Colusa Basin Drain	A017066 (5/2/56)	013869 (2/15/63)	008989 (2/21/69)	Primary: About Apr 1 to about Jun 30 Secondary: About Sep 1 to about Oct 31	50 cfs
Sacramento River, Colusa Basin Drain	A030812 (11/19/98)	21132 (6/13/02)	N/A	Nov 1 to Mar 31	290 cfs 24, 370 ac-ft/yr
Sacramento River	S020961 (1903, riparian)	N/A	N/A		

[a] Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b] N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c] The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d] The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e] The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

2.4.3.1 Surface Water

As identified above, the PCGID surface water supply entitlement is currently addressed in a contract entered into with Reclamation in 1964, Contract No. 14-16-200-0849A (Contract No. 0849A). This contract provides for an agreement between PCGID and the United States on PCGID's diversion of water from the Sacramento River during the period April 1 through October 31 of each year. Contract No. 0849A provides for a maximum total of 67,810 ac-ft/yr, of which 52,810 ac-ft is considered to be Base Supply and 15,000 ac-ft is CVP water (Project Supply), as shown in Table 2.4-3. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.4-3. PCGID: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	14,320	14,600
Non-critical Months	38,490	400
Total Annual	**52,810**	**15,000**

The contract specifies the total quantity of water that may be diverted by PCGID each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 1,400 ac-ft in August to a maximum of 13,500 ac-ft in May. CVP water (Project Supply) is available during the months of June, July, August, and September with entitlements of 400, 6,000, 8,400, and 200 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 14,320 ac-ft, and the total Project Supply is 14,600 ac-ft. There are no restrictions on the District's water sources.

Non-contract Period (November – March)

Contract No. 0849A does not limit PCGID from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. PCGID has filed and was granted a water right permit for non-contract-period diversions in the amount of approximately 24,400 ac-ft. Non-contract-period diversions are predominantly used for rice straw decomposition and pre-irrigation. PCGID has historically irrigated in months prior to April (pre-irrigation), especially for orchards, grains, tomatoes, and sugar beets. In response to increasingly stringent limitations on burning, some of the District's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. Approximately 1,200 to 2,500 acres have been flooded in the past. A lower percentage of rice acreage is flooded in PCGID compared to other adjacent districts because of the high cost of decomposition water (relative to other districts).

Other Surface Water Sources

Several minor creeks are located within PCGID boundaries, including Canal Creek and Bounde Creek. Canal and Bounde Creeks are seasonal and provide no additional surface water source during the irrigation season. However, these waterways are used as conveyance facilities for tailwater and/or recirculation purposes. PCGID has permits to pump water from the Colusa Basin Drain. PCGID may divert up to approximately 50 cfs from the drain from April 1 to June 30 and from September 1 to October 31. PCGID is also party to the Five-Party Agreement, which recognizes the shared operation of drains in the entities' service areas and the shared right to recirculation and reuse of drain water.

2.4.3.2 Groundwater/Conjunctive Use

The PCGID boundary overlies the Colusa Subbasin (DWR groundwater basin No. 5-21.52) of the Sacramento Valley Groundwater Basin and, therefore, within PCGID occurs in a broad alluvial basin and is not confined to any well-defined subsurface stream channels.

Past pumping and drought conditions have not historically negatively affected the overall long-term groundwater level trends in PCGID. Based on the long-term spring to spring water level information of DWR monitoring wells in the PCGID area that date back to the 1930s, there has been little significant change in groundwater levels over time. Groundwater level data since 1980 from over 2,300 wells in the Sacramento Valley were reviewed, and the historical trends show that groundwater levels in the PCGID area are generally stable over the long term, although short-term fluctuations in groundwater levels are observed that can be correlated with precipitation trends.

Approximately 20 privately owned wells and 5 District-owned wells are located within the District's boundaries. The total capacity of the District-owned wells is approximately 3,000 to 4,000 ac-ft/yr. Groundwater is used to help with the initial flooding of the rice fields and to increase flexibility during the peak demand periods. Operations of these wells are coordinated with the river pumps to maximize flexibility and serve those within the District during times of short water supplies (e.g., drought conditions). During the drought years of 2014 and 2015, PCGID participated in groundwater substitution transfers.

Although PCGID has no formal agreement with private well owners, in the past, the District has established seasonal agreements (one irrigation season duration). In 1994, PCGID developed a conjunctive water management program with landowners that encouraged landowners to pump groundwater to supplement Sacramento River diversions.

Intentional groundwater recharge is not currently practiced in the District. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from conveyance losses and irrigation application practices.

Groundwater Subbasin Conditions

PCGID lies within the north-central portion of the eastern Colusa Subbasin. Groundwater occurs in a broad alluvial basin and is not confined to subsurface stream channels. The area is located on recent alluvial sediments: channel, floodplain, basin, and alluvial deposits. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities. Stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeabilities. Underlying these recent fluvial deposits are the Tehama and Tuscan Formations (DWR 1978; DWR, 2003c).

Although the Tehama Formation is mostly fine-grained, it contains sufficient sand and gravel zones in many areas to provide large quantities of groundwater. In the northern portion of the Colusa Subbasin the Tehama Formation contains extensive deposits of interbedded gravel from the ancestral Stony Creek (the Stony Creek Member). The Stony Creek Member of the Tehama Formation is typically very productive, yielding a large quantity of water to wells. In the central and southern portion of the Colusa Subbasin, between Willows and Williams, the Tehama Formation is predominately clayey, and wells in this area are generally less productive than those in the northern portion of the subbasin (DWR, 1978). The most productive aquifers in the Colusa Subbasin are associated with the Stony Creek Member of the Tehama Formation.

The Tuscan Formation is an important water-bearing unit in the northeastern portion of the Sacramento Valley (DWR, 2003a). Deposited during the same period as the Tehama Formation, the Tuscan Formation consists of interbedded volcanic deposits (DWR, 1978). The unit grades from tuff breccias along the eastern margin of the Sacramento Valley to volcanic sands, gravels, and clays to the west. In the Colusa Subbasin, the Tuscan Formations is found at depths of 300 to 1,000 feet bgs, where it interfingers with the Tehama Formation (DWR, 2003a). Volcanic sands and gravels can provide high yields to domestic and irrigation wells; however, the unit is generally too deep to be tapped by wells west of Chico (DWR, 1978).

Groundwater quality in the Sacramento Groundwater Basin is generally good and sufficient for agricultural, domestic, and M&I uses. In general, natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges, because of the presence of marine sediments in the Coast Range (DWR, 2003c). The total depth of fresh water in PCGID is approximately 1,400 feet bgs (Berkstresser, 1973). The fresh water is underlain by saline water.

In the northern portion of PCGID, groundwater movement is generally to the southeast, toward the Sacramento River, at a gradient of 5 feet per mile. In the southern portion of the District, the flow changes to a more southerly direction with a gradient of about 2.3 feet per mile (DWR, 2003c). Seasonal fluctuations in groundwater level in the PCGID area show an atypical trend. During years of normal precipitation, groundwater levels have been shown to fluctuate up to 10 feet seasonally. During drought years, seasonal fluctuations are generally less than about 5 feet (DWR, 2003b). The trend is interpreted as being a result of lower recovery of spring water levels during drought years, resulting in an overall decrease in groundwater levels during consecutive drought years. Wells located near recharge sources typically show less of an annual change in groundwater levels (DWR, 2003b).

Groundwater Planning/Sustainable Groundwater Management Act

The District belongs to both the Glenn County and Colusa County Groundwater Authorities. The GWMPs are both in progress with expected completion dates of Jan 31, 2022. The District does not participate in groundwater banking.

Other Water Supplies

In recent years, PCGID has relied heavily on tailwater to supplement its Sacramento River entitlement. GCID has been the primary source of this tailwater. As discussed above, PCGID has water rights to tailwater in Colusa Basin Drain. Water pumped from this and other drains is metered by PCGID.

PCGID has initiated a Recapture Plan for recirculating water through the District. Currently, four recapture plants are located within PCGID. In the past, PCGID has recycled about 20,000 to 25,000 ac-ft annually. Water recirculated within PCGID is metered. Continued reuse and recycling efforts are expected to be influenced by an increasing need to manage salinity and other constituents that affect crop productivity and sustainability. PCGID is involved with several water transfer agreements. Several of the irrigation and reclamation districts adjacent to the Colusa Basin Drain have agreed to provide additional flow, when possible, to the drain for use by Colusa Basin Drain Mutual Water Company. The districts are compensated by Colusa Basin Drain Mutual Water Company for this water. In addition, PCGID is one of the irrigation districts that signed the Five-Party Agreement of June 2, 1956. This agreement represents a cooperative effort by GCID, PID, PCGID, MID, and two entities that have since dissolved (Compton-Delevan Irrigation District and Jaciento Irrigation District) to share O&M of the drains within their respective service areas and to share the right to recirculate the water in those drains.

2.4.4 Water Use

Water use within the District is predominantly agricultural as the District does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.4.4.1 Agricultural

Rice is the major crop grown within PCGID’s service area, in addition to orchard and row crops. Class I soils (i.e., sandy and gravelly soils) are generally present in the portions of the District directly adjacent to the river, which allow for orchards, but in turn result in greater seepage from the laterals and canals throughout the District. Rice accounts for approximately 75 percent of the District's irrigated acreage on an annual basis. As is the case with most of the other districts, water requirements are typically highest during the summer months (July and August) due to the requirements of rice and the area's hot, dry climate. Cultural practice water needs for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields. Water application requirements for orchards are typically greatest in June, July, and August. Historic irrigation methods, including flood irrigation for rice, are still used but now include more focused drip and micro sprinkler irrigation for some orchards. Many of the same facilities originally constructed by the District are in use today.

The vast majority of irrigation water requirements are met through the contract surface water supply, although groundwater is used in drought years on an individual grower basis and as per agreements with the District. Annual cropping patterns have remained fairly constant over the last few decades, other than in response to farm programs in the early 1980s. Associated water requirement needs and associated diversions have therefore been more a function of water-year type and climate than changes in cropping.

Many of the District's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. This practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture.

Future irrigation season cropping patterns and crops will likely shift, but overall associated water requirements and land use are anticipated to remain relatively the same as current conditions.

2.4.4.2 Urban

PCGID does not serve any municipal or industrial centers, including Princeton, and does not currently have plans to provide water for these uses. M&I water demand within the vicinity of the District is anticipated to increase only slightly, with additional annual water requirements in the year 2020 expected to increase by less than 5,000 ac-ft compared to 1995 estimated levels (DWR, Northern District). Future M&I requirements are assumed to be met by groundwater supplies. Although M&I requirements are not currently being served, the District does not preclude the possibility of serving such needs in the future.

2.4.4.3 Environmental/Natural and Cultural Resources

Approximately 50 acres of riparian vegetation are estimated to be incidentally supplied by irrigation including vegetation directly adjacent to delivery laterals or influenced through leakage from the delivery system. Such vegetation includes habitat used by the federally listed giant garter snake. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas.

Up to 2,500 acres of rice stubble have been flooded in the past, with associated winter habitat benefits to migratory waterfowl that use the area as part of the Pacific Flyway. Future estimates indicate that up to 4,000 acres may eventually be flooded. No managed designated environmental or wetlands areas are within the District.

There are currently no known cultural resources or historic structures within the District. There are many winter wildlife hunting opportunities within the District.

2.4.4.4 Topography and Soils

The District's topography generally consists of nearly level to gently sloping terrain. Because the District is relatively flat, the impact of the area's terrain on District water management practices is negligible. There are no impacts from any microclimates on water management within the District.

Soil associations for the Glenn County area and soil profile characteristics for the Colusa County area of the District are listed below. The total acreage for the individual soil associations and soil profiles within the District is shown in the General Soils Map and Profile Characteristic Map provided in the NRCS Soil Survey for Glenn and Colusa Counties. Agricultural limitations resulting from soil problems are nonexistent or unknown at this time.

Soil associations in the Glenn County area of PCGID are as follows (Attachment I):

- **Zamora-Marvin:** Well-drained to somewhat poorly drained silt to silty clay loam, moderately fine-textured and fine-textured soils on floodplains.
- **Willows-Plaza-Castro:** Somewhat poorly drained and poorly drained clay loam, medium- to fine-textured soils.

Soil profile characteristics in the Colusa County area of PCGID are as follows (Attachment I):

- Recent alluvial fan and floodplain soils with deep permeable profiles.
- Older alluvial fan and basin soils with moderately compacted subsoils.

2.4.4.5 Transfers and Exchanges

In general, the water transferred to the Colusa Basin Mutual Water Company is made available through the Colusa Basin Drain for Colusa Basin Mutual Water Company use. PCGID has, for many years, been a supporter of and participant in water transfers to other contractors within the basin. In addition, PCGID is one of the irrigation districts that signed the Five-Party Agreement of June 2, 1956. This agreement represents a cooperative effort by GCID, PID, PCGID, MID, and two entities that have since dissolved (Compton-Delevan Irrigation District and Jaciento Irrigation District) to share O&M of the drains within their respective service areas and to share the right to recirculate the water in those drains. PCGID has also transferred water, when available, to the state during dry periods.

2.4.4.6 Other Uses

No other significant water uses other than those discussed above occur within PCGID.

2.4.5 District Facilities

2.4.5.1 Diversion Facilities

PCGID operates one pumping plant on the Sacramento River. The Sidds Pumping Plant is located north of the community of Glenn at Sidds Landing and includes eight pump/motor units of various horsepower ratings and a combined capacity of approximately 605 cfs. The Sidds Plant was built in the late 1990s with PID with a capacity of 605 cfs. The facility has shared operation between the two districts. Table 2.4-4 summarizes PCGID's surface water supply facilities. See Attachment A for a map of PCGID's major conveyance facilities.

Table 2.4-4. PCGID Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
Sidds Landing Pump Station	Sacramento River	Pump	605	65,000
Schaad Pump Station	Sacramento River	Pump	0	0

PCGID operates five District-owned wells. Operation of these wells is coordinated with the Sacramento River pump stations to maximize flexibility and provide additional supplies during drought periods. Table 2.4-5 summarizes the District-owned groundwater wells. In addition, approximately 15 private wells are located within the District boundary. The District has no formal agreement with growers with regard to pumping private wells. Approximately 6,000 ac-ft/yr are available for pumping from the wells that are currently developed.

Table 2.4-5. PCGID Groundwater Wells

Map ID	Capacity (cfs)	Water Quality	Notes
Wright Well	4.5	Good	Little use–for an orchard only
Jones Well	8.2	Good	Drought/supplemental
Calvert Well	7.8	Good	Drought/supplemental
Tobin Well	8	Good	Drought/supplemental
Spencer Road Well*	5.6	Good	Drought/supplemental

* Well construction in progress.

2.4.5.2 Conveyance System

The District's distribution and conveyance system includes approximately 63 miles of canals and laterals, including the 15 miles of main canal from the Sacramento River diversion point.

PCGID's distribution system includes approximately 63 miles of unlined canals and main laterals. The River Branch Canal conveys water from Sidds Landing Pump Station at the northern end of the District down to the Armfield, Barnes, and four laterals in the central and southern portions of the District. The Sidds Landing Station capacity also supplies the Tobin Canal, Hart Canal, and the southern end of the River Branch Canal. Based on testing conducted in 1997, main canal seepage has been found to be approximately 20 percent. Given the proximity of the river and associated soils, seepage among the other District canals is assumed to vary from 15 to 25 percent. Table 2.4-6 summarizes PCGID's main canal and irrigation lateral features.

Table 2.4-6. PCGID Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
River Branch Canal	Sidds Landing Pumping Plant	350	No	None	25
Glenn Lateral	Sidds Landing Pumping Plant	100	No	Colusa Drain	15
Rasor Ditch Canal	River Branch Canal	60	No	Colusa Drain	15
Wood Canal	River Branch Canal	60	No	Tobin Canal	15
Armfield Canal	River Branch Canal	75	No	Tobin Canal	15
Edwards Canal	River Branch Canal	50	No	None	15
Tobin Canal	River Branch Canal	100	No	Colusa Drain	15
Commons Canal	Hart Canal	150	No	None	15
Hart Canal	River Branch Canal	200	No	Colusa Drain	15
Barnes Canal	River Branch Canal	60	No	Colusa Drain	15
Bert Nielsen Canal	River Branch Canal	150	No	Colusa Drain	15
Monolux Lateral	Hart Canal	75	No	Colusa Drain	15

2.4.5.3 Storage Facilities

PCGID currently has no storage facilities.

2.4.5.4 Spill Recovery/Outflow

PCGID has a network of unlined drainage ditches for conveying irrigation return flows. Some of the water in PCGID's drains comes from GCID via the Colusa Basin Drain; the rest is made up of internal District drainage. PCGID currently operates four drain pumps for recapturing and recirculating the water from the drains. The District has flowmeters with totalizers on each of the drain pumps, which allows them to keep records of their total drain pumpage. Approximately 25,000 ac-ft/yr are recycled from the drains within PCGID. Drains within the District generally empty into the Colusa Basin Drain, which flows south along the western boundary of the District. Table 2.4-7 summarizes PCGID's major drainage facilities.

Table 2.4-7. PCGID Drain Pump Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping Total (ac-ft/yr)
Hart Drain Pump	Hart Canal	Hart Canal	70	18,900
Spencer Drain Pump	Inter-district drains	Monolux Lateral	21	2,200
Dodge Drain Pumps	Inter-district drains	Bert Nielson Canal	29	7,300
Riz Road Pump*	Colusa Drain	Riz Lateral	35	Not known
Petty Pump	Local Drain	Wood Canal	10	2,000

* The Riz Road Pump is currently down. It will be back in operation soon. It was not used in the last couple of years.

2.4.5.5 Proposed O&M and Capital Improvements

The District has completed installation of meters on all District-owned groundwater wells and drain recapture facilities. The District is continuing to install individual field measuring devices and is currently about 50 percent complete. The cost to implement this turnout measurement program is $368,800.

2.4.6 District Operating Rules and Regulations

PCGID was formed under Chapter 11 of the California Water Code. As such, the District is subject to the rules and regulations of this code, including governing its actions through an elected Board of Directors, and is required to keep a minimum amount in financial reserves.

Water rotation, apportionment, and shortage allocation: Water orders must be made 24 hours in advance. Shutoff is also 24 hours in advance.

> According to Rule 5 of PCGID Rules and Regulations: *All requests for water service must be made in writing and must be delivered at the District's office at least three days before the water is needed. Effort will be made to make delivery in less than three days, and where possible, delivery will be made within twenty-four hours.*
>
> According to Rule 13 of PCGID Rules and Regulations: *When, through lack of water, lack of ditch capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof, the full supply of water required by the water users, such supply as can be delivered will be pro rated until such time as delivery of a full supply can be given.*

On 75 percent supply years, every landowner receives his or her proportionate share of water from all sources based upon their total assessed acres. Landowners are then able to trade or sell their allocation to another farmer within the District.

Use of drainage waters:

> *District landowner(s) are advised that drain water in the District is considered water supplied by the District, and any such water recaptured by the landowner(s) or user(s) may not be used to increase irrigated acreage.*

Policies for wasteful use of water:

> According to Rule 12 of PCGID Rules and Regulations: *Any consumer wasting water on roads, or vacant land, or land previously irrigated either willfully, carelessly, or on account of defective ditches, or who shall flood certain portions or the land to an unreasonable depth, or use an unreasonable amount of water in order to properly irrigate other portions or whose land has been improperly checked for the economical use of water or allows an unnecessary amount of water to escape from any tailgate, will be refused the use of water until such conditions are remedied.*

2.4.7 Water Measurement, Pricing, and Billing

PCGID currently serves 130 farms and has approximately 285 delivery points, with 0 delivery points serving more than 1 farm. The District currently measures flows at the main pump stations with flowmeters. District wells and all drain pumps are metered. Lateral headgate flows are measured using stage and gate position, or stage and weir geometry at flashboard turnouts. Minor increases in conveyance efficiency could be achieved by improved operations measurement, with installation of measuring facilities at intermediate points along the main canal and improved measuring at the heads of laterals. These new operations measurement facilitates would be integrated with the operations automation program described above to increase overall distribution system efficiency.

As of December 2022, PCGID measures about half of its field turnouts and anticipates measuring about 75 percent of its turnouts before the 2023 irrigation season begins. Flow rates are set to match the field demand based on the irrigation method and field conditions. The total quantity of water delivered to each turnout is determined using volume flow rate calculation via spot flow measurement with acoustic velocimeter. There are 136 measured delivery points, and 100 percent of delivered water is measured at the delivery point. The remaining 149 turnouts are scheduled for completion by the end of 2023, for measurement to begin during the 2024 irrigation season. Accuracy testing will begin when water use begins after all turnouts are completed, anticipated during the 2024 irrigation season. While the accuracy testing occurs, PCGID will investigate volumetric pricing options and coordinate with legal counsel. PCGID intends to implement volumetric pricing by 2025.

Table 2.4-8 presents an inventory of the District's water measurement devices, including the total number of turnouts that are measured using the Acoustic Doppler Velocimeter method.

Table 2.4-8. Agricultural Measurement Device Inventory for PCGID

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Propeller	14	±5%	Daily	Yearly	Yearly
Weirs	1	±10%	Daily	N/A	Yearly
Acoustic Doppler Velocimeter	136	To be determined	Daily	Calibrated at installation	Yearly
Magnetic Flowmeter	1	±5%	Continuously	Calibrated at installation	Yearly
Total	**152**				

Reclamation District No. 108

2.5 Reclamation District No. 108

2.5.1 History

Reclamation District No. 108 (RD 108 or the District) was formed in 1870 under the general Reclamation District Law of 1868 for the purpose of constructing levees to provide flood protection to over 100,000 acres of farmland along the west side of the Sacramento River from north of Colusa to Knights Landing. In the early 1900s, RD 108 was consolidated to approximately 58,000 acres to provide irrigation water service, flood control, and drainage for lands within its service area. In 1917, the District began construction of major irrigation distribution system facilities for delivery of water from the Sacramento River to approximately 48,000 acres. The District's first pumping plant was completed at Wilkins Slough in 1918 and is still the primary pumping plant for the District. Historic irrigation methods are similar to methods currently implemented, with many of the same facilities in use today that were constructed in the early 1900s. Current irrigation methods range from flood (e.g., rice) to drip (e.g., orchards and row crops) irrigation.

RD 108 entered into a negotiated agreement with Reclamation in 1964, quantifying the amount of water RD 108 could divert from the Sacramento River. The resulting negotiated agreement recognized RD 108's annual entitlement of Base Supply of 199,000 ac-ft/yr of flows from the Sacramento River and also provided for a 54,500 ac-ft allocation of Project Supply. In 1974, the District reduced its Project Supply allocation to 33,000 ac-ft with the expectation that conservation efforts including canal lining and recirculation of drainage water by the District would reduce diversion requirements from the Sacramento River. The subsequent contract entitlement is for a total of 232,000 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract and is included in Table 2.5-1.

Table 2.5-1. Schedule of Monthly Water Diversions – RD 108

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	34,000	0	34,000
May	50,500	0	50,500
June	49,000	0	49,000
July	31,500	16,000	47,500
August	16,500	15,000	31,500
September	16,000	2,000	18,000
October	1,500	0	1,500
Total	**199,000**	**33,000**	**232,000**

Notes:

Contract No. 14-06-200-876A-R-1
Points of Diversion: 43.1R, 43.3R, 51.1R, 56.4R, 59.1R, 61.05R, 61.2R, 62.3R, 63.2R, 70.4R

2.5.2 Service Area and Distribution System

The District's overall size is 58,000 acres; the service area that receives irrigation service is 48,000 acres and located within southern Colusa County and northern Yolo County along the west side of the

Sacramento River, between the towns of Grimes and Knights Landing. The service area is surrounded on three sides by flood control levees, i.e., on the east by the westerly levee of the Sacramento River, on the west and southwest by the Colusa Basin Drain (commonly referred to as the "Back Levee"), and on the southeast by the northerly levee of RD 787. RD 108 obtains its water supply from the Sacramento River under its riparian water rights and licenses for appropriation of surface waters. This water supply is supplemented when necessary by groundwater, using the District's five wells and several privately owned wells, and by diversion of water from the Colusa Basin Drain under the District's appropriative license. Approximately 140 landowners and water users grow a wide variety of crops including rice, wheat, corn, safflower, sugar beets, tomatoes, beans, vineseeds, fruits, and nuts. Rice is the predominant crop.

2.5.3 Water Supply

2.5.3.1 Surface Water

RD 108 holds a water right, primarily under 1917 and 1918 priority dates, to divert water from the natural flow of the Sacramento River. The RD 108 surface water supply entitlement was initially addressed in a contract entered into with Reclamation in 1964, Contract No. 14-06-200-0876A (Contract No. 0876A). This contract provided for an agreement between RD 108 and the United States on RD 108's diversion of water from the Sacramento River during the period April 1 through October 31 of each year. The length of this contract was 40 years and remained in effect until March 31, 2006, when it was extended an additional 40 years (Contract No. 876A-R-1). The various RD 108 water right maximum quantities and sources are summarized in Table 2.5-2.

Table 2.5-2. RD 108: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River (Locvich Pumping Plant)	S20641 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	13,000 acres
Sacramento River (Hine Pumping Plant)	S20645 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	13,000 acres
Sacramento River (North Steiner Pumping Plant)	S20649 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	13,000 acres
Sacramento River (South Steiner Pumping Plant)	S20653 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	13,000 acres
Sacramento River (Poundstone South Pumping Plant)	S20657 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	13,000 acres
Sacramento River (El Dorado Bend Pumping Plant)	S20661 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	13,000 acres
Sacramento River (Poundstone North Pumping Plant)	S20712 (Pre-1914 & riparian)	N/A	N/A	Jan 1 to Dec 31	600 acres
Sacramento River (Wilkins Slough Pumping Plant)	S20716 (Riparian)	1918	N/A	Jan 1 to Dec 31	13,000 acres

Table 2.5-2. RD 108: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	A000576 (1/25/1917)	000315 (7/24/1917)	003065 (2/24/1950)	Feb 1 to Oct 31	180
Sacramento River	A000763 (8/27/1917)	000388 (1/16/1918)	003066 (2/24/1950)	Feb 1 to Oct 31	500
Sacramento River	A001589 (12/26/1919)	001885 (11/22/1924)	003067 (2/24/1950)	May 1 to Oct 1	255.25
RD 108 Back Levee Borrow Pit (Colusa Basin Drain)	A011899 (5/26/1947)	008251 (12/20/1950)	007060 (11/06/1964)	Apr 1 to Oct 1	75
Sacramento River	A031436 (5/13/2003)	021274 (10/18/2010)	-	Nov 1 to Feb 1	240

[a] Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b] N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c] The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d] The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e] The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

The current contract provides for a maximum total of 232,000 ac-ft/yr, of which 199,000 ac-ft is considered to be Base Supply, and 33,000 ac-ft is CVP water (Project Supply), as shown in Table 2.5-3. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.5-3. RD 108: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	64,000	33,000
Non-critical Months	135,000	0
Total Annual	**199,000**	**33,000**

The contract specifies the total quantity of water that may be diverted by RD 108 each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 1,500 ac-ft in October to a maximum of 50,500 ac-ft in May. CVP water (Project Supply) is available during the months of July, August, and September with entitlements of 16,000, 15,000, and 2,000 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 64,000 ac-ft, and the total Project Supply is 33,000 ac-ft. There are no restrictions on the District’s water sources nor water quality concerns.

Non-contract Period (November – March)

Contract No. 0876A does not limit RD 108 from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. RD 108 also has riparian water rights to the Sacramento River, which allow for diversion during the entire water year (October through September). RD 108 has historically irrigated in months prior to April (pre-irrigation), especially for tomatoes and grain crops. With the phase-out of rice straw burning over the past several years, there has been an increased interest by rice growers in fall and winter flooding of rice fields to enhance decomposition of rice straw and stubble. An average of 12,000 acres were flooded each of the past 6 years.

The District received a permit on October 30, 2010, from SWRCB to divert up to 36,000 ac-ft of water from the Sacramento River at the Wilkins Slough Pumping Plant and the Emery Poundstone Pumping Plant during the winter months, from November 1 to February 1. The purpose of the permit is to supplement existing riparian rights for rice straw decomposition and waterfowl habitat.

Other Surface Water Sources

No creeks or other surface water sources other than the Sacramento River and the Colusa Basin Drain are available to RD 108. However, RD 108 is currently investing in the Sites Reservoir Project at a level of approximately 4,000 ac-ft, based on average annual yields.

2.5.3.2 Groundwater/Conjunctive Use

Irrigation water requirements are met through the contract surface water supply, although groundwater is used by a few individual growers to supplement the surface supply, particularly in dry years. Approximately 12 privately owned wells and 5 District-owned wells are located within the District's boundaries. During some dry years or peak demand periods, RD 108 uses groundwater to increase system flexibility and responsiveness to grower water needs (i.e., increase speed of water deliveries). The District's five groundwater wells have a total capacity of approximately 49 cfs. Annual District well groundwater pumping amounts range from 10,000 to 0 ac-ft depending on year type.

Intentional groundwater recharge is not currently practiced in the District. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from water conveyance and irrigation application practices. The District is not involved in any active groundwater banking program.

DWR monitors only one well in the region; although, historically (from the 1940s through the late 1970s), four additional wells have been monitored. The District began monitoring groundwater levels in its production wells in 2014. Examination of data from them, the DWR well, and additional monitoring wells within 2 miles of the RD 108 boundary indicates that during years of normal precipitation, groundwater levels in the unconfined portion of the aquifer fluctuate between 2 and 5 feet seasonally; while during drought years, groundwater levels have been shown to fluctuate up to 13 feet (DWR, 2003b). Groundwater levels in the confined portion of the aquifer system fluctuate between 8 and 35 feet during years of normal precipitation, and up to 40 feet under drought conditions. Historical trends show that groundwater levels in the RD 108 area are generally stable over the long term, although short-term fluctuations in groundwater levels are observed that can be correlated with precipitation trends.

Groundwater Subbasin Conditions

RD 108 lies within the southern portion of the Colusa Subbasin. The area is located on recent alluvial sediments: channel, floodplain, basin, and alluvial deposits. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeability. Stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeability. Underlying these recent fluvial deposits are the Tehama and Tuscan Formations (DWR 1978; DWR, 2003c).

Although the Tehama Formation is mostly fine-grained, it contains sufficient sand and gravel zones in many areas to provide large quantities of groundwater. In the northern portion of the Colusa Subbasin, the Tehama Formation contains extensive deposits of interbedded gravel from the ancestral Stony Creek (the Stony Creek Member). The Stony Creek Member of the Tehama Formation is typically very productive, yielding a large quantity of water to wells. In the central and southern portion of the Colusa Subbasin, between Willows and Williams, the Tehama Formation is predominately clayey, and wells in this area are generally less productive than those in the northern portion of the subbasin (DWR, 1978).

The Tuscan Formation is an important water-bearing unit in the northeastern portion of the Sacramento Valley (DWR, 2003a). Deposited during the same period as the Tehama Formation, the Tuscan Formation consists of interbedded volcanic deposits (DWR, 1978). The unit grades from tuff breccias along the eastern margin of the Sacramento Valley to volcanic sands, gravels, and clays to the west. In the Colusa Subbasin, the Tuscan Formations is found at approximate depths of 300 to 1,000 feet bgs, where it interfingers with the Tehama Formation (DWR, 2003a). Volcanic sands and gravels can provide high yields to domestic and irrigation wells; however, the unit is generally too deep to be tapped by wells west of Chico (DWR, 1978).

Groundwater quality in the Sacramento Groundwater Basin is generally good and sufficient for agricultural, domestic, and M&I uses. In general, natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges because of the presence of marine sediments in the Coast Range. The total depth of fresh water in RD 108 is approximately 1,200 feet bgs (Berkstresser, 1973). The fresh water is underlain by saline water.

Throughout RD 108, groundwater movement is generally to the southeast, toward the Sacramento River. In the northern portion of the District, the gradient is slightly greater than 2 feet per mile. In the southern portion of the District, the gradient is less than 2 feet per mile (DWR, 2003c).

Groundwater Planning/Sustainable Groundwater Management Act

Given the District is located in both Colusa and Yolo Counties, RD 108 is a member of both the Colusa Groundwater Authority and the Yolo Subbasin Groundwater Agency. The District is currently participating in both the Colusa and the Yolo Subbasins GSPs. These plans are scheduled to be completed by January 31, 2022. The District does not participate in groundwater banking.

2.5.3.3 Other Water Supplies

In recent years, RD 108 has relied heavily on tailwater and reuse/recirculation to supplement its Sacramento River entitlement. The Colusa Basin Drain has been the primary source of tailwater, as this canal flows along the western edge of the District. However, the tailwater supply from the Colusa Basin Drain is primarily used as an alternative supply. RD 108 holds a permit to pump 75 cfs from the Colusa Basin Drain (RD 108 Back Levee Borrow Pit).

Typically, the lock-up period was an 8- to 10-week period, approximately from May 1 to early July. Approximately 60,000 ac-ft were recycled annually during the lock-up program.

2.5.4 114BWater Use

Water use within the District is predominantly agricultural as the District does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.5.4.1 Agricultural

Rice is the predominant crop grown within RD 108's service area. Other key crops include tomatoes, walnuts, sunflowers, alfalfa, wheat, and vine seed. Rice accounts for approximately two thirds (67 percent) of the District's irrigated acreage on an annual basis. Water requirements are typically highest during May through early August due to the requirements of rice and the area's hot, dry climate. Water demands for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields and re-flooding, as well as meeting the needs of other crops.

Annual cropping patterns have remained fairly constant over the last few decades. Related water requirement needs and associated diversions have been more a function of water-year type and climate than changes in cropping. As discussed above under water supply, the District also uses water in the non-irrigation season to enhance decomposition of rice straw and stubble. Approximately 12,000 acres were flooded during each of the past 6 years. Given the District's relatively rural location, District lands are anticipated to remain in agricultural production for the foreseeable future. Future irrigation season cropping patterns and associated water requirements are anticipated to remain relatively the same as current conditions.

2.5.4.2 Urban

RD 108 does not currently serve water to any municipal or industrial users, and while they do not preclude it from happening in the future, it is not anticipated at this time.

2.5.4.3 Environmental/Natural and Cultural Resources

Approximately 100 acres of riparian vegetation are estimated to be incidentally supplied by irrigation, including vegetation directly adjacent to delivery laterals or influenced by leakage from the delivery system. Such vegetation includes habitat used by the federally listed giant garter snake. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas.

As described above, up to 12,000 acres of rice stubble have been flooded in the past, with associated winter habitat benefits to migratory waterfowl that use the area as part of the Pacific Flyway. This practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture. The District continues to work with Yolo County Resource Conservation District and Reclamation on a demonstration program of planting native vegetation along the District's irrigation and drainage canals to prevent erosion of levee slopes, to improve water quality, and to enhance wildlife habitat. No managed designated environmental or wetlands areas are within the District. There are also no managed recreational areas within the District (waterfowl hunting occurs on a limited basis on private lands within District boundaries).

2.5.4.4 Topography and Soils

The District's topography generally consists of nearly level to gently sloping terrain. Because the District has relatively high groundwater levels and primarily silty clay soils, seepage occurs into several canals and ditches. This makes lining of open canals and ditches difficult due to pressure exerted from groundwater. There are no agricultural limitations resulting from soil problems.

Soil associations for the Yolo County area and soil profile characteristics for the Colusa County area of the District are listed below. The total acreage for the individual soil associations and soil profiles within the District is shown in the General Soils Map and Profile Characteristic Map provided in the NRCS Soil Survey for Yolo and Colusa Counties.

Soil associations in the Yolo County area of RD 108 are as follows (Attachment I):

- Sycamore-Tyndall: Somewhat poorly drained, nearly level, very fine sandy loams to silty clay loams on alluvial fans.
- Sacramento: Poorly drained, nearly level silty clay loams and clays in basins.
- Capay-Sacramento: Moderately well-drained to poorly drained, nearly level, silty clay loams to clays in basins.

Soil profile characteristics in the Colusa County area of RD 108 are as follows (Attachment I):

- Young alluvial fan and basin soils with moderately compacted subsoils.
- Recent alluvial fan and floodplain soils with deep permeable profiles.
- Older alluvial fan and basin soils with moderately compacted subsoils.

Predominately clay soils located in the south, west, and central portions of the District are primarily used for rice production, while lands closer to the river support orchards and row crops. There are no impacts from any microclimates on water management within the District.

2.5.4.5 Transfers and Exchanges

RD 108 has a 5-year transfer agreement with Dunnigan Water District and Colusa County Water District. This agreement transfers 10,000 ac-ft (8,000 ac-ft to Colusa County Water District, 2,000 ac-ft to Dunnigan Water District) to help those districts have more water reliability and reduce groundwater pumping in them. There are no other wheeling or other transactions in and/or out of the District boundaries.

2.5.4.6 Other Uses

No other significant water uses other than those discussed above occur within RD 108.

2.5.5 District Facilities

RD 108 uses an arranged schedule to deliver irrigation water to District customers. RD 108 owns and operates an irrigation system that includes 11 pumping plants, 7 of which are located along the Sacramento River (Attachment A). Irrigation canals totaling about 120 miles convey the river water to farms within the District's service area. The District also owns and operates a drainage system used for removing drainage water and winter storm runoff. Because the District has no natural drainage outlet, excess drainage water and rainfall runoff, which accumulate in over 300 miles of District drains, are channeled to the Rough and Ready Pumping Plant (850-cfs capacity) near the southeast corner of the District where the water is pumped into the Sacramento River for use downstream. The Riggs Pumping

Plant on the northwest side of the District, adjacent to the Colusa Basin Drain, is a multipurpose facility. Drainage of water from the north can be discharged into the Colusa Basin Drain or pumped into the irrigation canal system for reuse. The plant is also used to divert water from the Colusa Basin Drain for irrigation of District lands as a supplemental supply.

Because a large portion of RD 108 lies within an area of relatively little slope, the District has a unique capability of recirculating drainage water so that no drainage is pumped into the Sacramento River. This "lock-up" capability allows the District to control rice-pesticide-contaminated water within its drainage and irrigation systems for the prescribed holding period, thereby permitting early release of pesticide water from rice fields. In addition, RD 108 has recirculated a certain amount of drainage water beyond the normal 2-month lock-up period as a water management practice. However, after about 15 years of water reuse during the peak irrigation season, it was found that continued recycling of drainage water created a detrimental effect on crop production within certain areas of the District caused by the build-up of salts in the soil. As a result, in 1997, RD 108 suspended the lock-up program and has curtailed its recirculation of drainage water.

The District is responsible for maintaining the integrity of the Back Levee, the primary flood control feature along the eastern side of the Colusa Basin Drain. The levee on the west bank of the Sacramento River is maintained by the Sacramento River West Side Levee District, a sister district to RD 108. Flood maintenance involves patrolling the levee and making repairs as necessary during high water condition, which have occurred in 3 of the last 5 years, in the Colusa Basin Drain. More substantial repairs were subsequently made by the U.S. Army Corps of Engineers.

RD 108 staff currently operate the Wallace Weir facility on the Knight's Landing Ridge Cut, which prevents salmon and steelhead from straying up the Ridge Cut to the Colusa Basin Drain. RD 108 staff will also operate the Knight's Landing Outfall Gate (KLOG) structure when repairs on it are complete. The KLOG also prevents salmon and steelhead from straying up the Colusa Basin Drain.

The District operates a 386 kW solar facility located at the south end of the District, which is tied to Sycamore Slough Pumping Plant through a PG&E NEMA agreement. The plant was installed and became operational in 2010.

2.5.5.1 Diversion Facilities

RD 108's primary water supply facilities include five pumping plants along the Sacramento River for diversion of water. The largest of these is the Wilkins Slough Pumping Plant and Fish Screen Structure near the northeast boundary of the District, which supplies the Wilkins Slough Main Canal. The District completed the new 300-cfs Emery Poundstone Pumping Plant and Fish Screen facility in 2007, which replaced the Boyer's Bend, Howell's Landing, and Tyndall Mound pump stations. Table 2.5-4 summarizes RD 108's surface water supply facilities. See Attachment A for a map of RD 108's major conveyance facilities.

Table 2.5-4. RD 108 Surface Water Pumping Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
Wilkins Slough Pumping Plant	Sacramento River	Pump/gravity	830	95,000
Emery Poundstone Pumping Plant	Sacramento River	Pump/gravity	300	38,900*
Steiner Bend – N Pump Station	Sacramento River	Pump	8	350

Table 2.5-4. RD 108 Surface Water Pumping Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
North Poundstone	Sacramento River	Pump	10	1,400
El Dorado Bend Pump Station	Sacramento River	Pump/gravity	80	6,400

* Sum of historical diversions of the three pumping plants replaced.

2.5.5.2 Conveyance System

RD 108's distribution and conveyance system includes approximately 84 miles of earthen canals and 35 miles of concrete-lined canals. The Wilkins Slough Main Canal serves laterals in the northern and western portions of the District and is supplied from the Wilkins Slough Pumping Plant. Irrigation Canals 12, 13, and 15 serve the central portion with water from the Emery Poundstone Pumping Plant. Irrigation Canal 14 serves the western and southern boundary of the District and is supplied from the El Dorado Bend Pump Station. Several of these canals can also be supplied by the District's drain recapture pumps, as described below. Table 2.5-5 summarizes RD 108's primary distribution facilities.

Table 2.5-5. RD 108 Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Wilkins Slough Main Canal	Wilkins Slough Pumping Plant	800	Earth	None	*
Irrigation Canals No. 12, 13, and 15	Emery Poundstone	300	Concrete	Main Drainage Canal	*
Irrigation Canal No. 14	El Dorado Pumping Plant	300	Earth	Main Drainage Canal	*
Irrigation Canal – Lateral 7J Canal	New Steiner Bend Pumping Plant	30	Earth	7J Drain	
Irrigation Canal No. 10P	Riggs Ranch Drain Pump	200	Earth	Main Drainage Canal	*

* Varies. See District deep percolation studies.

In 1997, RD 108 began upgrading and automating major supply and canal control facilities. Currently, all of the District's facilities are linked via a centralized SCADA system. The District is continuing this program with the goal of automating major canal and lateral control structures. Operational spills are currently at the lower practical amount for an open-channel irrigation system, and further significant reductions are limited. Conveyance system automation, when essentially completed over the next few years, will be fully developed as a management option for RD 108 and does not offer significant potential for new water conservation.

2.5.5.3 Storage Facilities

As noted previously, RD 108 has the ability to retain its drainage for reuse. This resulted in average annual savings of 57,200 ac-ft in the past 6 years (2014 through 2019). Water quality is monitored to ensure crop thresholds are not exceeded and to prevent the deposition of salts in the soils.

2.5.5.4 Spill Recovery/Outflow

RD 108 has an extensive network of drainage facilities, including over 300 miles of drains that serve 72,000 acres including land outside of the District, and five major drain pump stations for removal or reuse of irrigation return flows and winter stormwater runoff. Because of the topography and the surrounding levees, drainage must be pumped out of the District. The drainage is generally conveyed to the southeast corner of the District where the Rough and Ready, El Dorado Bend, and Sycamore Slough pumping plants are used to convey the drainage either through the flood control levees and into the Sacramento River or back into the distribution laterals for reuse. Sycamore Slough lifts drainage water into Lateral 14A, which conveys water to El Dorado for removal or to the irrigation system for reuse. The Riggs Ranch Pumping Plant conveys drainage from the northern portion of the District into either the Colusa Basin Drain or back into the supply conveyance system (Irrigation Canal 10P) for reuse. The Lateral 8 Pumping Plant lifts drainage water into Wilkins Slough Main Canal for reuse. The Rough and Ready Drain Pump Station is not used for irrigation (shown on RD 108 map in Attachment A). The pump discharges regional drainage into the Sacramento River when a gravity discharge is prevented by a high river stage. Tables 2.5-6 and 2.5-7 summarize the main RD 108 drainage facilities.

Table 2.5-6. RD 108 Drain Pump and Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping Total (ac-ft/yr)
Sycamore Slough	Main Drainage Canal	Irrigation Canal 14	220	31,000
Riggs Ranch	Drain No. 9	Irrigation Canal 10P/Colusa Basin Drainage Canal	70	9,000
Lateral 8	Drain No. 8	Wilkins Slough Main Canal	180	20,000

Table 2.5-7. RD 108 Drainage Laterals

Name	End Spill	Downstream Diverters/Recapture
Main Drainage Canal	Rough and Ready Drain Pump/Sycamore Slough Drain Pump	No
Drain No. 8	Main Drainage Canal	No
Drain No. 9	Main Drainage Canal	No

2.5.5.5 Proposed O&M and Capital Improvements

The District is currently in the process of completing a project that leverages both federal and State Water Use Efficiency grant funds. The project installed a pipeline from the County Line Road Groundwater Well to the 15D Canal in 2019 and will install up to 27 automated gates in supply laterals throughout the District. It is also scheduled to put in a pipeline at Steiner Bend that will serve the area currently served by the North Steiner Pumping Plant and includes added pumping capacity at New Steiner Pumping Plant.

Future improvements include the following:

- Possible expansion of the Sycamore Slough Solar Plant and addition of battery energy storage
- Installation of in-canal low-flow hydropower
- Installation of more automated gates
- Installation of groundwater wells
- Groundwater storage bank development and groundwater recharge projects
- Possible recirculation pumping plant at Howell's Point
- Steiner Bend Pipeline extension
- SCADA system upgrades

2.5.6 District Operating Rules and Regulations

RD 108, pursuant to Section 50911 (a) of the Water Code of the State of California, has produced rules and regulations covering the distribution of water within their District. The headings of the 22 rules and regulations that RD 108 adopted on November 8, 1989, are as follows: control of system, employees, distribution of water, applications for water, charges for water, time of payment, shortage of water, waste of water, measurement of water, determination of acreage irrigated, access to land, control of regulation structures, condition of private ditches, delivery gates or turnouts, responsibility of the District, liability of irrigators, encroachments, abatement of nuisance, drainage water from sources outside the District system, enforcement of rules, complaints, and amendments and other changes.

Water rotation, apportionment, and shortage allocation:

> Water is ordered 24 hours prior to necessary delivery date. Rule 7 of RD-108 Rules and Regulations states: *Whenever a general shortage of water appears imminent, the Board of Trustees shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary, local or similar shortages, the Manager is authorized to place in effect such variations in service as in his judgement* [sic] *the occasions requires.*

Use of drainage waters:

> Rule 19 of RD 108 Rules and Regulations states: *A charge will be made to cover the cost of conveying and disposing of drainage water from each tract of land situated outside the District. This charge shall be established annually by the Board of Trustees*

Policies for wasteful use of water:

> Rule 8 of RD 108 Rules and Regulations states: *Any water user who deliberately, carelessly or otherwise wastes water on roads, vacant land or land previously irrigated or who floods certain portions of the land to an unreasonable depth or who uses an unreasonable amount of water in order to irrigate properly other portions or who irrigates land which has been improperly checked for the economical use of water or who allows an unnecessary amount of water to escape from any field will be refused the use of water until such conditions are remedied or will have his use curtailed by the amount of waste, as the Manager may determine.*
>
> *The District reserves the right to refuse delivery of water to any lands when it appears to the satisfaction of the Manager that its proposed use or method of use would require such excessive quantities of water as would constitute waste.*

2.5.7 Water Measurement, Pricing, and Billing

Reclamation currently measures water at each of the seven Sacramento River pump stations using flowmeters. RD 108 measures the Rough & Ready Drain Pump using pump curves. Flows in canals and laterals are measured using head measurements at gates and weirs. Some improvement in water measurement could be achieved along main canals and laterals with the installation of low-headloss flow measurement devices.

RD 108 currently serves 438 farms and has approximately 620 delivery points, with 19 delivery points serving more than 1 farm. The District measures flow rate at turnouts using methods listed below. Flow rates are set to match the field demand based on the irrigation method and field conditions. The total quantity of water delivered to each turnout is determined using volume flow rate calculation via spot flow measurement with acoustic velocimeter or accumulation on magnetic flowmeter. Information on the accuracy of the turnout measurement system is included in Attachment C. Table 2.5-8 presents an inventory of the District's water measurement devices, Including those used at diversion and reuse stations.

Table 2.5-8. Agricultural Measurement Device Inventory for RD 108

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Propeller	8	±5%	Continuously	Maintained yearly by Reclamation	
Acoustic Doppler Velocimeter	469	±4.6%	Daily	Calibrated at installation	Yearly
Magnetic Flowmeter	151	±5%	Continuously	Calibrated at installation	Yearly
Ultrasonic – Pipe	3	±5%	Continuously	Calibrated at installation	Yearly
Rubicon Overshot Leaf Gate	17	±5%	Continuously	Calibrated at installation	Yearly
Total	**648**				

Water pricing and billing is set up with two components, the first is a per-acre irrigated charge of $10/acre (2020 prices) that is due when water is ordered in March. The second component is based on per ac-ft as measured, with a price of $15/ac-ft (2020 price). The actual volumes used are invoiced in July, for "to date use" and November, for remaining total. Year 2020 is the first year using this system, which replaced a three-tier system that was used from 2016 through 2019 and resulted in the first water rate increase in those 4 years.

Reclamation District No. 1004 (RD 1004)

2.6 Reclamation District No. 1004

2.6.1 History

Reclamation District No. 1004 (RD 1004 or the District) was formed in 1912 and entered into a negotiated agreement with Reclamation in 1964, quantifying the amount of water RD 1004 could divert from the Sacramento River. The resulting negotiated agreement recognized RD 1004's annual entitlement of a Base Supply of 56,400 ac-ft/yr of flows from the Sacramento River and also provided for a 15,000 ac-ft allocation of Project Supply, resulting in a total contract entitlement of 71,400 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract and are included in Table 2.6-1 for RD 1004. RD 1004 subsequently worked with Reclamation and counsel to finalize a new 40-year contract in 2005 maintaining the District's 56,400 ac-ft of Base Supply and 15,000 ac-ft of Project Supply.

Table 2.6-1. Schedule of Monthly Water Diversions – RD 1004

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	6,300	0	6,300
May	14,700	0	14,700
June	12,200	0	12,200
July	6,100	600	12,100
August	3,600	8,400	12,000
September	8,200	600	8,800
October	5,300	0	5,300
Total	**56,400**	**15,000**	**71,400**

Notes:

Contract No. 14-060-200-890A-R-1
Points of Diversion: 84.28L, 85.3L, 89.12R, 111.8L

2.6.2 Service Area and Distribution System

RD 1004 is located on the east side of the Sacramento River approximately 2 miles east of the town of Colusa and directly west of the Sutter Buttes. The District is primarily in Colusa County, with the southeasternmost portion extending into Sutter County and the extreme northern portion in Glenn County. Butte Creek runs along a portion of the eastern edge of RD 1004. The District's service area encompasses approximately 22,000 acres, ___ of which are irrigated, and includes 44 landowners. Rice is the predominant crop grown within the District.

2.6.3 Water Supply

RD 1004 holds water rights to divert water from the natural flow of the Sacramento River, Butte Creek, and the Butte Slough. These diversions differ in the quantity and timing in which they can be used, as indicated in Table 2.6-2.

Table 2.6-2. RD 1004: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantitye (cfs)
Sacramento River	A000027 (4/2/15)	000031 (11/1/15)	003165 (4/30/51)	About Apr 1 to About Oct 15	166 cfs 56,000 ac-ft/yr
Sacramento River	S020164 (Pre-1914)	N/A	N/A		
Unnamed Drain to Butte Creek	S020165 (Riparian and pre-1914)	N/A	N/A		
Butte Creek, Sacramento River	S020166 (Riparian and pre-1914)	N/A	N/A		
Sacramento River	S020167 (Pre-1914)	N/A	N/A		
Butte Creek	S020168 (Riparian and pre-1914)	N/A	N/A		
Butte Slough	S020169 (Riparian and pre-1914)	N/A	N/A		
Sacramento River	S020170 (Riparian and pre-1914)	N/A	N/A		
Unnamed Drain to Butte Creek	S020172 (Riparian and pre-1914)	N/A	N/A		
Butte Slough, Butte Creek, and Unnamed Drain	A023201 (12/26/68)	016771 (10/27/75)	Pending	Apr 1 to Jun 15, Sep 1 to Sep 15, and Sep 15 to Jan 31 (for recreation purposes)	110 cfs 15,000 ac-ft (irrigation) 140 cfs 21,000 ac-ft (recreation)

[a]Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b]N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c]The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d]The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e]The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

2.6.3.1 Surface Water

As identified above, the RD 1004 surface water supply entitlement is currently addressed in a contract entered into with Reclamation in 1964, Contract No. 14-06-200-0890A (Contract No. 0890A). This contract provides for an agreement between RD 1004 and the United States on RD 1004's diversion of water from the Sacramento River during the period April 1 through October 31 of each year.

Contract No. 0890A provides for a maximum total of 71,400 ac-ft/yr, of which 56,400 ac-ft is considered to be Base Supply and 15,000 ac-ft is CVP water (Project Supply), as shown in Table 2.6-3. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.6-3. RD 1004: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	17,900	15,000
Non-critical Months	38,500	0
Total Annual	**56,400**	**15,000**

The contract specifies the total quantity of water that may be diverted by RD 1004 each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 3,600 ac-ft in August to a maximum of 14,700 ac-ft in May. CVP water (Project Supply) is available during the months of July, August, and September with entitlements of 6,000, 8,400, and 600 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 17,900 ac-ft, and the total Project Supply is 15,000 ac-ft, as shown in Table 2.6-3. There are no restrictions on the District's water sources.

Non-contract Period (November – March)

In addition to the contract water, RD 1004 has filed and was granted a water right permit for non-contract-period diversions for wetlands and rice straw decomposition. Also, RD 1004 holds several Statements of Water Diversion and Use for riparian and pre-1914 claims for diversions during the non-contract period. The quantities of diversions in the recent past for non-contract periods have been approximately 10,000 to 15,000 ac-ft.

Other Surface Water Sources

Butte Creek is located along the eastern edge of the RD 1004 service area, and Butte Slough is located on the southeastern edge. RD 1004 has established water rights to both Butte Creek and Butte Slough, and has a permit and Statements of Water Diversion and Use to divert water from these sources, as shown in Table 2.6-2.

2.6.3.2 Groundwater/Conjunctive Use

Intentional groundwater recharge is not currently practiced in the District. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from conveyance losses and irrigation application practices. Amounts of groundwater pumped and delivered range from 0 to 2,000 ac-ft annually.

Groundwater Subbasin Conditions

The RD 1004 boundary overlies the Butte Subbasin (DWR groundwater basin number 5-21.70) of the Sacramento Valley Groundwater Basin, and therefore within RD 1004, occurs in a broad alluvial basin and is therefore not confined to any well-defined subsurface stream channels. RD 1004 is located on recent alluvial sediments: channel, floodplain, basin, and alluvial fan deposits. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities. Alluvial fan and stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeabilities. These recent sediments are underlain by older deposits of the Tehama and Tuscan Formations (DWR, 2003c).

Beneath the fluvial deposits are the Tehama and Tuscan Formations. In the Butte Subbasin, the Tehama Formation is composed of silts, gravels, sands, and clays deposited by streams draining the Coast Ranges. Although the Tehama Formation is mostly fine-grained, it contains sufficient sand and gravel zones in many areas to provide large quantities of groundwater. Interfingering with the Tehama Formation are the volcanic deposits of the Tuscan Formation. In the vicinity of RD 1004, this unit consists of volcanic sands and gravels as well as layers of finer grained materials such as tuffaceous silts and clays. Maximum thickness of these deposits is approximately 2,500 feet near the western boundary of the District (DWR, 2003c; DWR, 1978; Page, 1980). The most productive aquifers in RD 1004 are associated with the Tehama and Tuscan Formations.

Groundwater quality in the Sacramento Groundwater Basin is generally good and sufficient for agricultural, domestic, and M&I uses. In general, natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges because of the presence of marine sediments in the Coast Range. The total depth of fresh water in RD 1004 is 500 to 1,400 feet bgs (Berkstresser, 1973). The fresh water is underlain by saline water.

In the northern portion of RD 1004, groundwater movement is generally to the south/southeast, away from the Sacramento River. In the southern portion of the District, flow direction is more southerly. The overall gradient of groundwater movement in RD 1004 is approximately 2.3 feet per mile (DWR, 2003c). Seasonal fluctuations in groundwater level are minimal and generally less than about 10 feet, but can be up to 18 feet in drought years (DWR, 2003b). Wells located near recharge sources typically show less of an annual change in groundwater levels.

Past pumping and drought conditions have not historically negatively affected the overall long-term groundwater level trends in RD 1004. Based on the water level information of eight wells in the RD 1004 area that date back to the 1950s, there has been little significant change in groundwater levels over time (DWR, 2003b). Groundwater level data since 1980 from over 2,300 wells in the Sacramento Valley were reviewed, and the historical trends show that groundwater levels near the RD 1004 area are generally stable over the long term, although short-term fluctuations in groundwater levels are observed that can be correlated with precipitation trends.

Groundwater Planning/Sustainable Groundwater Management Act

RD 1004 formed Reclamation District No. 1004 GSA - Butte 1 as an exclusive GSA, and signed a resolution to develop, adopt, and implement a GSP for the Butte Subbasin as outlined in the SGMA. The GSP will be available for review and public comment in mid-2021 and finalized by 2022.

2.6.3.3 Other Water Supplies

RD 1004 currently uses an average tailwater amount of 20,000 ac-ft/year. The District relies heavily on recaptured tailwater to supplement other water sources. During the regular irrigation season, drains are ponded to allow pumping, and essentially no water flows out from the drains.

2.6.4 Water Use

Water use within the District is predominantly agricultural as the District does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.6.4.1 Agricultural

Land use within RD 1004's service area is primarily rice, due to the presence of fine-textured and poorly drained soils within the majority of the District. Rice accounts for over 80 percent of the District's irrigated acreage on an annual basis (DWR, Northern District). Water requirements are typically highest during the summer months (July and August) due to the requirements of rice and the area's hot, dry climate. Cultural practice water needs for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields. Although surface water is the primary source of irrigation water, groundwater is used in drought years on an individual grower basis and as per agreements with the District. Historic irrigation methods including flood irrigation for rice are still used but now include more focused drip irrigation for some orchards. Many of the facilities originally constructed by the District are in use today. There are no anticipated land use changes.

Annual cropping patterns have remained fairly constant over the last few decades, other than in response to farm programs in the early 1980s. Associated water requirement needs and associated diversions have therefore been more a function of water-year type and climate than changes in cropping.

In response to increasingly stringent limitations on burning, many of the District's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. Approximately 12,000 acres have been flooded in the past; this practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture.

Future irrigation season cropping patterns and associated water requirements are anticipated to remain relatively the same as current conditions.

2.6.4.2 Urban

RD 1004 does not provide water service for either municipal or industrial use. M&I water demand within the vicinity of the District is anticipated to increase only slightly, with additional annual water requirements in the year 2020 expected to increase by less than 100 ac-ft compared to 1995 estimated levels (DWR, Northern District). Future M&I water requirements are assumed to be met by groundwater supplies. Although it is considered unlikely, RD 1004 could provide M&I water, but current estimates of future M&I demand are minimal.

2.6.4.3 Environmental/Natural and Cultural Resources

Approximately 35 acres of riparian vegetation are estimated to be incidentally supplied by irrigation, including vegetation directly adjacent to delivery laterals or influenced by leakage from the delivery system. Such vegetation includes elderberry shrubs, which provide habitat for the federally listed valley elderberry longhorn beetle, and habitat used by the giant garter snake. No other natural resources are located within the District, and the District does not manage any natural resources.

There are no known cultural resources or structures on the National Register of Historic Places within the District.

2.6.4.4 Topography and Soils

The District's topography generally consists of nearly level to gently sloping terrain. Because the District is relatively flat, the impact of the area's terrain on District water management practices is negligible. There are no impacts from any microclimates on water management within the District.

Soil associations for the Sutter County area and soil profile characteristics for the Colusa County area of the District are listed below. The total acreage for the individual soil associations and soil profiles within the District is shown in the General Soils Map and Profile Characteristic Map provided in the NRCS Soil Survey for Sutter and Colusa Counties. There are no agricultural limitations resulting from soil problems within the District.

Soil associations in the Sutter County area of RD 1004 are as follows (Attachment I):

- **Zamora-Marvin:** Well-drained to somewhat poorly drained silt to silty clay loam, moderately fine-textured and fine-textured soils on floodplains.
- **Clear Lake-Capay:** Deep and very deep, level to nearly level, poorly drained and moderately well-drained clay and silty clay in basins and on basin rims.
- **Shanghai-Nueva-Columbia:** Very deep, level to nearly level, somewhat poorly drained silt loam, loam, and fine sandy loam on floodplains.

Soil profile characteristics in the Colusa County area of RD 1004 are as follows (Attachment I):

- Young alluvial fan and basin soils with moderately compacted subsoils.
- Recent alluvial fan and floodplain soils with deep permeable profiles.
- Older alluvial fan and basin soils with moderately compacted subsoils.

2.6.4.5 Transfers and Exchanges

RD 1004 has no standing long-term water transfer agreements but has participated in short-term 1-year water transfers during drier years. RD 1004 is limited in its ability to participate in water transfers due to District policies that prohibit participation during Shasta Critical years. As recently as 2020, the District has participated in a groundwater substitution transfer, pumping approximately 1,700 ac-ft of groundwater. It is estimated that any future transfer will be of similar quantities.

2.6.4.6 Other Uses

No other water uses other than those discussed above occur within RD 1004.

2.6.5 District Facilities

2.6.5.1 Diversion Facilities

RD 1004's primary water supply facility is a surface water diversion on the Sacramento River northeast of the town of Princeton. The RD 1004 Pump Station and flat plate fish screen structure has an approximate capacity of 360 cfs. The eastern portion of the District is also served by the White Mallard Diversion, located on Butte Creek. Table 2.6-4 summarizes RD 1004's primary surface water supply facilities. See Attachment A for a map of the RD 1004 major conveyance facilities. The District owns three wells that are used primarily in drought years and are not significant water sources. There are private wells owned and operated by growers, independent of District operations.

2.6.5.2 Conveyance System.

The District's distribution and conveyance system includes approximately 50 miles of canals and laterals. Several other main canals are located throughout the District and generally flow from north to south. These additional canals include the Frog Pond Canal, the Morgan Levee Canal, and the White Mallard Canal. Major laterals include the Terril Highline Lateral, the District Borrow Pit Lateral, and Avis Channel. Table 2.6-5 summarizes the District's primary distribution facilities. Leakage associated with the operation of the main canal is typically in the range of 15 percent (percentage of diversion water that seeps through the canal wall, and as a result, is unavailable for conveyance).

Table 2.6-4. RD 1004 Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
RD 1004 Pump Station at River Mile 112.1	Sacramento River	Pump	360	49,000
White Mallard Dam/Gravity Surface Diversion	Butte Creek	Gravity	80	3,300
Five Points	Butte Creek	Pump	50	1,900
Butte Creek Farms	Sacramento River	Pump	30	3,000
Butte Creek Farms	Sacramento River	Pump	30	0
Butte Creek Farms	Butte Creek	Pump	30	1800
Rancho Caleta West	Butte Creek	Pump	10	1300
Rancho Caleta East	Butte Creek	Pump	10	2044
Rancho Caleta	Sacramento River	Pump	15	307

Table 2.6-5. RD 1004 Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Terril Highline	Drumheller Slough	110	No	East Levee Drain	5
Main Canal	RD 1004 Pump Station	360	Partial (1,300 feet)	5-Points Drain	7
White Mallard Canal	White Mallard Diversion Dam	180	No	5-Points Drain	5
Avis Channel	Main Canal	95	No	East Levee Drain	5
Morgan Levee Canal	District Borrow Pit	80	No	Frog Pond Drain	5
Frog Pond Canal	Main Canal	80	No	Frog Pond Drain	5
Boat Canal	Main Canal	100	No	Butte Creek Drain	5
District Borrow Pit Lateral	Felly Pumps No. 119 and No. 120	90	No	5-Points Drain	5

2.6.5.3 Storage Facilities

RD 1004 currently has no storage facilities.

2.6.5.4 Spill Recovery/Outflow

RD 1004 has a network of unlined drainage ditches for conveying irrigation return flows. The East Levee Drain accommodates a majority of the drainage in the eastern portion of the District. The East Levee Drain discharges into Butte Creek via the 5-Points Drain Pump and drain lateral. Several major drain laterals and six drain pump stations are also located in the southern portion of the District. Drainage flows in this portion of the District are pumped to the Sacramento River via the three drain pump stations. In addition, the District operates six pumping plants that recapture return flows within the District. Tables 2.6-6 and 2.6-7 summarize the main drainage facilities within RD 1004.

Table 2.6-6. RD 1004 Drain Pump Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping Total (ac-ft/yr)
5-Points Drain Pump	East Levee Drain	5-Points Drain to Butte Creek	30	2,000
Pole Line No. 107	Womble Drain	Main Canal	40	1800
Trailer Camp No. 108	Gridley Highway Drain	Terril Highline	25	3,000
Drumheller No. 113	Drumheller Slough	Avis Channel	30	N/A
Pearl No. 114	Drumheller Slough	Boat Canal	30	1,700
Butte Lodge	Butte Creek Drain/ Butte Lodge Drain	Flyway Ditch	20	1,300

Table 2.6-7. RD 1004 Drainage Laterals

Name	End Spill	Downstream Diverters/Recapture
Butte Creek Drain	Butte Creek	Butte Slough diverters
Butte Lodge Drain	Butte Creek	Butte Slough diverters
5-Points Drain	Butte Creek	Butte Slough diverters
North Levee Drain	East Levee Drain/5-Points Drain/Butte Creek	Butte Slough diverters
Womble Drain	Drumheller Slough	Butte Slough diverters
Frog Pond Drain	Drumheller Slough	Butte Slough diverters

2.6.5.5 Proposed O&M and Capital Improvements

To be completed.

2.6.6 District Operating Rules and Regulations

RD 1004, pursuant to Section 50911 (a) of the Water Code of the State of California, has produced rules and regulations covering the distribution of water within their District. The following is a portion of the topics covered within these rules and regulations.

Water rotation, apportionment, and shortage allocation:

> *Water is ordered 24 hours prior to necessary delivery date. Whenever a general shortage of water appears imminent, the Board of Trustees shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary, local or similar shortages, the Manager is authorized to place in effect such variations in service as in his judgment the occasions requires.*

A copy of the current year shortage policy is included as Attachment E.

Policies for wasteful use of water:

> *Any water user who deliberately, carelessly or otherwise wastes water on roads, vacant land or land previously irrigated or who floods certain portions of the land to an unreasonable depth or who uses an unreasonable amount of water in order to irrigate properly other portions or who irrigates land which has been improperly checked for the economical use of water or who allows an unnecessary amount of water to escape from any field will be refused the use of water until such conditions are remedied or will have his use curtailed by the amount of waste, as the Manager may determine.*

2.6.7 Water Measurement, Pricing, and Billing

Water measurement is considered fully implemented as a conservation measure at RD 1004. The District measures flow and quantity at its river and creek diversion pump stations using flowmeters. Canal and lateral flow rates are measured using meters and totalizers installed at intermediate points such as road culverts. The three District wells are metered. Drain pump flows are either metered or estimated based on power consumption and pump efficiency data. The only operations level that is not fully metered is the drain pumps, although the power consumption records and efficiency data provide fairly accurate estimates of total volumes pumped.

RD 1004 currently serves approximately 133 delivery points and has flowmeters installed on its customer turnouts. The meters are read and cleaned regularly, generally every 2 days. The District uses the meter data to record flow rates and total volume delivered at each turnout. There are 133 measured delivery points, and 100 percent of delivered water is measured at the delivery point. These data are then used for the billing, which is based on a dollar-per-ac-ft charge. Information on the accuracy of the flowmeters is included in Attachment C. Table 2.6-8 presents an inventory of the District's water measurement devices.

Table 2.6-8. Agricultural Measurement Device Inventory for RD 1004

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Propeller	133	±5%	1 to 3 days	As needed	Yearly or as needed
Total	**133**				

Meridian Farms Water Company (MFWC)

2.7 Meridian Farms Water Company

2.7.1 History

Meridian Farms Water Company (MFWC or the Company) was formed in 1926, under the state corporation laws and codes and was 9,600 acres. The Company entered into a negotiated agreement with Reclamation in 1964, quantifying the amount of water MFWC could divert from the Sacramento River. The resulting negotiated agreement recognized MFWC's annual entitlement of a Base Supply of 23,000 ac-ft/yr of flows from the Sacramento River and also provided for a 12,000 ac-ft allocation of Project Supply, resulting in a contract entitlement of 35,000 ac-ft/yr. The Company subsequently worked with Reclamation and counsel to finalize a new 40-year contract in 2006 maintaining the Company's 23,000 ac-ft of Base Supply and 12,000 ac-ft of Project Supply. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract for MFWC, and is shown in Table 2.7-1.

Table 2.7-1. Schedule of Monthly Water Diversions – MFWC

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	4,400	0	4,400
May	6,200	0	6,200
June	5,900	0	5,900
July	2,000	5,000	7,000
August	1,100	5,000	6,100
September	3,400	2,000	5,400
October	0	0	0
Total	**23,000**	**12,000**	**35,000**

Notes:

Contract No. 14-06-200-838A-R-1
Points of Diversion: 71.L, 74.8L, 80.0L

In addition to the contract water, MFWC has entitlements to pump water from drains within the service boundary for water recycling. The Company operates six wells to supplement surface water supplies. These wells are used in conjunction with the river pumps and recycling pump to meet irrigation needs.

2.7.2 Service Area and Distribution System

MFWC is located on the east side of the Sacramento River east of the community of Meridian and directly southwest of the Sutter Buttes. The Company encompasses approximately 9,900 acres; 9,100 acres are irrigated, and the Company serves 73 landowners. The main pumping facility is located at River Mile 134 on the Sacramento River.

MFWC uses an arranged schedule to deliver irrigation water to Company customers. MFWC also pumps water from the Sacramento River using two other pump stations. The Company's distribution and conveyance system includes approximately 16 miles of main canals and 19 miles of major laterals. Seepage from the canals and laterals is approximately 15 percent. MFWC coordinates drain operations with RD 70, and has no specific agreements in place to handle floodwaters. MFWC has usable groundwater resources within its boundaries and uses groundwater as a normal part of its resource mix, although some nearby wells have low-quality groundwater as a result of connate water upwelling. The western edge of the Company abuts a number of independent farmers with individual contracts with Reclamation. These landowners, called “rimlanders,” are not within Company boundaries, but contribute runoff that may be reused by Company farmers. Past efforts to coordinate operations with these landowners have failed.

The Company relies heavily on recirculating water. In previous years, the Company could rely on runoff from outside the Company to supplement their own water sources. Farming practices have since changed, forcing the Company to rely on Sacramento River diversions.

MFWC continues to aggressively maintain their system and work with farmers to maintain irrigation reliability and efficiency.

2.7.3 Water Supply

MFWC holds water rights to divert water from the Sacramento River as well as the RD 70 Main Drain, Lateral Drain No. 4, and Long Lake (Table 2.7-2). These diversions differ in the quantity and timing in which they can be used, as indicated in Table 2.7-1.

There are no restrictions on the Company’s water sources.

2.7.3.1 Surface Water

The MFWC surface water supply entitlement is currently addressed in a contract entered into with Reclamation in 1964, Contract No. 14-06-200-0838A (Contract No. 0838A). This contract provides for an agreement between MFWC and the United States on MFWC’s diversion of water from the Sacramento River during the period April 1 through October 31 of each year.

Table 2.7-2. MFWC: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	A001074B (9/10/18)	000591 (6/10/19)	004676B (8/6/57)	Mar 1 to Nov 1	138
RD 70 Main Drain, Long Lake, and Lateral Drain No. 4	A009737	005935 (3/12/42)	007160 (3/10/65)	Apr 1 to Oct 1	100

[a]Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b]N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c]The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d]The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e]The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

Contract No. 0838A provides for a maximum total of 35,000 ac-ft/yr, of which 23,000 ac-ft is considered to be Base Supply and 12,000 ac-ft is CVP water (Project Supply), as shown in Table 2.7-3. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.7-3. MFWC: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	6,500	12,000
Non-critical Months	16,500	0
Total Annual	**23,000**	**12,000**

The contract specifies the total quantity of water that may be diverted by MFWC each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 1,100 ac-ft in August to a maximum of 6,200 ac-ft in May. Although the contract period is April through October, no Base or Project Supply is allocated for the month of October. However, Base and Project Supply can be shifted between non-critical months. CVP water (Project Supply) is available during the months of July, August, and September with entitlements of 5,000, 5,000, and 2,000 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 6,500 ac-ft, and the total Project Supply is 12,000 ac-ft, as shown in Table 2.7-3.

Non-contract Period (November – March)

Contract No. 0838A does not limit MFWC from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. MFWC has historically irrigated in months prior to April (pre-irrigation), especially for grain crops, tomatoes, and orchards. Additional water is also diverted from the Sacramento River prior to April 1 to prime the Company's conveyance and distribution facilities, including Long Lake. MFWC only diverts water for rice decomposition in late October on a limited amount of acres due to having an agreement with the local Reclamation District who then has the responsibility to pump tail water back into the Sacramento River at the southern end of the Company.

Other Surface Water Sources

The Sacramento River is the only existing surface water source for MFWC. No additional surface water sources are available to MFWC.

2.7.3.2 Groundwater/Conjunctive Use

Three privately owned well and six Company-owned wells are located within MFWC's boundaries. MFWC operates and maintains the privately owned wells, which have a capacity of approximately 15 cfs. The six Company-owned wells have a combined capacity of approximately 30 cfs. Groundwater is used to supplement surface water supplies during peak demand and drought periods (DWR, 1978).

Intentional groundwater recharge is not currently practiced in the Company. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from conveyance losses and irrigation application practices.

Groundwater Subbasin Conditions

The MFWC service area overlies the Sutter Subbasin (DWR groundwater basin number 5-21.62) of the Sacramento Valley Groundwater Basin. MFWC lies within the northwestern corner of the Sutter Subbasin. The area is located on recent alluvial sediments including channel, floodplain, basin, and alluvial fan deposits. Flood-basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities.

Alluvial fan and stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeabilities. These recent sediments are underlain by older deposits of the Laguna, Mehrten, and Tehama Formations (DWR, 2003c).

The Laguna Formation is predominantly composed of silt, clay, and sand with local sand and gravel lenses (Page, 1980). The unit is highly variable, ranging from predominantly silt with sandy lenses to sand with clay and silt lenses (DWR, 1978). The Laguna Formation was deposited as a westward thickening “wedge” on low-sloping alluvial fans by streams draining the Sierra Nevadas.

The Mehrten Formation includes both hard-gray tuff breccias derived from eruptions in the Sierra Nevadas and fluvatile volcanic silts, sands, and gravels (DWR, 1978; Page, 1980). These deposits dip southwestward and range in thickness from 0 to 325 feet. Although tuff breccias and clays yield little water, the volcanic sands of the Mehrten Formation can yield large quantities.

The Tehama Formation dips eastward from the western margin of the subbasin (near the Sacramento River), forming the base of the continental deposits. In the Sutter Subbasin, the Tehama Formation consists of alluvial sediments (predominantly sand, silt, and clay) deposited by streams draining the Coast Ranges (DWR, 1978).

Groundwater quality in the Sacramento Groundwater Basin is generally good and is sufficient for agricultural, domestic, and M&I uses. The northwest trending Sutter Basin Fault creates water quality problems within the Sutter Subbasin (DWR, 2003a). The fault acts as a conduit for the upward movement of connate water from deeper marine sediments. It has been reported that saline intrusion has displaced as much as 2,000 feet of fresh water in the continental deposits, forming a mound of saline water in the east-central portion of the subbasin. The total depth of freshwater aquifer in the MFWC area is approximately 1,400 to 1,600 feet bgs (Berkstresser, 1973). The freshwater is underlain by saline water in older marine units.

Groundwater in the vicinity of MFWC generally flows to the southwest, toward the Sacramento River, at a gradient of approximately 1.5 feet per mile (DWR, 2003a). Seasonal fluctuations in groundwater levels are generally less than 10 feet, but can be as much as 35 feet in drought years (DWR, 2003b).

In the northern portion of MFWC, groundwater movement is generally to the southeast, toward the Sacramento River, at a gradient of 4.8 feet per mile. In the southern portion of MFWC, the flow changes to a more southerly direction with a gradient of approximately 2.5 feet per mile (DWR, 2003a). Limited groundwater data are available for the MFWC area, because DWR monitors only one well in the area. During years of normal precipitation, groundwater levels have been shown to fluctuate from 2 to 4 feet seasonally; during drought years, groundwater levels have been shown to fluctuate as much as 6 feet (DWR, 2003b).

Historically, past pumping and drought conditions have not negatively affected the overall long-term groundwater-level trends in the MFWC service area. Groundwater-level data since 1980 from more than 2,300 wells in the Sacramento Valley were reviewed, and the historical trends show that groundwater levels in the MFWC area are generally stable over the long term, although short-term fluctuations are observed that correlate to precipitation trends.

Groundwater Planning/Sustainable Groundwater Management Act

The MFWC boundary is within the service area of Reclamation District 70(RD 70). In 2017 RD 70 became a GSA in the Sutter Sub Basin. The Sutter Sub basin submitted an alternative plan that was subsequently denied. Sutter Subbasin is now pursuing a GSP. Although MFWC is not a GSA, MFWC intends to play an active role in the development of the GSP. The Company does not participate in groundwater banking.

2.7.3.3 Other Water Supplies

MFWC has relied heavily on recirculation/recycling to supplement its Sacramento River entitlement. In the past, MFWC pursued an aggressive recapture program. Approximately 40 percent of the acreage within the Company is irrigated with recirculated water. MFWC has permits to pump 100 cfs from its own main drain.

MFWC uses eight relift pumps throughout the system to efficiently reuse water. MFWC has the capability of pumping water from the bottom of the service area back up to the upper portion of Long Lake for reuse. Long Lake is within MFWC's boundaries and functions as a regulatory reservoir; Long Lake is an integral part of the tailwater recovery system. The capacity of Long Lake is not significant from a water supply standpoint, but it is essential from a regulatory and tailwater reuse standpoint.

MFWC does not actively pump tailwater from sources outside of its boundaries. MFWC receives minor quantities of tailwater from the lands that lie north of it along the Sacramento River.

2.7.4 Water Use

Water use within the Company is predominantly agricultural as the Company does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.7.4.1 Agricultural

MFWC operates similarly to larger districts in terms of cropping patterns and cultural practices. In the recent past, rice has typically accounted for less than half of the Company's irrigated acreage on an annual basis; other key crops include tomatoes, safflower, alfalfa, wheat, beans, and walnuts (DWR, Central District). As is the case with most of the other districts, water requirements are typically highest during the summer months (July and August) due to the requirements of the crops grown and the area's hot, dry climate. Cultural practice water needs for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields, as well as to meet the needs of other crops. Local rice production is assisted by using recycled water and storing water in canals and Long Lake. Recycling and brief storage allow for warming of the water, which benefits rice production. Also, several fields have recently been certified as organic farms. Organically grown rice is a higher-value crop that requires additional water to offset herbicides commonly used for weed control. Irrigation water requirements are met through the contract surface water supplies, recycling, and groundwater. As noted above, the Company has been experiencing an increase in rice production in the service area and a reduction in tomato production due to changing market conditions. This increase in rice production has placed additional demands on the water service system, which has limited capacity in the middle of the Company due to a relatively flat slope and the need to maintain full canals to recirculate. Currently, tomato crops are trending toward the use of greenhouse-grown seedlings. Use of seedlings allows for farmers to plant as soon as weather forecasts are favorable, which may be as early as March, earlier than typical start dates for seed-grown tomatoes. Seedlings use less water because the soil does not need to be kept as moist as typically required for seed emergence.

The Company's Board of Directors issued a policy directive against the use of winter water for rice straw decomposition. The policy directive was issued in response to concerns regarding flood pumping capacity; if a flood were to occur during decomposition, existing drain pumps would not be able to remove floodwater and decomposition water. Removal of rice straw has not been a large issue in the service area because of the regular practice of crop rotation. Rice straw is usually disked under after the growing season, before the field is planted with a different crop the following year.

Future irrigation season cropping patterns and associated water requirements are anticipated to continue the current trend toward increased rice production and a reduction in tomato production, with rotations of beans, wheat, and safflower. There are no anticipated land use changes.

2.7.4.2 Urban

MFWC is near the agricultural and residential town of Meridian, but it does not provide water service for either municipal or industrial use.

2.7.4.3 Environmental/Natural and Cultural Resources

Long Lake is a 200-acre, privately owned environmental resource within the Company boundary supporting migratory waterfowl, including pelicans. Additionally, the lake has catfish, crappie, bass, frogs, and crawdads, supporting a modest local sport fishery. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas. The Company does not serve any private duck clubs, nor are there any formally designated wetlands habitat areas.

2.7.4.4 Topography and Soils

The Company's topography generally consists of nearly level to gently sloping terrain. Because the Company is relatively flat, the impact of the area's terrain on Company water management practices is negligible. There are no agricultural limitations resulting from soil problems. There are no impacts from any microclimates on water management within the Company.

The soil associations that are found within the Company are identified below. Complete descriptions of the soil associations and the corresponding acreage of each association in the Company are provided in the NRCS Soil Surveys for Sutter County.

Soil profile characteristics in the Sutter County area of MFWC are as follows (Attachment I):

- Clear Lake-Capay: Deep and very deep, level to nearly level, poorly drained and moderately well-drained clay and silty clay in basins and on basin rims.
- Shanghai-Nueva-Columbia: Very deep, level to nearly level, somewhat poorly drained silt loam, loam, and fine sandy loam on floodplains.

2.7.4.5 Transfers and Exchanges.

Currently, MFWC does not participate in water transfers. There are no other trades, wheeling, wet/dry exchanges, or other transactions into or out of MFWC.

2.7.4.6 Other Uses

No other significant water uses other than those discussed above occur within MFWC.

2.7.5 District Facilities

2.7.5.1 Diversion Facilities

MFWC's main supply facility is River Pump No. 1 located at River Mile 134 on the Sacramento River. MFWC also pumps water from the Sacramento River using River Pump No. 3 at River Mile 128.6 and River Pump No. 4 at River Mile 126. Table 2.7-4 summarizes MFWC's surface water supply facilities. See Attachment A for a map of MFWC's major conveyance facilities. MFWC currently operates six groundwater wells, shown on the map in Attachment A, with a combined capacity of 30 cfs.

The Company diverts water at three locations along the left bank of the Sacramento River near Meridian, at River Mile (RM) 71.1L, RM 74.8L, and RM 80.0L. The main pump plant is located at RM 80.L. The Company also has State-issued water rights to divert, and to collect and divert water from drains/sloughs within the Company's boundary. The Company uses a system of canals, ditches, and drains to convey water diverted from the Sacramento River as well as other inflow and recirculated tailwater to its customers.

Diversions from the Sacramento River are measured using meters. The meters at two of the three diversion locations, RM 74.8L and RM 80.0L, are installed and maintained by Reclamation. The meter at the pumping plant located at RM 71.1L is owned and maintained by the Company. All of the meters provide both instantaneous flow rate and volumetric data. The meters are read and data recorded at least monthly by Reclamation staff. Maintenance and calibration of these meters is performed by Reclamation in accordance with their standard operating procedures. It has been noted by Company staff that at times the culvert or pipe where the meter for the pumping plant at RM 80.0L is installed does not remain full. This condition affects the accuracy of the measured flow at this location.

Table 2.7-4. MFWC Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
River Pump No. 1	Sacramento River	Pump	100 to 125	17,000
River Pump No. 3	Sacramento River	Pump	40	3,500
River Pump No. 4	Sacramento River	Pump	30 to 35	5,500

2.7.5.2 Conveyance System

MFWC has approximately 16 miles of main canal and 19 miles of major laterals. The main canals are the primary conveyance facilities for the Company. Table 2.7-5 summarizes MFWC's main canal and irrigation lateral features. MFWC has four relift pumps that are used to convey water from canals with lower elevations to canals with higher elevations.

Table 2.7-5. MFWC Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Railroad Main Lateral	River Pump No. 1	40	Partial (2.5 miles)	Eastern District Boundary, 0.25 mile South of Highway 20	15
No. 1 Main Lateral	River Pump No. 1	100	Yes	Drain Pump No. 9	15
No. 3 Main Lateral	River Pump No. 3	30	Partial (0.5 mile)	Hageman Road Drain	15
No. 4 Main Lateral	River Pump No. 4	50	Partial (0.25 mile)	Mills Road Drain	15
No. 5 Main Lateral	Drain Pump No. 5	50	No	Wood Road Southern Drain	15
No. 7 Main Lateral	Drain Pump No. 7	50	No	Wood Road Southern Drain	15

2.7.5.3 Storage Facilities

MFWC currently has no storage facilities.

2.7.5.4 Spill Recovery/Outflow

MFWC has a network of drainage lines for conveying irrigation return flows and regional surface runoff. The flows are generally from north to south within the Company. Drainage water is pumped via several relift pumps back into supply laterals. Forty percent of the water users within the Company are supplied with water from the drains. For MFWC, the drains act as a key part of their distribution facilities. MFWC pumps approximately 25,000 ac-ft of water from the drains annually. The RD 70 Drain Pump Station shown on the MFWC map in Attachment A is not used for irrigation. This pump discharges regional drainage into the Sacramento River when a gravity discharge is prevented by a high river stage. Tables 2.7-6 and 2.7-7 summarize the MFWC drainage facilities.

Table 2.7-6. MFWC Drain Pump Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping (ac-ft/yr)
Drain Pump No. 5	Wood Road-Southern Drain	No. 5 Main Lateral	23	2,700
Drain Pump No. 7	Mills Road Drain	No. 7 Main Lateral	34	3,900
Drain Pump No. 9	Wood Road-Northern Drain	Long Lake Lateral	23	2,700
Drain Pump No. 10	Summy Road Drain	No. 1 Main Lateral	27	3,000
Drexler Drain Pump No. 11	Wood Road-Northern Drain	Drexler Road Lateral	23	2,700

Table 2.7-7. MFWC Drainage Laterals

Name	End Spill	Downstream Diverters/Recapture*
Wood Road-Northern Drain	Long Lake	No
Summy Road Drain	Hageman Road Drain	No
Hageman Road Drain	Mills Road Drain	No
Mills Road Drain	Wood Road-Southern Drain	No
Wood Road-Southern Drain	Sacramento River	No
Girdner Road Drain	Wood Road-Southern Drain	No
Gormire Road Drain	Girdner Road Drain	No

* Drainage that leaves the Company is discharged to Sacramento River via the RD 70 Pump Station.

2.7.5.5 Proposed O&M and Capital Improvements

To address the measurement requirements of the Regional Criteria and to comply with the provisions of its Settlement Contract, the Company intends to implement a turnout measurement program. The measurement program will include the following:

1) Evaluate typical operational canal water level fluctuations.
2) Develop and implement system/methodology for monitoring changes in canal levels related to turnouts.
3) Verify number, type, and size of gates.
4) Obtain or develop ratings for screw-gates.
5) In the field, verify accuracy of screw-gate ratings and modify ratings if/as appropriate.
6) Evaluate options for measurement of portable pump deliveries. Options include but are not limited to:
   a) Flowmeters
   b) Pump capacity/time of use
   c) Pump capacity/energy usage
7) Develop system for field recording of delivery data.
8) Develop database for recording deliveries.
9) Develop O&M procedures to assure accurate measurement of deliveries.

Table 2.7-8 provides a proposed schedule of verification tasks.

Table 2.7-8. Proposed Schedule of Verification Tasks

Major Tasks	2021	2022	2023	2024	2025
Evaluate Canal Water Level Fluctuation	X	X			
Develop and Implement System/Methodology for Monitoring Changes in Canal Levels Related to Turnouts	X	X	X	X	X
Obtain or Develop Ratings for Screw-gate Deliveries	X	X	X		

Table 2.7-8. Proposed Schedule of Verification Tasks

Major Tasks	2021	2022	2023	2024	2025
Field Verification or Accuracy of Screw-gate Ratings and Modifying Ratings if/as Appropriate	X	X	X	X	X
Evaluate Options for Measurement of Portable Pump Deliveries			X	X	
Conduct Measurements to Check/Verify Ratings at Approximately 10 to 20 percent of Company Turnouts Each Year	X	X	X	X	X
Develop System/Methodology for Field Recording of Delivery Data	X	X			
Develop O&M Procedures to Assure Continued Accuracy of Turnout Measurement Devices			X	X	
Purchase/Develop Database to Incorporate Volumetric Pricing				X	X
Develop and Implement Volumetric Pricing Policy				X	X
Hire New Staff				X	
Purchase Pickup			X		
Initial Estimate of Annual Costs	$35,000	$95,000	$55,000	$85,000	$50,000

The Company proposes to implement the Measurement Program in phases. The first phase will be to conduct steps 1 through 7 from the list above within one of the systems within the Company. This phased approach will allow evaluation measurement options and challenges on a limited scale before expanding the program throughout the Company. It is hoped the phased approach will help minimize the overall cost of the program. The program approach and associated costs will be reviewed and revised as the program is developed. Revisions and updates will be included in the annual updates to the RWMP.

The above has been prepared to address specific requirements of the CVPIA and the Regional Criteria. Company staff have identified additional improvements that they believe would provide equal or greater benefits to overall water use efficiency within the Company. These include the following:

- Update its existing outdated SCADA system
- Expand the SCADA to include water level monitoring at key locations

These SCADA system improvements would allow Company staff to better operate its delivery system by monitoring and coordinating river diversions and canal operations. Because of the costs associated with developing and implementing the turnout measurement program described above and the Company's limited resources, any improvements to the SCADA system will be dependent on outside funding sources.

2.7.6 District Operating Rules and Regulations

Delivery of water must be ordered 48 hours in advance of need. Wasteful practices are not allowed, and no water is delivered until all financial obligations are met. MFWC is a mutual water company and governed by a Board of Directors consisting of seven members. The O&M of the canals, laterals, and irrigation works of the Company are under the exclusive management and control of the manager, who works at the pleasure of the Board of Directors as set forth in the Company's rules and regulations.

Water users or customers are required to apply for water in March prior to the beginning of the irrigation season. Water orders identify the field, crop, type of irrigation (flood, sprinkler, drip, etc.) and number of acres to be irrigated for the upcoming season. The Company water charges are annually based on the crop to be irrigated and number of acres to be planted. Water charges are payable in three installments due April 1, June 1, and October 1. The ditch tender is responsible for maintaining water levels throughout the Company, as well as starting and stopping deliveries to customers. Deliveries throughout the Company are made on demand with 48-hour notice to the ditch tender when changes in deliveries are required.

Water rotation, apportionment, and shortage allocation:

> Rule 4 of MFWC rules and regulations: *All demands for water must be made in writing on blanks furnished by the Company, and must be delivered to the ditchtender or Manager at least 48 hours before water is needed.*
>
> Rule 10 of MFWC rules and regulations: *When, for any reason, the full supply of water required cannot be delivered to the users or stockholders, such supply as can be delivered shall be prorated until such time as delivery of full supply can be resumed.*

Use of drainage water:

> Rule 13 of MFWC rules and regulations: *Before water will be turned from the canals or laterals of the Company for service to consumers or stockholders, seep ditches and farm service ditches must be constructed along the toe of slopes of main service laterals of the Company and across and along the boundaries of the fields of the water users to be irrigated in such way and manner as will control the water upon the lands of the user and provide an outlet to the District drainage canals provided for that purpose.*

Policies for wasteful use of water:

> Rule 9 of MFWC rules and regulations: *Any user of water, consumer or stockholder wasting water on roads or vacant land or land previously irrigated, either willfully, carelessly, or on account of defective farm service ditches, or who shall flood certain portions of the land to an unreasonable depth or amount in order to irrigate other portions, or whose land has been improperly checked, furrowed or leveled for the economical use of water, or who is causing damage to adjoining lands, through lack of farm service, drains or drainage ditches, will be refused the use of water until such conditions are remedied. The Company reserves the right to refuse delivery of water to any lands when it appears that its proposed use, or method of use will require such excessive quantities of water, and will cause such damage to adjoining or other lands of the stockholders as will constitute waste. All lands to be flood irrigated shall first be prepared for use of water by the construction of levees or borders following the natural contours of the ground, checks to be spaced at intervals not to exceed three tenth of one foot between borders or levees. Borders and levees shall be of sufficient height and width so as to prevent water from wasting outside of the boundaries of the field to be irrigated.*

2.7.7 Water Measurement, Pricing, and Billing

MFWC measures water at its three river diversion pump stations using flowmeters. Canal and lateral flow rates are measured using weir or gate head/flow curves. Wells are metered. Drain pump flows are measured by meters that have been recently installed. Minor increases in water savings are possible through a program of improved water measurement that includes installation of intermediate measurement points along the main canals, improved lateral headgate measurement, and drain pump metering. These new measurement facilitates would be integrated with the operations automation program described above to increase overall distribution system efficiency.

The Company provides water for irrigation purposes to approximately 108 customers at approximately 187 individual field turnouts or farm gates by gravity. Table 2.7-9 provides a summary of the Company's turnout structures. In addition to the gravity turnouts, water for some fields is pumped by the Company using portable diesel pumps, and in a small number of instances, water is pumped by customers using private pumps. The Company's Manager also serves as Manager for Reclamation District 70, Reclamation District 1660, and the Butte Slough Irrigation District. The Company shares a secretary with Reclamation District 70 and employs one fulltime ditch tender and a maintenance person.

The Company's ditch tender operates canals and laterals to maintain water levels at the headgates of laterals to assure sufficient head for gravity deliveries. Water levels are monitored at canal head gates as well as at check structures at key locations along the canals. Water levels throughout the system are maintained based on the ditch tenders' experience and knowledge of the system and the water requirements of crops.

All deliveries to individual fields are made by gravity though 191 screw-gates. Delivery rates are set based on water orders, the Ditch tenders' experience and knowledge of the system and its demands, and communication with individual customers. In some cases, deliveries are made to fields or a group of fields by Company-owned portable pumps and to a small number of fields by landowner or operator-owned pumps. Currently, the Company does not measure or record information regarding deliveries to fields. However, as part of a Reclamation grant-funded canal modification project, MFWC will construct six new automated check structures in the Main Canal, which provides irrigation deliveries to approximately 7,500 acres of farmland (from 15 turnouts). The new check structures will consist of a long-crested weir and automated level-control gate to maintain consistent water level through a wide range of flow, improving water management and water measurement practices. Fluctuating canal water levels negatively affect the ability to provide accurate farm gate delivery measurements. Therefore, the purpose of this proposed project is to augment the current project by constructing check structures that can accommodate a wide range of flows while minimizing fluctuations that result from demand changes. This project is part of step 2 identified in Section 2.7.5.5. As part of the project, MFWC is going to be replacing 15 turnouts along the canal with upgraded measurement boxes and plans to implement either the Remote Tracker system or standard measurement practices as described by Irrigation and Training Research Center (ITRC) (see documents enclosed in Attachment C). Construction on this project is anticipated to occur until spring 2025; and when completed, MFWC plans to start implementing measurement in this part of its system in 2025, also identified in Table 2.7-8. Assuming it is successful, MFWC plans to continue implementation Companywide, replacing about 15 turnouts per year, for full measurement by 2035. During this time, MFWC also intends to develop a volumetric pricing policy and, through coordination with its legal counsel, will determine if the policy can be implemented before all turnouts are measured.

Table 2.7-9. Summary of Turnout Structures

Measurement Type	Number[a]	Estimated Accuracy	Reading Frequency	Maintenance Frequency
Screw-gates	191	N/A	Daily or when changes are made	Annual/as needed
Company Owned Pumps	3	N/A		Annual/as needed
Private Pumps	10	N/A		
Total	204	N/A		

[a] The number of each type of device will be verified during the inspection and certification process.

Table 2.7-10 presents an inventory of the Company's water measurement devices.

Table 2.7-10. Agricultural Measurement Device Inventory for MFWC

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Ultrasonic	10	10%	Continuously	Yearly	Yearly
Weirs	107	5%	Daily	N/A	Yearly
Total	**117**				

Sutter Mutual Water Company (SMWC)

2.8 Sutter Mutual Water Company

2.8.1 History

Sutter Mutual Water Company (SMWC or the Company) was formed February 5, 1919, under the California corporation laws and codes and included 50,071 acres. The Company entered into a negotiated agreement with Reclamation in 1964, quantifying the amount of water SMWC could divert from the Sacramento River. The contract was re-negotiated in 2005, resulting in SMWC's annual entitlement of a 169,500 ac-ft/yr Base Supply for water diversion from the Sacramento River. The contract also provided a 56,500 ac-ft allocation of Project Supply, resulting in a total contract entitlement of 226,000 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract for SMWC and is included in Table 2.8-1. SMWC completed negotiations with Reclamation for a contract renewal and executed that contract in 2005. In addition to the contract water, SMWC has entitlements to pump water during the non-irrigation season for wetlands and rice straw decomposition given appropriative rights during the winter months of approximately 250 cfs.

Table 2.8-1. Schedule of Monthly Water Diversions – SMWC

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	20,000	0	20,000
May	42,500	0	42,500
June	48,000	0	42,500
July	28,500	25,000	53,500
August	20,000	24,000	44,000
September	5,000	7,500	12,500
October	5,500	0	5,500
Total	**169,500**	**56,500**	**226,000**

Notes:

Contract No. 14-06-200-856A-R-1
Points of Diversion: 32.4L, 40.6L, 63.75L

2.8.2 Service Area and Distribution System

SMWC is located approximately 45 miles northwest of Sacramento and is bordered by three levee systems. The Company encompasses approximately 50,000 acres (46,746 are irrigated acres) and serves 150 landowners. Company boundaries encompass the town of Robbins. The Company operates four pumping plants at three locations: Tisdale Pumping Plant (960-cfs capacity), State Ranch Bend Pumping Plant (128 cfs), and Portuguese Bend Pumping Plant (106 cfs). SMWC also has 14 booster pump sites with a total flow capacity of 260 cfs (they typically operate 6 to 11 in any given year). These facilities are used for water reuse and are located in the central and northeast portions of the Company. Additionally, SMWC uses five portable booster pumps for flexibility and maximizing its ability to recapture/recycle drain water.

SMWC is interlaced with drainage ditches (which are operated and maintained by RD 1500) that carry water toward the Main Drain and eventually out of the service area at the southern end of the Company at the Karnak Pump Station. Drainage ditches in the eastern portion of the Company intercept naturally occurring saline groundwater, called “connate water.” This saline groundwater tends to be most prevalent toward the eastern portion of the Company associated with artesian pressure through the Sutter Basin Fault. Salinity concentrations tend to increase with depth (NRCS, 1996). Irrigation practices using Sacramento River water and drainage systems have allowed the Company and other districts/landowners to maintain suitable crop yields and keep the connate water below the crop root zones.

The western edge of the Company abuts a number of independent farmers with individual contracts with Reclamation. These landowners, called “rimlanders,” are not within Company boundaries, but contribute drain water to the RD 1500 drainage system. Company operations are coordinated with RD 1500 and Pelger Mutual Water Company. RD 1500 manages drainage in the service area, and SMWC delivers water to the majority of water users in the area.

SMWC uses an arranged schedule to deliver irrigation water to Company customers. The Company’s distribution and conveyance system includes approximately 56 miles of irrigation water delivery canals and 144 miles of laterals. Delivery system leakage associated with the operation of the Company is approximately 15 to 18 percent of the diversion during the spring, summer, and early fall irrigation season. Approximately 45 privately owned wells have been drilled within the Company boundaries, but most have been curtailed or abandoned due to high salinity levels and lack of sustained yield as discussed above. Reuse of water is driven in part by year type; however, the high water table and its saline nature limit the amount of water that can be successfully reused without affecting crop yields and salt accumulation in the soil profile. Winter operations call for most drains to be opened around Labor Day of each year to allow for the dewatering of the basin in preparation for the passage of winter flows.

2.8.3 Water Supply

The Sacramento River serves as the principal water source for the Company. The Company has water rights to the Sacramento River as shown in Table 2.8-2. The following discussion describes this source and its historical use.

2.8.3.1 Surface Water

As identified above, SMWC holds a water right to divert water from the natural flow of the Sacramento River. The SMWC surface water supply entitlement is currently addressed in a contract entered into with Reclamation in 1964, Contract No. 14-06-200-0815A (Contract No. 0815A) and re-negotiated in 2005. This contract provides for an agreement between SMWC and the United States on SMWC’s diversion of water from the Sacramento River during the period April 1 through October 31 of each year. The area sits upon a connate water lake and high electrical conductivity is a concern if groundwater instead of surface water was to become more widely used.

Table 2.8-2. SMWC: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	A000581 (2/1/17)	000287 (5/8/17)	002817 (3/6/46)	Mar 1 to Oct 31	45
Sacramento River	A000878 (1/3/18)	000419 (4/4/18)	002818 (3/6/46)	Mar 1 to Oct 31	116.72

Table 2.8-2. SMWC: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River	A000879 (1/3/18)	000420 (4/4/18)	002819 (3/6/46)	Mar 1 to Oct 31	25.25
Sacramento River	A000880A (1/3/18)	000421 (4/4/18)	002820A (3/6/46)	Mar 1 to Oct 31	404.82
Sacramento River	A001160 (1/24/19)	000569 (5/9/19)	002822 (3/6/46)	Mar 1 to Oct 31	40.5
Sacramento River	A001758 (4/9/20)	001103 (7/26/22)	000552 (11/5/26)	Apr 1 to Oct 31	1.5
Sacramento River	A001763 (4/9/20)	001108 (7/31/22)	001110 (9/15/31)	Apr 15 to Sep 15	3
Sacramento River	A001769 (4/9/20)	001117 (8/9/22)	000547 (6/22/26)	Apr 1 to Oct 31	7.67
Sacramento River	A001772 (4/9/20)	001120 (8/10/22)	000657 (1/31/28)	May 1 to Oct 1	0.31
Sacramento River	A003195 (12/27/22)	002169 (7/25/25)	000882 (11/30/29)	Apr 1 to Oct 31	1.38
Sacramento River	A007886 (3/29/34)	004354 (7/3/34)	002240 (6/19/41)	Mar 1 to Oct 1	7.32
Sacramento River	A009760 (11/3/39)	005510 (4/1/40)	002821 (3/6/46)	Jan 1 to Dec 31	250
Sacramento River	A010658 (6/16/43)	006189 (10/14/43)	002823 (3/6/46)	Mar 1 to Oct 31	7.52
Sacramento River, West Borrow Pit Sutter Bypass	A011953 (6/23/47)	007194 (10/25/48)	004562 (2/25/57)	Apr 1 to Oct 1	7.5
Sacramento River	A012470A (4/13/48)	0072687A (12/17/49)	008547A (8/16/95)	Apr 1 to Nov 1	35.9
Sacramento River	A016677 (10/20/55)	013867 (2/15/63)	008220 (9/7/67)	Primary: Apr 1 to Jun 15 Secondary: Sep 1 to Oct 31	7.5

[a] Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b] N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c] The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d] The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e] The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

Contract No. 0815A provides for a maximum total of 226,000 ac-ft/yr, of which 169,500 ac-ft is considered to be Base Supply and 56,500 ac-ft is CVP water Project Supply, as shown in Table 2.8-3. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.8-3. SMWC: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	53,500	56,500
Non-critical Months	116,000	0
Total Annual	**169,500**	**56,500**

The contract specifies the total quantity of water that may be diverted by SMWC each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 5,000 ac-ft in September to a maximum of 48,000 ac-ft in May. CVP water (Project Supply) is available during the months of July, August, and September with entitlements of 25,000, 24,000, and 7,500 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 53,500 ac-ft, and the total Project Supply is 56,500 ac-ft, as shown in Table 2.8-3.

Non-contract Period (November – March)

In addition to the contract water, SMWC has entitlements to pump water during the non-contract period for other uses including rice straw decomposition given appropriative rights during the non-contract months. These entitlements allow for a maximum diversion of 250 cfs. Approximately 4,000 to 16,000 acres have been flooded in the past for rice straw decomposition. Due to flood control and drainage concerns, the maximum acreage that may be flooded is considered and managed by acreage limitations adopted by the Company each year.

Other Surface Water Sources

Excluding Sacramento River water rights/contract entitlements, SMWC does not hold water rights to any other surface water sources.

2.8.3.2 Groundwater/Conjunctive Use

Although groundwater use within the subbasin is of limited use, it is believed by local and state agencies that there could be potential for cultivating the resource if carefully managed in conjunction with surface water supplies. It is generally believed that the use of the groundwater resource may be more limited in the southern portion of the basin due to areas of connate water than in the northern portion where such issues are not as prevalent. SMWC is working with Sutter County, RD 1500, and Pelger Mutual Water Company to better define the local groundwater resource and is working with these entities to explore potential conjunctive management and groundwater monitoring opportunities. In 2020, SMWC transferred groundwater to SLDMWA.

Although no direct groundwater recharge plan is practiced, the basin is routinely recharged by groundwater percolation resulting from conveyance losses and irrigation application practices.

Groundwater Subbasin Conditions

The SMWC boundary overlies the Sutter Subbasin (DWR groundwater basin number 5-21.62) of the Sacramento Valley Groundwater Basin. SMWC lies within the southwestern portion of the Sutter Groundwater Subbasin. The area is located on recent alluvial sediments: channel, floodplain, basin, and alluvial deposits. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities. Stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeabilities. Underlying these recent fluvial deposits are the Tehama, Mehrten, and Laguna Formations (DWR 1978; DWR, 2003c).

In the Subbasin, the Tehama Formation interfingers with the Laguna and Mehrten Formations, forming the base of the continental deposits in this area. Although the Tehama Formation is mostly fine-grained, it contains sufficient sand and gravel zones in many areas to provide large quantities of groundwater. From its source area in the Coast Ranges, the Tehama Formation dips eastward beneath the valley floor (DWR, 1978).

The Laguna Formation overlies the Mehrten Formation and is composed predominantly of fine-grained poorly sorted reddish to yellowish brown silt, clay, and sand with local sand and gravel lenses (Page, 1980). The unit is highly variable, ranging from predominantly silt with sandy lenses to sand with clay and silt lenses (DWR, 1978). The Laguna Formation was deposited as a westward thickening "wedge" on low-sloping alluvial fans by streams draining the Sierra Nevadas. Thickness ranges from 300 feet along the Sierra Nevada foothills to as much as 1,000 feet near the Sacramento River (DWR, 1978). Deposits of the Laguna Formation exhibit low to moderate permeability.

The Mehrten Formation includes both hard-gray tuff breccias derived from eruptions in the Sierra Nevadas and interbedded fluvatile volcanic silts, sands, and gravels (DWR, 1978; Page, 1980). These deposits dip southwestward and range in thickness from 0 to 325 feet. While tuff breccias and clays yield little water and function as confining layers, the volcanic sands of the Mehrten Formation can yield large quantities to agricultural wells (DWR, 2003c).

Groundwater quality in the Sacramento Groundwater Basin is generally good and sufficient for agricultural, domestic, and M&I uses. In general, natural groundwater quality is influenced by streamflow and recharge from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges because of the presence of marine sediments in the Coast Range. The northwest-trending Sutter Basin Fault creates water quality issues within the Sutter Subbasin (DWR, 2003c). The fault may act as a conduit for the upward movement of connate water from deeper marine sediments. It has been reported that saline intrusion has displaced up to 2,000 feet of fresh water in the continental deposits, forming a mound of saline water in the east-central portion of the subbasin. The total depth of fresh water in SMWC is approximately 400 feet bgs (Berkstresser, 1973). The fresh water is underlain by saline water.

In the northern portion of SMWC, groundwater generally flows from the northeast and northwest at a gradient of approximately 2.3 feet per mile. Flow converges in the central portion of the Company. In the southern portion of SMWC, the horizontal gradient becomes very flat, and groundwater flow directions vary. Limited recent groundwater data are available for the SMWC area, as DWR monitors only one well within the Company. Three other wells have been monitored in the past; however, data collection was discontinued between 1964 and 1980. The closest monitoring wells are located within 2 miles of the Company boundary (DWR, 2003b). Examination of available data indicates that during years of normal precipitation, groundwater levels in the unconfined portion of the aquifer fluctuate between 2 and 6 feet seasonally; while during drought years, groundwater levels have been shown to fluctuate up to 8 feet

(DWR, 2003c). In the confined portion of the aquifer system, groundwater levels have been shown to fluctuate between 4 and 6 feet during years of normal precipitation and up to 26 feet during drought conditions.

Past pumping and drought conditions have not historically negatively affected the overall long-term groundwater level trends in SMWC. Groundwater level data since 1980 from over 2,300 wells in the Sacramento Valley were reviewed, and the historical trends show that groundwater levels in the SMWC area are generally stable over the long term, although short-term fluctuations in groundwater levels are observed that can be correlated with precipitation trends.

Groundwater Planning/Sustainable Groundwater Management Act

SMWC participates in the RD 1500 GSA and is very active in the Sutter Subbasin GSP which is led by Sutter County. Both plans are in process and will be completed by Jan 31, 2022.

The Company does not participate in groundwater banking.

2.8.3.3 Other Water Supplies

SMWC presently uses approximately 35,000 to 65,000 ac-ft/yr of drainage water from sources both inside and outside of the Company. Private landowners pump an additional 5,000 to 15,000 ac-ft from these sources. The western edge of the Company abuts a number of independent farmers with individual contracts with Reclamation. Company operations are coordinated with RD 1500 and Pelger Mutual Water Company. RD 1500 manages drainage in the service area, and SMWC delivers water to the majority of water users in the basin area.

SMWC currently operates fourteen booster pumps and has dismantled one internal recirculation system (ML 10, which has three booster pump locations but is now inoperative) with a total combined capacity of 260 cfs. These facilities are used for water reuse and are located in the central and northeast portions of the Company. Additionally, SMWC uses four portable booster pumps for flexibility and maximizing its ability to recapture/recycle drain water. As identified above, drainage ditches in the eastern portion of the Company intercept naturally occurring saline groundwater that seeps into the drain ditches and causes an increase in salinity in the drains. Irrigation practices using Sacramento River water and drainage systems have allowed the Company and other districts/landowners to maintain suitable crop yields and keep the connate water below the crop root zones.

2.8.4 Water Use

Water use within the Company is predominantly agricultural as the Company does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.8.4.1 Agricultural

The two major crops grown within the Company's service area are tomatoes (grown in rotation with corn, wheat, safflower, and beans) and rice (sometimes grown in rotation with wheat, safflower, beans, and melons, or grown 7 or 8 years consecutively without rotation).

Rice is the predominant crop grown within SMWC's service area, accounting for, in recent years, approximately 65 percent of the Company's irrigated acreage on an annual basis. As is the case with most of the other districts, water requirements are typically highest during the summer months (June, July, and August) due to the requirements of rice and the area's hot, dry climate. Cultural practice water needs for rice and other crops are greatest early in the growing season during dry years associated with irrigating previously dry fields. The vast majority of irrigation water requirements are met through the contract surface water supply, although recaptured drain water is extensively used depending on availability and quality.

The prevalence of relatively rich, well-drained soils allows for a diversity of crops within the Company boundary. Tomato acreage has declined in recent years due to processors (canneries) leaving the area, resulting in more acres of rice and substitute crops. Therefore, associated water requirement needs and associated diversions are driven by changes in cropping patterns, as well as water-year type. There are no anticipated land use changes.

Many of the Company's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. Approximately 4,000 to 16,000 acres have been flooded recently, a trend that may continue or increase assuming other options (including the sale of stubble for ethanol production) are not determined to be more economically feasible. Flood-related concerns currently considered by the Company may limit the total acreage potentially available for rice decomposition. This practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture. Future irrigation season cropping patterns and associated water requirements are anticipated to change over time, and the total water requirements for the Company will change accordingly based primarily on the amount of rice acreage in future cropping patterns.

2.8.4.2 Urban

SMWC overlies the agricultural and residential town of Robbins, but does not provide water service for either municipal or industrial use. M&I water demand within the vicinity of the Company service area is anticipated to increase only slightly, with additional annual water requirements in the year 2020 expected to increase by approximately 1,900 ac-ft compared to 1995 estimated levels (DWR, Central District). Future M&I requirements are assumed to be met by groundwater supplies. In the future, SMWC may provide M&I water to meet growing future M&I requirements.

2.8.4.3 Environmental/Natural and Cultural Resources

In 1990, approximately 250 acres of riparian vegetation were estimated to be incidentally supplied by irrigation, including vegetation directly adjacent to delivery laterals or influenced by leakage from the delivery system. Such vegetation includes habitat used by the federally listed giant garter snake. Other endangered species that occur within the service area include the western yellow-billed cuckoo, Swainson's hawk, bank swallow, wood duck, western pond turtle, California tiger salamander, California red-legged frog, valley elderberry longhorn beetle, and the California hibiscus. Agricultural development has favored other species, notably waterfowl and ring-necked pheasants. Drainage ditches support blue and channel catfish, carp, crayfish, and bullfrogs.

Up to 16,000 acres of rice stubble have been flooded in the past, with associated winter habitat benefits to migratory waterfowl that use the area as part of the Pacific Flyway. As previously described, the Company has considered limitations on total flooded acres due to winter flooding and drainage risks and concerns. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas. No formally managed designated environmental or wetlands areas are within the Company.

There are no recreational and/or cultural resource areas within the Company.

2.8.4.4 Topography and Soils

The Company's topography generally consists of nearly level to gently sloping terrain. Because the Company is relatively flat, the impact of the area's terrain on Company water management practices is negligible. There are no agricultural limitations resulting from soil problems.

The soil associations that are found within the Company are identified below. Complete descriptions of the soil associations and the corresponding acreage of each association in the Company are provided in the NRCS Soil Surveys for Sutter County. Most of the soil is a heavy clay only beneficial to the cultivation of rice.

Soil profile characteristics in the Sutter County area of SMWC are as follows (Attachment I):

- San Joaquin-Cometa: Moderately deep and very deep, level to nearly level, well-drained sandy loam and loam on terraces.
- Oswald-Gridley-Subaco: Moderately deep, level to nearly level, poorly drained and moderately well-drained clay and clay loam in basins and on basin rims.
- Clear Lake-Capay: Deep and very deep, level to nearly level, poorly drained and moderately well-drained clay and silty clay in basins and on basin rims.
- Shanghai-Nueva-Columbia: Very deep, level to nearly level, somewhat poorly drained silt loam, loam, and fine sandy loam on floodplains.

There are no impacts from any microclimates on water management within the Company.

2.8.4.5 Transfers and Exchanges

In 2020 SMWC took part in a transfer of 4,600 ac-ft to San Luis & Delta-Mendota Water Authority (SLDMWA). There were no other trades, wheeling, wet/dry exchanges, or other transactions.

2.8.4.6 Other Uses

No significant water uses other than those discussed above occur within SMWC.

2.8.5 District Facilities

2.8.5.1 Diversion Facilities

SMWC operates four pumping plants in three locations on the Sacramento River: Tisdale Pumping Station, State Ranch Bend Pumping Plant, and Portuguese Bend Pumping Plant. Company operations are coordinated with RD 1500 and Pelger Mutual Water Company to manage the supply and recapture/recycle system conveyance. RD 1500 manages drainage within the SMWC service area. SMWC also supplies water to Company users in the RD 1660 area north of the Tisdale Bypass. Table 2.8-4 summarizes the primary SMWC surface water supply facilities. The Company does not own or operate any groundwater wells. Approximately 45 privately owned groundwater wells exist within the Company boundaries, but most have been curtailed or abandoned because of high salinity levels, lack of sustained yield, and readily available surface water supplies. See Attachment A for a map of SMWC's major conveyance facilities.

Table 2.8-4. SMWC Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
Tisdale Pumping Plant	Sacramento River	Pump	960	170,500
State Ranch Bend Pumping Plant	Sacramento River	Pump	128	23,000
Portuguese Bend Pumping Plant	Sacramento River	Pump	106	11,800

2.8.5.2 Conveyance System

SMWC's distribution and conveyance system includes approximately 56 miles of irrigation water delivery canals and 144 miles of laterals. The Company service area's main distribution facilities include seven canals, listed in Table 2.8-5. The Main Canal supplies water from the Tisdale Pumping Plant to the West Canal, RD 1660 Main Canal, the Central Canal, and the East Canal. The State Ranch Bend Main Canal supplies water from the State Ranch Bend Pumping Plant to Lateral S and the West Side Canal. The Portuguese Bend Main Canal supplies water from the Portuguese Bend Pumping Plant to the southern end of the Company service area.

Table 2.8-5. SMWC Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Main Canal	Tisdale Pumping Plant	960	No	Reclamation Drain	15
East Canal	Main Canal	300	No	Reclamation Drain	15
Central Canal	Main Canal	300	No	Reclamation Drain	15
West Canal	Main Canal	300	No	Reclamation Drain	15
Portuguese Bend Main Canal	Portuguese Bend Pumping Plant	106	Portion	Reclamation Drain	15
State Ranch Bend	State Ranch Bend Pump Plant	128	No	Risers into drains along canals	15
1660 Main Canal	Main Canal	45	No	Risers into drains along canals	15

2.8.5.3 Storage Facilities

SMWC currently has no storage facilities.

2.8.5.4 Spill Recovery/Outflow

Drainage for SMWC is handled by RD 1500. The area is interlaced with drainage ditches that carry water toward the Reclamation District Main Drain and eventually out of the service area at the southern end of the Company via the RD 1500 Karnak Pumping Plant. The Company currently operates 14 active drain recapture pumps, ranging in size from 12 to 50 cfs. Additionally, SMWC uses five portable booster pumps for flexibility and maximizing its ability to recapture/recycle drain water. The Company currently recaptures and recycles between 25,000 and 60,000 ac-ft/yr with these pumps. All drain water is pumped into Sacramento Slough by the Karnak Plant owned by RD 1500.

2.8.5.5 Proposed O&M and Capital Improvements

To be completed.

2.8.6 District Operating Rules and Regulations

SMWC is a private mutual water company formed under California corporate laws and operates as a non-profit entity. The Company functions by its approved articles of incorporation and adopted bylaws. The Company is governed by a Board of Directors made up of seven elected shareholders (landowners) or appointed representatives. Elections are held each year in April. An annual budget is developed and approved each year so that the Company can perform on a cost-of-doing-business basis. Cash reserves are kept at a minimum and held essentially only to meet working capital and emergency capital needs.

Water rotation, apportionment, and shortage allocation: Lead times for water orders and shutoff under normal conditions is 24 hours.

> Requests for water delivery and shutoff can be given to the canal operator by 9 a.m. the day water is needed.
>
> Agricultural water allocation policy: *Water is allocated by share of Stock ownership and based on unit duty of crops grown.*
>
> According to Rule 5 of SMWC Rules and Regulations: *Whenever a general shortage of water appears imminent, the Board of Directors shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary, local or similar shortages, the Manager is authorized to place in effect such variations in service as in his judgment the occasion requires*.

Use of drainage waters:

> According to Rule 18 of SMWC Rules and Regulations: *The Company has an agreement with Reclamation District No. 1500 which allows the Company shareholders to make use of water from the District drains for irrigation purposes. Pursuant to this agreement, a user (shareholder/landowner) may pump drain water without further permission from either the District or Company by pumping directly from a drain situated in the Company service area boundaries for use on lands within the Company.*
>
> Policies for wasteful use of water: According to Rule 6 of SMWC Rules and Regulations: *Any water user who deliberately, carelessly or otherwise wastes water on roads, vacant land or land previously irrigated or who floods certain portions of the land to an unreasonable depth or who uses and unreasonable amount of water in order to irrigate other portions or who irrigates land which has been improperly checked for the economical use of water will be refused the use of water until such conditions are remedied or will have his use curtailed by the amount of waste, as the Manager may determine.*

The Company reserves the right to refuse delivery of water to any lands when it appears to the satisfaction of the Manager that its proposed use or method of use would require such excessive quantities of water as would constitute waste or unreasonable use.

Management shall be authorized to shut off water or reduce the flow when the ditchtender sees that the irrigation is finished, or water is being wasted, after first attempting to advise the person by telephone designated in the water order to be advised.

The Company currently has no water transfer policies.

2.8.7 Water Measurement, Pricing, and Billing

SMWC currently serves 78 farms and has approximately 512 delivery points, with 120 delivery points serving more than 1 farm. The Company measures flows at the main pump stations using flowmeters and pump flowcharts. Flows at lateral headgates are measured using headgate position. Drain lift pump flows are measured using seametrics insetion mag meters and transferred back to the operations via a SCADA system. Drainage leaving the Company is measured using a DWR formula for the main drainage discharge pump station. Minor increases in conveyance efficiency could be achieved by increased operations measurement, with installation of measuring facilities along the main canal and at the heads of laterals. Any new operations measurement program should be integrated with the long-term operations automation program.

SMWC is in the process of implementing a new turnout measurement program. As of December 2022, SMWC measures 281 turnouts using the Remote Tracker system, similar to RD 108, PID, and PCGID. Flow rates are set to match the field demand based on the irrigation method and field conditions. The total quantity of water delivered to each turnout is determined using volume flow rate calculation via spot flow measurement with acoustic velocimeter. At the remaining turnouts, flow rates are measured using canal stage and turnout gate position. The volume of delivery is measured based on the flow rate and time of delivery (typically 24 hours). SMWC continues to replace its turnouts with the new measurement system and expects that all turnouts will be completed by April 2024, for measurement of 100 percent of water delivered using the Remote Tracker system. Each installation costs about $5,000, for a total cost of $2.5 million to complete all 512 turnouts. Accuracy testing will begin when water use begins during the 2024 irrigation season, after all of the turnouts have been completed. At RD 108, this measurement system has an estimated accuracy of 4.6 percent, and similar accuracy is expected at SMWC. As of 2022, SMWC's pricing is fully volumetric. Table 2.8-6 presents an inventory of the Company's water measurement devices, including the existing turnouts that have not yet been replaced for measurement using the Acoustic Doppler Velocimeter method. In 2022, the Company changed its pricing structure to be volumetric pricing, on the basis of these measured deliveries.

Table 2.8-6. Agricultural Measurement Device Inventory for SMWC

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Concrete Large Weirs	15	±6 to 10%	Daily	N/A	Yearly if needed
Measured Gates	122	±6 to 10%	Daily	Yearly or as frequently as needed	Yearly if needed
Measured Risers	14	±6 to 10%	Daily	Yearly or as frequently as needed	Yearly or as frequently as needed
Acoustic Doppler Velocimeter	281	To be determined	Daily	Calibrated at installation	Yearly

Table 2.8-6. Agricultural Measurement Device Inventory for SMWC

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Measured Checks	95	±6 to 10%	Daily	Yearly or as frequently as needed	Yearly or as frequently as needed
Total	**527**				

Natomas Central Mutual Water Company (NCMWC)

2.9 Natomas Central Mutual Water Company

2.9.1 History

Natomas Central Mutual Water Company (NCMWC or the Company) was organized under the California Irrigation District Act of 1897 and included 50,000 acres. The Company entered into a negotiated agreement with Reclamation in 1964, quantifying the amount of water it would divert from the Sacramento River. The resulting negotiated agreement recognized NCMWC's annual entitlement to a Base Supply of 98,200 ac-ft/yr of flows from the Sacramento River and also provided for a 22,000 ac-ft allocation of Project Supply, resulting in a total contract entitlement of 120,200 ac-ft/yr. The schedule of monthly diversions of the Contract Total, Base Supply, and Project Supply are identified in Exhibit A to the Settlement Contract for NCMWC and is included in Table 2.9-1. The Settlement Contract negotiated in 1964 was renewed in May 2005 and will run until March 2045.

Table 2.9-1. Schedule of Monthly Water Diversions – NCMWC

Month	Base Supply (ac-ft)	Project Water (ac-ft)	Contract Total (ac-ft)
April	14,000	0	14,000
May	27,700	0	27,700
June	23,000	0	23,000
July	11,500	7,200	18,700
August	3,900	14,800	18,700
September	16,100	0	16,100
October	2,000	0	2,000
Total	**98,200**	**22,000**	**120,200**

Notes:

Contract No. 14-06-200-885A-R-1
Points of Diversion: 2.15L, 6.1L, 7.5L, 14.1L, 16.0L, 19.6L (Cross Canals 1.0S and 2.0S)

In addition to the contract water, NCMWC has entitlements to divert Sacramento River water during the non-irrigation season for wetlands and rice straw decomposition. There are approximately 65 privately owned wells and three NCMWC-owned wells within its boundaries. These wells are used in conjunction with the river pumps and recycling pump to meet irrigation needs on an as-needed basis. Rice is the predominant crop grown within the Company boundaries, in addition to managed marsh and grain.

2.9.2 Service Area and Distribution System

NCMWC is located on the east side of the Sacramento River between the towns of Knights Landing and Sacramento in the Counties of Sutter and Sacramento within the southern portion of the North American Subbasin. NCMWC's service area encompasses approximately 55,000 acres, which includes approximately 32,000 acres that are typically irrigated. The Company serves approximately 280 landowners. The Company's service area includes the Sacramento Municipal Airport and several residential developments, which are proposed in response to continued growth within and adjacent to the Sacramento area. NCMWC has four main pump stations located on the Sacramento River: Sankey Pump Plant, Prichard Lake

Pumping Plant, Riverside Pumping Plant, and Elkhorn Pumping Plant. Water diverted from the Sacramento River flows generally flow from west to east or south.

2.9.3 Water Supply

NCMWC holds water rights to divert water from the natural flow of the Sacramento River, the Natomas Cross Canal, and various drains within the Company. These diversions differ in the quantity and timing in which they can be used, as indicated in Table 2.9-2.

Table 2.9-2. NCMWC: Water Rights

Source	Water Rights[a,b]				
	Application[c] (Priority Date)[d]	Permit (Date)	License (Date)	Diversion Season	Maximum Quantity[e] (cfs)
Sacramento River, Natomas Cross Canal	A000534 (12/13/16)	000247 (3/16/17)	001050 (5/28/31)	Apr 1 to Oct 1	42.18 cfs
Sacramento River, Natomas Cross Canal	A001056 (8/22/18)	000511 (11/27/18)	002814 (2/18/46)	Mar 15 to Oct 15	38 cfs
Sacramento River, Natomas Cross Canal	A001203 (3/5/19)	000580 (6/10/19)	003109 (9/28/50)	May 1 to Oct 31	160 cfs
Sacramento River, Natomas Cross Canal	A001413 (8/27/19)	001129 (8/16/22)	003110 (9/28/50)	May 1 to Oct 1	120 cfs
Sacramento River, Natomas Cross Canal	A015572 (10/8/53)	015015 (8/26/66)	009794 (5/26/71)	Apr 1 to Jun 30	131 cfs
RD 1000 East Drain, RD 1000 Main Drain, RD 1000 West Drain	A022309 (10/8/65)	015314 (2/21/67)	009989 (1/26/73)	Primary: Mar 1 to Jun 30 Secondary: Sep 1 to Oct 31	14 cfs
Sacramento River, Natomas Cross Canal, RD 1000 East Drain, RD 1000 Main Drain, RD 1000 West Drain	A025727 (5/1/78)	019400 (2/7/85)	Pending	Oct 1 to Apr 1	168 cfs 10,000 ac-ft/yr

[a] Source: SWRCB; Division of Water Rights (https://www.waterboards.ca.gov/waterrights/).

[b] N/A – Priority Dates and License/Permit Information are not applicable for some types of water rights.

[c] The type of water right is indicated by the first letter in the Application reference, as follows:
A = Appropriative right
J = Adjudication
S = Statement of Water Diversion and Use
Z = Section 12 filings

[d] The Priority Date is the basis for defining the seniority of the water right, and is based on the application date.

[e] The amount of water diverted under the water right will be in accordance with the principles of reasonable and beneficial use.

2.9.3.1 Surface Water

The NCMWC surface water supply entitlement is currently addressed in a contract with Reclamation entered into in 2005, Contract No. 14-16-200-0885A-R-1 (Contract No. 0885A-R-1). This contract provides for an agreement between NCMWC and the United States on NCMWC's diversion of water from the Sacramento River during the period April 1 through October 31 of each year.

Contract No. 0885A-R-1 provides for a maximum total of 120,200 ac-ft/yr, of which 98,200 ac-ft is considered to be Base Supply and 22,000 ac-ft is CVP water (Project Supply), as shown in Table 2.9-3. The contract also provides that additional Project Supply can be purchased if surplus water is available.

Table 2.9-3. NCMWC: Settlement Contract Supply

	Base Supply (ac-ft)	Project Supply (ac-ft)
Critical Months	31,500	22,000
Non-critical Months	66,700	0
Total Annual	**98,200**	**22,000**

The contract specifies the total quantity of water by NCMWC that may be diverted each month during the period April through October each year. The monthly Base Supply ranges from a minimum of 2,000 ac-ft in October to a maximum of 27,700 ac-ft in May. CVP water (Project Supply) is available during the months of July and August with entitlements of 7,200 and 14,800 ac-ft, respectively. The contract identifies July, August, and September as the critical months. For the critical months, the total Base Supply is 31,500 ac-ft, and the total Project Supply is 22,000 ac-ft, as shown in Table 2.9-2. There are no restrictions on the Company's water sources.

Non-contract Period (November – March)

Contract No. 0885A does not limit NCMWC from diverting water for beneficial use during the months of November through March, to the extent authorized under California law. In response to increasingly stringent limitations on burning, many of the Company's landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. The number of flooded acres has consistently increased since 1994. In 1994, 500 acres were flooded in comparison to 4,000 acres in 1998 and 10,000 acres in 2019.

Other Surface Water Sources

NCMWC has water rights to several of the drainage facilities located within or bordering the Company including RD 1000 East Drain, RD 1000 West Drain, and the RD 1000 Main Drain.

2.9.3.2 Groundwater/Conjunctive Use

The vast majority of irrigation water requirements are met through the contract surface water supply, although groundwater is used in drought years on an individual grower basis, as well as per agreements with the Company. There are approximately 65 privately owned wells and 3 NCMWC-owned wells within its boundaries. These wells are used in conjunction with the river pumps and recycling pump to meet irrigation needs on an as-needed basis. The Company's three groundwater wells have a total capacity of approximately 15 cfs. Annual Company well groundwater pumping amounts range from 50 ac-ft to 2,400 ac-ft depending on year type.

Intentional groundwater recharge is not currently practiced in the Company. Incidental groundwater recharge occurs routinely from groundwater percolation resulting from conveyance losses and irrigation application practices.

Groundwater Subbasin Conditions

The total thickness of the freshwater aquifer increases from a few hundred feet in the east to more than 2,000 feet to the west. The area is located on recent alluvial sediments: channel, floodplain, basin, and terrace deposits. Flood basin and channel deposits have a maximum thickness in the area of approximately 100 feet. Flood basin sediments are deposited in low-energy environments; therefore, they typically exhibit low permeabilities. Stream channel sediments are deposited in higher energy environments. Because they are coarser grained, these materials generally have high permeabilities.

Underlying recent fluvial deposits are the Riverbank and Modesto Formations. These units consist of terrace deposits that range in thickness from 50 to 75 feet. Permeability of these formations is generally moderate; however, the occasional coarse-grained lenses have high permeability. These sediments are underlain by older deposits of the Laguna, Turlock, and Mehrten Formations (DWR, 1978; DWR, 2003c).

The Laguna and Turlock Formations underlie the Riverbank and Modesto Formations. These units are exposed along the eastern margin of the basin and dip westward (Page, 1980). Thickness of these formations is generally less than 200 feet. Deposits consist of a heterogeneous assemblage of interbedded silt, clay, and sand with gravel lenses. The coarse-grained deposits yield large quantities of water to wells.

The Mehrten Formation forms the base of the freshwater aquifer system in the North American Subbasin. This formation consists of two distinct units. The first unit consists of gray to black andesitic sands and gravels deposited by streams eroding the Sierra Nevadas. The second is a dark gray tuff breccia. Sand and gravel deposits have high yields, while the lower-permeability breccias act as confining units (DWR, 2003c).

Groundwater quality in the Sacramento Valley Groundwater Basin is generally good and sufficient for agricultural, domestic, and M&I uses. In general, natural groundwater quality is influenced by streamflow and recharges from the surrounding Coast Ranges and Sierra Nevada. Runoff from the Sierra Nevada is generally of higher quality than runoff from the Coast Ranges because of the presence of marine sediments in the Coast Range (DWR, 2003c). The total depth of fresh water in the NCMWC area is approximately 1,400 feet bgs (Berkstresser, 1973). The fresh water is underlain by saline water.

Groundwater movement in the NCMWC area is influenced by the pumping depression present in the southern portion of the North American Subbasin, groundwater subbasin number 5-21.64. Groundwater in the southern portion of the Company flows to the southeast, toward the pumping depression, at a gradient of 10 feet per mile. In the northern portion of the Company, groundwater flows to the south, toward the Sacramento River, at a gradient of 4 feet per mile (DWR, 2003c). Seasonal fluctuations of groundwater levels in the unconfined portion of the aquifer system ranges from 2 to 6 feet during years of normal precipitation and can range up to 10 feet during drought conditions (DWR, 2003b). In the semi-confined portion of the aquifer system, groundwater levels fluctuate 3 to 6 feet annually and up to 25 feet during drought conditions (DWR, 2003b). Wells located near recharge sources typically show less of an annual change in groundwater levels.

Past pumping and drought conditions have not historically negatively affected the overall long-term groundwater level trends in NCMWC. Until the late 1990s in a large part of northern Sacramento County immediately to the east of NCMWC, substantial historical M&I pumping stress had resulted in a progressive groundwater-level decline on the order of 1.5 feet per year for the last 50 years. Over the last 20 years, the water levels have consistently risen annually due to water use changes through the Water Forum Agreement. Overall, the historical lack of groundwater development in NCMWC has resulted in long-term, relatively stable, high groundwater levels in the NCMWC area.

Groundwater Planning/Sustainable Groundwater Management Act

NCMWC is an active partner in the SGMA planning process and GSP preparation through an agreement with Sutter County in the North American Subbasin. North American Subbasin is being managed by five Groundwater Sustainability Agencies: Sacramento Groundwater Authority, Sutter County, West Placer GSA, RD 1001, and South Sutter Water District. Currently the GSAs are actively working on a groundwater model and draft GSP. Draft chapters of the GSP are expected to be released for review late in 2020, and the plan is anticipated to be completed by January 31, 2022.

NCMWC does not participate in groundwater banking.

2.9.3.3 Other Water Supplies

In recent years, NCMWC has relied heavily on recycled water as an alternate supply to its Sacramento River entitlement. The source of this recycled water has been primarily from inside of the Company, although some recycled water is available from the lands on the western edge of the Company that are adjacent to the Sacramento River (approximately 7,000 acres). High groundwater levels in much of the Company service area also contribute inflow to the drains. Approximately 40,000 ac-ft of recycled water are used annually. Continued reuse and recycling efforts are expected to be influenced by an increasing need to manage salinity, pH, and other constituents that affect crop productivity and sustainability.

The Company completed the installation of a recirculation system in 1986 to improve water quality for the city of Sacramento and increase overall efficiency within the Company boundaries. The recirculation system has since provided for the following benefits:

- Improve water quality discharge from RD 1000 pumping plants into the Sacramento River.
- Reduce pumping during the summer months by RD 1000, thus reducing their operation costs.
- Increase water availability to parts of the service area with a history of "poor service."
- Reduce costs to customers (drain rate) who install drain pumps to receive tailwater exclusively.
- Reduce diversions and water costs paid (Restoration Fund) for Project Supply.
- Improve water conservation practices through the installation and operation of a Companywide recycling program.
- Allow greater flexibility for growers in method and timing of water application and crop selection without the institution of a metered water charge system.

The recirculation system includes 16 pumping stations at various locations that recapture water for reuse either directly into fields or back into the main irrigation canals. During a normal irrigation season, no agricultural drainage water returns to the Sacramento River until after the end of the rice irrigation season (between August 15 and September 1).

2.9.4 Water Use

Water use within the Company is predominantly agricultural as the Company does not currently serve water to any municipal or industrial users. Water balance summaries were developed for each SRSC and are included in Attachment M for the 2018 and 2019 irrigation years. These summaries are based on the

Agricultural Water Inventory Tables (Standard Tables) in the WMP (Reclamation, 2020) to meet the 2020 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production.

2.9.4.1 Agricultural

Rice is the overwhelmingly predominant crop grown within NCMWC's service area. Other crops include alfalfa, managed marsh, and truck farming along with rotation crops such as wheat, sunflower, and safflower, which are rotated with rice. Rice typically accounts for approximately 70 to 75 percent of the Company's irrigated acreage on an annual basis. Agriculture in NCMWC is under increasing pressure to convert to urbanized, residential use in the face of growth in the greater Sacramento region. Additionally, some of the urban developments, such as the airport, use Company water for ornamental landscaping, truck gardens, and fruit stands.

As is the case with most of the other water providers, water requirements are typically highest during the spring and summer months (May, June, July, and August) due to the requirements of rice and the area's hot, dry climate. Cultural practice water needs for rice are greatest early in the growing season associated with the flooding up of previously dry rice fields, as well as to meet the needs of other crops. The vast majority of irrigation water requirements are met through the contract surface water supply, although groundwater is used in drought years on an individual grower basis, as well as per agreements with the Company. The types of crops planted in NCMWC have not changed much over the last decade but annual cropping patterns have fluctuated due to weather-related issues. In 2017 and 2019, late spring rains caused fields to be too wet for planting, and the field remained fallow. Associated water requirement needs and associated diversions have therefore been more a function of water-year type and climate than changes in cropping. In response to increasingly stringent limitations on burning, some of the Company's rice-growing landowners flood a portion of their fields to clear their land of leftover rice straw by allowing the rice stubble to decompose. Approximately 5,780 acres were flooded in 1999, 6,700 acres were flooded in 2004, and 10,000 acres were flooded in 2020. This practice provides additional winter habitat for waterfowl above that which has been available within the Sacramento Valley since the development of agriculture.

2.9.4.2 Urban

As noted above, NCMWC has been experiencing increased growth pressure from the Sacramento area. The Company does not currently provide treated water for M&I, although it does provide water for landscaping. The Company's Board of Directors is currently coordinating with the City, County of Sacramento, and landowners to accommodate projected urban growth in the Natomas area.

M&I water demand within the North American Subbasin, which includes NCMWC, is anticipated to increase substantially over the next 20 years.

2.9.4.3 Environmental/Natural and Cultural Resources

Company lands are currently not all included in the Natomas Basin Habitat Conservation Plan that has been prepared to address long-term habitat needs for the giant garter snake, the American peregrine falcon, the valley elderberry longhorn beetle, and multiple other state- and federal-listed or threatened species. The preparation of the Natomas Basin Habitat Conservation Plan underscores the continuing resource agency concern with the continued urban development of lands within the NCMWC service area, which currently provide valuable habitat for a number of sensitive species. Adoption and implementation of this habitat conservation plan has placed additional constraints on both agricultural and M&I water use, including deliveries of water in the winter and cropping requirements. However, implementation of the

Natomas Basin Habitat Conservation Plan is expected to limit the amount of additional Company lands that could be converted to urban use**.**

Approximately 635 acres of riparian vegetation are estimated to be incidentally supplied by irrigation, including vegetation directly adjacent to delivery laterals or influenced by leakage from the delivery system. Such vegetation includes habitat used by the federally listed giant garter snake and other species that use such habitat as discussed above.

Up to 6,700 acres of rice stubble were flooded in 2004, with associated winter habitat benefits to migratory waterfowl that use the area as part of the Pacific Flyway. The flooding of rice fields in the spring and summer provides wetlands habitat during these periods for waterfowl and terrestrial species. Rice fields that are not flooded also provide habitat for waterfowl and upland birds as resting areas. Of these lands, the Natomas Basin Conservancy manages approximately 3,396 acres of environmental or wetlands areas within the Company.

There are no recreational and/or cultural resource areas within the company.

2.9.4.4 Topography and Soils

The Company's topography generally consists of nearly level to gently sloping terrain. Because the Company is relatively flat, the impact of the area's terrain on Company water management practices is negligible. There are no impacts from any microclimates on water management within the Company.

The soil associations that are found within the Company are identified below. Complete descriptions of the soil associations and the corresponding acreage of each association in the Company are provided in the NRCS Soil Surveys for Sutter and Sacramento Counties. There are no agricultural limitations resulting from soil problems.

Soil profile characteristics in the Sutter and Sacramento County areas of NCMWC are as follows (Attachment I):

- **San Joaquin-Cometa:** Moderately deep and very deep, level to nearly level, well-drained sandy loam and loam on terraces.
- **Clear Lake-Capay:** Deep and very deep, level to nearly level, poorly drained and moderately well-drained clay and silty clay in basins and on basin rims.
- **Shanghai-Nueva-Columbia:** Very deep, level to nearly level, somewhat poorly drained silt loam, loam, and fine sandy loam on floodplains.
- **Sailboat-Scribner-Cosumnes:** Somewhat poorly drained and poorly drained silt to clay loam with a seasonal high water table and are protected by levees.
- **Egbert-Valpac:** Somewhat poorly drained and poorly drained silty clay loam with a high water table throughout the year or during part of the year and are protected by levees.
- **Columbia-Cosumnes:** Sandy loam to silt loam, somewhat poorly drained soils that are subject to flooding or are protected by levees.
- **Clear Lake:** Somewhat poorly drained clay that has a seasonal high water table, is protected by levees, and is very deep or deep over a cemented hardpan.
- **San Joaquin:** Moderately well-drained loam that is moderately deep over a cemented hardpan.

2.9.4.5 Transfers and Exchanges

NCMWC periodically participates in transfers on dry years. These transfers fall into two categories: project water transfers and conjunctive use transfers. Periodically NCMWC will have small amounts of project water available for transfers. These transfers are north of the Delta transfers as part of the Reclamation transfer program. These transfers are typically to water districts on the Tehama Colusa Canal. Conjunctive use transfers are to the SLDMWA and consist of pumping of groundwater to supply lands within the Company with water, thus freeing up river water to be transferred. NCMWC had participate in three of these types of transfers in the last 10 years.

There are no other trades, wheeling, wet/dry exchanges, or other transactions.

2.9.4.6 Other Uses

No other significant water uses other than those discussed above occur within NCMWC.

2.9.5 District Facilities

2.9.5.1 Diversion Facilities

NCMWC has four main pump stations located on the Sacramento River: Sankey Pump Plant, Prichard Lake Pumping Plant, Riverside Pumping Plant, and Elkhorn Pumping Plant. Water diverted from the Sacramento River generally flows east or south. Table 2.9-4 summarizes these surface water supply facilities. A separate 75-cfs capacity pump at the Elkhorn Pumping Plant supplies landscape irrigation water for the Sacramento Metropolitan Airport. See Attachment A for a map of NCMWC's major conveyance facilities.

The Company owns groundwater wells, which are periodically used for water supply.

Table 2.9-4. NCMWC Surface Water Supply Facilities

Facility Name	Water Source	Pump/Gravity	Capacity (cfs)	Average Historical Diversion (ac-ft/yr)
Sankey Pump Plant	Sacramento River	Pump	430	68300
Prichard Lake Pumping Plant	Sacramento River	Pump	150	9500
Elkhorn Pumping Plant	Sacramento River	Pump	90	5300
Riverside Pumping Plant	Sacramento River	Pump	50	5000

2.9.5.2 Conveyance System

NCMWC's distribution and conveyance system includes approximately 260 miles of canals and laterals. Two main canals, the Northern Main Canal and the Bennett Main Canal, serve the northern and eastern portion of the Company service area with water from the Sankey Pumping Plant. The Central Main Canal, the Garden Highway Canals, and their associated laterals serve the central and southern portions of the service area. Table 2.9-5 summarizes the main distribution facilities.

Table 2.9-5. NCMWC Canals and Laterals

Facility Name	Source Facility	Capacity (cfs)	Lined	End Spill Location	Percent Leakage Loss Estimate
Bennett Main Canal	Sankey Pump Plant	100	No	Sankey Road Ditch	12
Central Main Canal	Prichard Lake Pumping Plant	130	No	Plant 8 Pumps	12
Northern Main Canal	Sankey Pump Plant)	200	No	Swimming Hole Diversion	12
Chappel Main Canal	Sankey Pumping Plant	50	No	None	12
East Drain	East Drain Pumps	20	No	None	12
Garden Highway South	Drain Pump No. 3	20	Yes	None	12
Garden Highway North	Riverside Pumping Plant	37	no	None	12
Elkhorn Canal	Elkhorn Pumping Plant	45	no	West Drain	10
Reservoir Road	Elkhorn Pumping Plant	45	Yes	Airport Drain	10
Pullman	Pullman Pumps	150	No	No. 3	12
No. 3	Pullman	60	No	Lateral 3C	12
No. 8	Central Main Canal	100	No	Sills Lateral	12
No. 13	Plant No. 13 Pumps	20	No	State Check Ditch	15

2.9.5.3 Storage Facilities

NCMWC currently has no storage facilities.

2.9.5.4 Spill Recovery/Outflow

NCMWC is drained by four main drainage canals: Natomas East Main Drainage, North Drainage, East Drainage, and West Drainage Canals. The Natomas East Main Drainage Canal drains directly into the Sacramento River, just north of its confluence with the American River. The West Drainage Canal and the East Drainage Canal join in the south and drain to the Sacramento River in the southern portion of the Company via a drain pump. In addition, the Company completed the installation of a recirculation system in 1986 to increase water quality for the city of Sacramento and increase overall efficiency of the Company. The recirculation system includes 16 pumping stations at various locations that recapture for use either directly onto fields or back into the main irrigation canals. Tables 2.9-6 and 2.9-7 summarize the main NCMWC drainage facilities.

Table 2.9-6. NCMWC Drain Pump Stations

Pump Station ID	Source	Discharges To	Capacity (cfs)	Average Historical Pumping Total (ac-ft/yr)
San Juan Pump	San Juan Ditch	San Juan Lateral	14	1,300
Plant No. 13 Pumps	West Drainage Canal	No. 13	20	200
Plant No. 8 Pumps	E Drainage Canal	H Road Lateral	75	4,200
E Drain Pumps	East Drainage Canal	E Drainage Canal	37	2,400
T-Drain Pump	T-Drain	Northern Main	18	4,300

Table 2.9-7. NCMWC Drainage Laterals

Name	End Spill	Downstream Diverters/Recapture
T-Drain	Northern Main Canal	N/A
North Drainage Canal	H1/Pullman Pumps	N/A
E Drainage Canal	Natomas E Main Drainage Canal	N/A
Airport Drain	West Drainage Canal	N/A
West Drainage Canal	Fisherman's Lake/Natomas Main Drainage	N/A
Fisherman's Lake	West Drainage Canal	N/A
San Juan Ditch	West Drainage Canal	N/A
Natomas E Main Drainage Canal	RD 1000 Pumping Plant	N/A

Note:

N/A = not applicable

During the growing season, drains are managed by NCMWC to deliver water. RD 1000 manages them in the off season (after October 1), when most drainage is returned to the Sacramento River. Outflow water monitoring is conducted by RD 1000.

2.9.5.5 Proposed O&M and Capital Improvements

Table 2.9-8 lists NCMWC's proposed O&M and capital improvements.

Table 2.9-8. NCMWC's Proposed O&M and Capital Improvements

Project	Description	Year
Garden Highway Canal Relocation	Relocation and replacement of Garden Highway canal with a new canal and pipeline	2020
Prichard Lake Pump Plant Upgrade	Replacement of discharge pipes through levee along with the installation of an additional river pump	2022
Riverside Pump Plant	Reconstruction and installation of fish screen	2021
Elkhorn Pump Plant	Reconstruction and installation of fish screen	2023

2.9.6 District Operating Rules and Regulations

NCMWC is a private mutual water company as defined in the California Public Utilities Code, Section 2705, formed for the delivery of water to its shareholders at cost. NCMWC is subject to local land use controls, including those of Sacramento and Sutter Counties and the City of Sacramento. The service area of the NCMWC, as defined by its contract for water with Reclamation, consists of the entire Natomas Basin. Within this defined 55,000-acre service area, NCMWC controls surface water rights for over 280 landowners who are shareholders of the Mutual Water Company. NCMWC is governed by a seven-member Board of Directors, which is elected every year by its shareholders.

Water rotation, apportionment, and shortage allocation:

> Policy 25 of NCMWC Water Policies: *All requests for water will be filled on the basis of when the request was submitted and the availability of water in each particular service area. Water requests will be filled as soon as possible and a request submitted before 11:00 a.m. will be filled that same day, when water is available. Requests submitted after 11:00 a.m., may not be filled until the following day, unless it is an emergency situation.*

Use of drainage water:

> Policy 8 of NCMWC Water Policies: *The water within all of the drainage canals is the sole property of the Company. The staff has been directed to maintain the drain canals at a consistent level. The water level for each drainage system is set to maximize the efficiency of the Company pumps which operate out of that system, but prevent drain water from reentering fields that are in the lower parts of that drain system.*

Policies for wasteful use of water:

> Policy 12 of NCMWC Water Policies: *Excessive spillage or dumping of water into the drains must be avoided to prevent the problem of drain level fluctuations. The field staff has been directed to report any spillage that looks to be out of the ordinary or excessive. The Company's permits and contract for water are based upon its ability to assure "Reasonable and Beneficial Use of a Public Resource" and its use of a number of "Best Management Practices." Several of those "practices" involve the reduction and/or elimination of spillage from all crops. You will be notified of any spills that are deemed excessive and be asked to reduce the spills. If management feels that spills continued to be above reasonable levels, it will be forced to reduce or stop the delivery of water to the identified parcel.*

NCMWC does not currently have a water transfer policy.

2.9.7 Water Measurement, Pricing, and Billing

NCMWC serves approximately 236 fields through 400 plus turnouts. NCMWC meters all water pumped from the Sacramento River through magnetic and ultra-sonic flowmeters installed and calibrated by the Company. Most turnouts are measured through meter gates, and some are metered with propeller meters (those that are on a pipeline). The propellered metered area (pipeline) is moving toward volumetric pricing. Accuracy information is included within Attachment C. The Company is currently in the process of replacing/retrofitting and calibrating all of the remaining meter gates to improve accuracy and is evaluating use of the Remote Tracker system for use in the future. NCMWC currently bills these turnouts on a per-acre basis but intends to move to volumetric pricing once Companywide measurement is completed.

Table 2.9-9 presents an inventory of the Company's water measurement devices.

Table 2.9-9. Agricultural Measurement Device Inventory for NCMWC

Measurement Type	Number	Accuracy (± percentage)	Reading Frequency	Calibration Frequency	Maintenance Frequency
Magnetic	13	±1	Continuous	3 years	Yearly
Ultrasonic	4	±1	Continuous	3 years	Yearly
Acoustic Doppler	20	±5	Continuous	3 years	Yearly
Propeller	28	±2	Continuous	3 years	Yearly
Certified Meter Gates	62	±10	Daily	Upon installation	Yearly
Total	**127**				

Section 3
District Best Management Practices

3. District Best Management Practices

This chapter provides a summary of each of the SRSCs' water management practices and coordinated efforts to date, as well as addresses district-specific best management practices identified in Reclamation's WMP, developed to meet the 2017 Standard Criteria for Agricultural and Urban Water Management Plans. Prior to this 2021 RWMP, the participating SRSCs worked with Reclamation to develop and implement the Regional Criteria. The Regional Criteria were developed in 2004 as an alternative "experimental" pilot program to the "Standard Criteria for Evaluating Water Management Plans." The Regional Criteria recognized the ongoing coordination of water management within and among the subregions of the Sacramento Valley served by the CVP, and coordination among SRSCs within and across those subregions. The Regional Criteria were used by the SRSCs and Reclamation over the last decade to allow and encourage both individual and joint efforts toward improved water management in the Sacramento Valley. The SRSCs intend to continue their successful coordination as part of meeting the Reclamation standard criteria and associated BMPs.

In accordance with the Regional Criteria, prior SRSC RWMPs analyzed what were termed "quantifiable objectives" (QOs) and "targeted benefits" (TBs) identified by the CALFED Water Use Efficiency Program. The coordinated actions driven in part by the CALFED process that have been developed and continue to be implemented by the SRSCs are discussed below prior to the review of district-specific BMPs.

3.1 Development of CALFED Targeted Benefits

In December of 2000, CALFED published Details of Quantifiable Objectives (CALFED, 2000). The purpose of this document was to provide the background, purpose, and conceptual approach to the development of QOs and TBs to achieve these goals. The Water-use Efficiency Element was one element of several elements in the CALFED Bay-Delta Program. The two primary goals of the Water-use Efficiency Element were as follows:

1) Encourage more water users and water suppliers to implement locally cost-effective, efficient, water management practices.
2) Provide funding to foster the implementation of practices that are cost effective from a statewide perspective but are not locally cost effective.

The development of TBs and QOs was intended to result in the ability to track and monitor the implementation of CALFED's Ag WUE Incentive Program. A total of 196 TBs were identified with specific objectives drawn primarily from CALFED documents, the Impaired Water Body List (303d), and discussions with local agricultural representatives. To account for variability in the valley, smaller, generally homogenous areas (subregions) were designated to assist in the development of TBs that address their unique nature. SRSCs are located within 4 of the 21 CALFED subregions identified across the state.

The voluntary Ag WUE Incentive Program identified incentives to motivate water suppliers and water users to institute practices that can most effectively and efficiently address regional or statewide objectives. The voluntary practices, which are proposed by local participants, are targeted at achieving region-specific benefits in water quality and quantity and in-stream flow and timing.

3.2 Sacramento Valley Water Quality Coalition

The Sacramento Valley Water Quality Coalition (Coalition) was formed in 2003 to enhance and improve water quality in the Sacramento River, while sustaining the economic viability of agriculture, functional values of managed wetlands, and sources of safe drinking water. The Coalition is composed of more than

8,600 farmers and wetland managers encompassing more than 1.1 million irrigated acres. It is supported by more than 200 agricultural representatives, natural resource professionals, and local governments throughout the region to improve water quality for Northern California farms, cities, and the environment. The vast majority of landowners and farmers within the service areas of the SRSCs participate directly as members of the Coalition and support it by disseminating information. This Coalition assists in meeting all required water quality requirements including monitoring for the presence and levels of constituents such as pesticides, turbidity, salinity, and other parameters in irrigation tailwater.

3.3 Prior SRSC Water Management Efforts

This section summarizes the SRSCs' previous efforts (in addition to plans and updates developed under the former Reclamation Regional Criteria) in identifying multi-benefit projects and programs, and the associated proposed actions in addressing the previous Regional Criteria.

3.3.1 Sacramento River Basinwide Water Management Plan

The BWMP, the precursor to this Regional Plan, was prepared and completed by the SRSCs in 2004 with assistance and input from DWR and Reclamation. Development of the BWMP, included extensive coordination among the participating districts and companies, as well as with DWR and Reclamation. The BWMP identified potential water management improvements, including subbasin-level management actions and system improvement (water use efficiency) projects. This planning process was a large step forward toward increasing cross-district communication and recognizing the potential for mutually beneficial projects and operations. Several recommendations, including potential inter- and intra-district projects and policy actions were identified and summarized in Chapter 8, "Implementation Conclusions and Recommendations," of the BWMP Plan Summary. The partnerships, cooperation, and ideas developed as part of the initial phases of the BWMP were a primary catalyst for the Sacramento Valley Water Management Agreement.

3.3.2 Sacramento Valley Water Management Agreement and Program

In July 1998, the SWRCB conducted a water rights hearing to consider how to implement the 1995 Water Quality Control Plan (WQCP). This administrative action was taken to allocate responsibility for achieving the 1995 WQCP objectives to water right holders, affecting the beneficial uses of the Bay-Delta. The proceedings were divided into eight phases to facilitate testimony, cross-examination, and potential settlements. After the completion of Phases 1 through 7, which involved the San Joaquin Valley and other Delta issues, Phase 8 addressed the responsibility of water right holders within the Sacramento Valley for meeting the 1995 WQCP. Phase 8 was expected to entail years of litigation and judicial review. This extended process would have undermined the progress of emerging regional efforts, including the BWMP and other statewide water management initiatives.

These projects and anticipated benefits led to the development and signing of the Sacramento Valley Water Management Agreement with Reclamation; DWR; U.S. Fish and Wildlife Service; the California Department of Fish and Game; and the State Water Contractors, which represent water users in Southern California, the Central Coast, and the San Joaquin Valley. Counties throughout the Sacramento Valley supported the agreement including ensuring that local needs were met. The signing of the agreement in 2002 resulted in the Sacramento Valley Water Management Program (SVWMP). The SVWMP was focused on water-short areas of the Sacramento Valley, providing additional water supplies for the Delta, and supporting water transfers to CVP and SWP users. It established a framework to meet water supply, water quality, and environmental needs in the areas of origin and throughout California. On January 31, 2003, the SWRCB officially dismissed the Phase 8 proceedings.

3.4 Implementation of Best Management Practices

Standard Criteria were developed by Reclamation in response to the CVPIA (Public Law 102-575) and in accordance with the RRA (Public Law 97-293). The Standard Criteria apply to any Water Management Plan submitted to Reclamation as required by applicable CVP water service contracts, repayment contracts, Settlement Contracts, or any contract that specifically invokes the Standard Criteria. The SRSCs have prepared this Regional Plan in accordance with the 2020 draft Standard Criteria while continuing and encouraging the cooperative approach among the participating SRSCs toward improved regional water management.

The 2020 draft Standard Criteria identifies that "Water contractors can coordinate with other agencies to develop and submit a single, regional plan. Reclamation will work with contractors submitting a regional plan to ensure compliance with the Criteria." Therefore, the participating SRSCs and Reclamation have agreed to develop a regional water management plan (this Regional Plan) to address the Standard Criteria while documenting the continued successful coordination of the SRSCs in overall regional water management. As such, this plan summarizes ongoing actions to address the BMPs identified below in coordination with other SRSCs and Sacramento Valley water districts as applicable. It is intended that future updates to this plan will be jointly prepared to reinforce the continued regional coordination across the SRSCs and the Sacramento Valley in general. Table 3-1 summarizes the progress in meeting each of the applicable BMPs by district. BMPs are identified by two categories per Reclamation's WMP that was developed to meet the 2020 Standard Criteria:

- *Critical Agricultural Best Management Practices* – these BMPs are considered to be the basic elements of good water management and are required to be implemented by agricultural districts with Reclamation water contracts.
- *Exemptible Agricultural Best Management Practices* – these BMPs are not always considered appropriate or possible for a given contractor to implement. In the case a contractor is considered exempt, all exemptions are required to be justified following the exemption process available in Addendum A of the 2020 WMP.

3.4.1 Best Management Practices (BMPs) Implementation by District – Critical Agricultural BMPs

The following summarizes implementation status for the five critical agricultural BMPs for each of the SRSCs:

- Water Measurement
- Water Conservation Coordinator and Contact Information
- Water Conservation Education and Outreach Programs
- Pricing Structure
- Evaluate and Improve the Efficiency of the District's Pumps

Project Water deliveries to ACID for the period 2014 through 2020 averaged less than 2,000 ac-ft/yr (copies of these records are available within Reclamation's files). Therefore, ACID is exempt from federal requirements to prepare a water management plan. ACID has voluntarily elected to continue its participation in the regional SRSC efforts and be included within this plan. The status of BMPs by ACID are described in this plan; however, while ACID continues to improve its water management capabilities, the District does not have an obligation to implement the BMPs.

3.4.1.1 Measure the Volume of Water Delivered by the District to Each Turnout with Devices that Are Operated and Maintained to a Reasonable Degree of Accuracy, Under Most Conditions, to +/- 6%

Table 3-2 summarizes the status of water measurement for each of the districts including number of delivery points and associated measurement. The majority of the participating SRSCs are continuing to make progress in their measurement efforts subject to annual funding limitations.

Table 3-1. Summary of Best Management Practices

BMP	ACID[a]	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
Critical Agricultural Best Management Practices									
A1: Water Measurement	Exempt	In progress	Implemented	In progress	Implemented	In progress	In progress	Implemented	In progress
A2: Water Conservation Coordinator and Contact Information	Implemented								
A3: Water Conservation Education and Outreach Programs	Implemented Regionally								
A4: Pricing Structure	Exempt	No	No	No	Implemented	No	Implemented	Implemented	In progress
		SRSCs that have not yet implemented this BMP intend to develop pricing structure once BMP A1-Water Measurement is fully implemented							
A5: Evaluate and Improve the Efficiency of the District's Pumps	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Exemptible Best Management Practices for Agricultural Contractors									
B1: Facilitate Alternative Land Use	Not Applicable								
B2: Facilitate Use of Available Recycled Water That Otherwise Would Not Be Used Beneficially	Not Applicable								
B3: Facilitate the Financing of Capital Improvements for On-farm Irrigation Systems	Implemented								
B4: Incentive Pricing	Exempt	No	No	No	No	No	No	Implemented	No
		SRSCs that have not yet implemented this BMP intend to evaluate incentive pricing options once BMP A1-Water Measurement is fully implemented							
B5A: Line Pipe Ditches and Canals	Implemented								
B5B: Regulatory Reservoirs	Not Applicable								
B6: Increase Flexibility in Water Ordering by, and Delivery to, Water Users	Implemented								
B7: Construct and Operate District Spill and Tailwater Recovery Systems	Implemented								
B8: Measure Outflow	Exempt	No	No	Implemented	No	No	Implemented	Implemented	Implemented
B9: Optimize Conjunctive Use of Surface and Groundwater	Implemented								
B10: Automate Distribution and/or Drainage System Structures	Implemented								
B11: Customer-owned Pump Testing and Evaluation	Implemented								
B12: Geographic Information System Mapping	Implemented								

[a] ACID average Project Water diversions during the last 5 years are less than 2,000 ac-ft (copies of these records are available within Reclamation's files). Therefore, ACID is exempt from federal requirements to prepare a water management plan. ACID has voluntarily elected to continue its participation in the regional SRSC efforts and be included within this plan. Therefore, the status of BMPs by ACID are described in this plan, but ACID does not have an obligation to implement the BMPs.

Table 3-2. Water Measurement

Critical BMP	ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
A1: Water Measurement	**Exempt**	**In progress**	**Implemented**	**In progress**	**Implemented**	**In progress**	**In progress**	**Implemented**	**In progress**
Number of delivery points (turnouts and connections)	774	236	228	2,470	198	191	523	620	513
Number of measured delivery points (meters and measurement devices)	0	136	228	264	198	0	279	620	85

As identified in Tables 3-1 and 3-2, PID, RD 108, and RD 1004 have fully implemented BMP A1. PID and RD 108 are using a Remote Tracker system. This measurement program uses long-crested weirs and other devices to maintain steady water levels in delivery canals, and devices that assure delivery pipes remain full. Ratings are maintained for each delivery point based on velocity measurement taken daily and when changes are made to the gate openings using Remote Tracker devices. An overview of the Remote Tracker system is available here: https://davidsengineering.com/projects/implementation-of-computer-based-customer-delivery-measurement-data-collection-and-accounting/. Deliveries using this system have been documented to be accurate to within ±4.6 percent at RD 108 (Davids Engineering, 2012), enclosed in Attachment C. A similar accuracy report has not yet been produced for PID since the system was just recently installed as of the date of this report and will begin collecting data when water deliveries start in 2023.

Many of the other SRSCs who are "in process" for implementing this BMP are adopting the same approach and methods for all (PCGID and SMWC) or some (MFWC and NCMWC) of their turnouts. For example, PCGID has already installed 136 meter boxes and purchased the Remote Tracker system in 2022, and intends to complete installation at its remaining turnouts in 2023. Similarly, SMWC purchased the Remote Tracker system in 2022 and completed 279 turnouts, and anticipates completing the remainder in 2024 (replacing about 80 to 100 turnouts per year). MFWC and NCMWC are currently testing this approach in certain parts of their systems. For example, MFWC has budgeted funds to replace 10 to 15 turnouts in 2023 and purchase the brackets and computers. In addition, as part of a Reclamation grant-funded fish screen and canal modification project, MFWC is going to be replacing 15 turnouts along the canal with the upgraded measurement boxes. Construction on this project is anticipated to occur until spring 2025; and when completed, MFWC plans to continue replacing turnouts and start implementing in these parts of its system in 2025. Assuming it is successful, MFWC plans to continue implementation Companywide, replacing about 15 turnouts per year, for full measurement by 2035.

RD 1004 has fully implemented BMP A1 using a different measurement approach, with propeller flowmeters permanently installed at each of its turnouts. At RD 1004, most of the meters are McCrometer Water Specialties propeller meters, with the majority being the "open flow meter" type and a few being the "strap-on saddle meter" type. The meters are factory certified to be accurate to within ±2 percent (see enclosed specification sheets in Attachment C). The District maintains the meters in accordance with the manufacturer recommendations. A few of the other SRSCs who are "in process" for implementing this BMP are adopting the same approach for some of their turnouts (MFWC and NCMWC). For example, NCMWC has installed Water Specialties propeller meters on all turnouts along a pipeline. The Water Specialties meters are factory certified to be accurate to within ±2 percent (see enclosed specification sheet in Attachment C) and include totalizers that record volume continuously. MFWC will likely use some type of flowmeter on its pumped turnout deliveries but needs to investigate potential options, particularly for its portable pumps, before determining the type and manufacturer. MFWC plans to conduct this investigation in 2023, with testing to occur in 2024.

GCID is also in the process of implementing a turnout measurement program. The measurement program includes a combination of measurement devices, which may include propeller meters, acoustic doppler meters, portable acoustic doppler meters, weirs with pressure transducers, and ITRC-calibrated meter gates. The installation of standard meter gates have been tested and certified by the ITRC to be within the accuracy requirements of the CVPIA. Additional details on GCID's plan (including specific measurement devices and accuracy of those devices) are included in Attachment C, report titled *Glenn-Colusa Irrigation District SB X7-7 Water Measurement Compliance Program - December 2016 Update*. As previously stated, the District has currently achieved automated turnout-level measurement of 30 to 50 sites per year the past 3 years and has a goal to increase to 100+ sites per year over the next 5 years. This would result is automated turnout-level measurement at all of GCID's turnouts in approximately 25 years. Concurrently, the District will undertake a public outreach effort that will include a series of public landowner and water

Table 3-3. Water Conservation Coordinator Contact Information

Category	ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
First Name	Jered	Lance	Lance	Greg	Terry	Andy	Roger	William	Brett
Last Name	Shipley	Boyd	Boyd	Krzys	Bressler	Duffey	Cornwell	Vanderwaal	Gray
Title	General Manager	General Manager	General Manager	Water Resources Manager	General Manager	General Manager	General Manager	Deputy Manager	General Manager
Address	2810 Silver St. Anderson, CA 96007	P.O. Box 98 Princeton, CA 95970-0098	258 S. Butte Street Willows, CA 95988	P.O. Box 150 Willows, CA 95988-0150	317 4th Street Colusa, CA 95932	P.O. Box 187 Meridian, CA 95957	P.O. Box 128 Robbins, CA 95676	P.O. Box 50 Grimes, CA 95950	2601 West Elkhorn Blvd. Rio Linda, CA 95673
Phone	530-365-7329	530-934-4801	530-934-4801	530-934-8881	530-458-7459	530-696-2456	916-765-0187	530-812-6276	916-826-7672
Email	gm@acidistrict.org	lboyd52@aol.com	lboyd52@aol.com	jkrzys@gcid.net	rd1004@comcast.net	aduffey@succeed.net	rcornwelld@sutterbasinwater.com	wvanderwaal@rd108.org	bgray@natomaswater.com

user meetings to educate stakeholders on the costs and the water rate increases that will be necessary to comply with these BMPs. Through a series of meetings with its water users, the District will ultimately settle on one preferred rate structure, and in accordance with the requirements of California's Proposition 218, an Engineer's Report will be prepared by a registered civil engineering firm. After the Engineer's Report is completed, the District will hold a public meeting to review the Engineer's Report and proposed rate structure. This meeting will trigger the start of a 45-day period that will allow all landowners to participate in a mail ballot election on the proposed changes to the rate structure. At the end of the 45-day period, the District will hold a hearing to tally the mail ballot results and set the rates. This is anticipated to occur once GCID has implemented automated turnout-level measurement on the majority of its system, approximately 2035.

Project Water deliveries to ACID for the period 2014 through 2020 averaged less than 2,000 ac-ft/yr (copies of these records are available within Reclamation's files). Therefore, ACID is exempt from federal requirements to prepare a water management plan. ACID has voluntarily elected to continue its participation in the regional SRSC efforts and be included within this plan. Therefore, the status of BMPs by ACID are described in this plan; however, ACID does not have an obligation to implement the BMPs. At this time, ACID is not actively pursuing a program to implement turnout measurement, beyond its current practices of estimating deliveries at each turnout with rated gates.

3.4.1.2 Designate a Water Conservation Coordinator to Develop and Implement the Plan and Develop Progress Reports

The participating SRSCs have identified Holly Dawley of GCID as the Regional Water Conservation Coordinator for this plan. Table 3-3 identifies the individual Water Conservation Coordinator for each contractor. The Regional Water Conservation Coordinator will lead the regional efforts related to the BMPs and coordinate group efforts including scheduling meetings and distributing information. Ms. Dawley is a registered California civil engineer with 20 years of water resources engineering and planning experience in the Sacramento Valley. Job duties of all Water Conservation Coordinators identified in Table 3-3 include 5-year plan preparation; implementation and annual updates; managing the work and communication with Reclamation; and attending Reclamation workshops to assist with plan development, preparation, implementation, and evaluation. Minimum qualifications of the Water Conservation Coordinator position include knowledge of SRSC operations and delivery systems, communication and organizational skills, and managerial skills to oversee work by staff and consultants.

3.4.1.3 Provide or Support the Availability of Water Management Services to Water Users

The SRSCs develop and conduct individual and cooperative programs with other contractors through regional actions to provide and support the availability of water management services to water users. Many of the SRSCs and programs provide newsletters, blog posts, website updates, or emails to inform water users. Attachment N provides an example of some of these materials. Services provided by SRSCs to assist their growers include on-farm irrigation and drainage systems evaluations, irrigation scheduling and crop evapotranspiration information, surface/ground/drainage water quantity and quality data, water management educational programs and materials for farmers and staff (and public), software, efficient irrigation techniques, crop water budgets, and program delivery via workshops, seminars, newsletters, websites, field days, and demonstrations. In addition, each SRSC will continue to support grower education programs including helping make information available related to farm herbicide use and salinity management. Each SRSC will continue to provide information to individual farmers about grower education programs, newsletters, and involvement in the Coalition through existing methods. In addition to the individual SRSC efforts, the Regional Water Conservation Coordinator (see BMP A2 above), has implemented a program to distribute education and outreach program regionally via post cards. The post cards include a link to a regional website focused on water conservation education and outreach programs, such as those previously described. These regional efforts have been implemented beginning in 2021.

One specific example of water conservation education the SRSCs share with landowners is the WATERIGHT website developed by the Center for Irrigation Technology at California State University, Fresno with support from Reclamation. WATERIGHT is designed to be a multi-function, educational resource for irrigation water management. An important resource available through the site is the irrigation scheduling programming that helps users develop site-specific, seasonal irrigation schedules. WATERIGHT is connected to the California Irrigation Management Information System (CIMIS). These weather stations provide the scheduling routines with reference evapotranspiration data for specific areas. In addition to the irrigation scheduling support and resources, the SRSCs offer/provide field and crop-specific water delivery information to the water user, as well as SRSC surface water diversion data as required under their water rights pursuant to SB 88 and the SWRCB's Measurement Regulation. The SRSCs also provide training and education of their staff for efficient water management. Many conduct staff training inhouse, and/or send water operators to the classes through ITRC at California State San Luis Obispo as well California State Chico. In addition to staff training, the SRSCs support and sponsor programs to encourage water conservation by the water users, such as a mobile lab to provide irrigation evaluations and recommendations.

3.4.1.4 Pricing Structure (Based at Least in Part on Quantity Delivered)

Table 3-4 provides individual district status for adopting a water pricing structure.

Table 3-4. Water Pricing Structure

Question	ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
Is your District in compliance with adopting a water pricing structure for District water users based at least in part on quantity delivered?	Exempt	No	No	No	Yes	No	Yes	Yes	No
If "no," are you meeting the milestones to adopt such a structure?	N/A	Yes	Yes	Yes	N/A	Yes	N/A	N/A	Yes

The SRSCs typically set price structures that cover O&M costs and long-term capital replacement and improvement costs. Some of the current price structures include a direct or indirect quantity component. There is an ongoing movement toward full measurement compliance, with some SRSCs currently at full compliance. Those in full compliance have also adopted pricing structures based on the measured quantity delivered. The remaining SRSCs intend to develop quantity-based pricing programs once turnout measurement BMP A1 is fully implemented. Generally, pricing structures include a basic annual maintenance charge (e.g., $10 per ac-ft/yr or $10 per share of company stock per year) that is independent of water use. In addition to this annual charge, pricing structures typically include one of the following charges; per acre, per irrigation, or per ac-ft. Additional details about individual SRSC water pricing structures are included in Chapter 1.

3.4.1.5 Evaluate and Improve Efficiencies of District Pumps – Implemented and Ongoing

The SRSCs monitor all pumps within their respective service areas daily during operation to verify pump performance and evaluate the need for pump repair on an as-needed basis. All pumps are tested on an as-needed basis and/or on a regular maintenance schedule. Most SRSCs have installed variable frequency drives (VFD) at many or all of their facilities to improve energy use efficiency and decrease energy costs. Individual SRSCs are researching future funding opportunities to install additional VFD controllers at key locations within their individual conveyance and drainage systems to further improve the efficiency of the water systems. Detailed information and the number of wells and lift pumps for each SRSC is provided within Chapter 2.

3.4.2 Exemptible BMPs for Agricultural Contractors

3.4.2.1 Facilitate Alternative Land Use – Not Applicable

Drainage characteristics of the land within the SRSCs do not feature high water tables (<5 feet), poor drainage, groundwater selenium concentration >50 parts per billion, or poor productivity. The lands are well suited to agricultural uses. Furthermore, no acres were converted this year, and no acres will be converted in following years. The SRSCs' irrigation does not contribute to significant problems. Therefore this BMP is not applicable to the SRSCs.

3.4.2.2 Facilitate Use of Available Recycled Urban Wastewater – Not Applicable

No recycled urban wastewater is available to the SRSCs that otherwise would not be used beneficially, meets all health and safety criteria, and does not cause harm to crops or soils. Therefore, this BMP is not applicable to the SRSCs.

3.4.2.3 Facilitate the Financing of Capital Improvements for On-farm Irrigation Systems – *Implemented*

Financial aid to farmers may include cataloging available funding sources and procedures and/or obtaining funding, administering the program, and providing low-interest loans.

The SRSCs do not have the purview or resources to provide on-farm financial assistance or provide low-interest loans. However, information regarding funding sources and procedures, grant administration, and loan programs is disseminated to water users/landowners on request and regularly via the SRSCs' individual and regional websites, landowner meetings, annual notices, and newsletters, as previously described under Critical BMP A3. Also, the district Water Conservation Coordinators are available to assist farmers that are interested in improving their on-farm irrigation systems. This includes informing users of funding sources such as grants or loans and other assistance to facilitate improvements. This BMP is considered implemented.

3.4.2.4 Incentive Pricing

Table 3-5 summarizes the current status of incentive pricing programs for each of the participating SRSCs.

Table 3-5. Incentive Pricing

Question	ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
Do you have a pricing structure that promotes efficient use of water at the farm or field level	Exempt	No Possibly when measure-ment implemented	No Possibly when measure-ment implemented	No Possibly when measure-ment implemented	Yes	No Possibly when measure-ment implemented	No Possibly when measure-ment implemented	Yes	No Possibly when measure-ment implemented

RD 1004 delivers water primarily to customers that require irrigation water for rice. Farmers are charged for 6 ac-ft of water per acre at the beginning of the season; those that use less based on measured deliveries are given refunds, and those that use more are charged for the additional water used. RD 108 charges for water used in part a flat rate and in part based on the measured volume delivered. In 2020, RD 108 adopted a resolution to reduce its flat rate component and increase its volumetric charge component to incentivize more efficient water use. This change shifted the flat rate price from $23 per acre to $10 per acre, and the volumetric price up to $15 per ac-ft. Therefore, those that use more water pay more than those who use less. In 2022, SMWC changed its pricing structure to be fully based on volume delivered, so those that use more water pay more than those who use less. The remaining SRSCs intend to develop incentive pricing programs once turnout measurement, BMP A1 is fully implemented. ACID is exempt from complying with BMP B4.

3.4.2.5 Line or Pipe Ditches and Canals – *Implemented*

Each of the participating SRSCs has lined or piped portions of their distribution systems to the extent feasible to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage where needed. The majority of the SRSCs' systems are unlined canals (many of which have relatively low seepage rates given significant amounts of clay soils within many districts). Associated seepage contributes to conjunctive use and groundwater recharge, particularly in districts with more porous soils. The SRSCs continue to evaluate their distribution systems and seepage rates, and will evaluate future projects to maintain and/or expand the lined or piped sections in the future. If any such projects are identified, the SRSCs will evaluate available funding sources to implement such projects.

Since the last Regional Plan was prepared, several of the SRSCs have completed canal lining or piping improvements in areas of very high seepage and/or requiring repairs. ACID completed a canal lining project in 2016. In 2019 PCGID installed a concrete floor for about 100 feet in a high-loss canal (cost of $12,000). In 2020 PID installed about 600 feet of pipe along its Highline Ditch (cost of $30,000)

Some SRSCs are in the process of canal lining or piping improvements to their delivery facilities. The following summarizes proposed/planned projects among the participating SRSCs:

- RD 108 has a grant proposal to pipe an additional 3,500 feet that it hopes to complete in the winter of 2020/2021.
- ACID intends to add about 3,600 feet of pipeline during the winter of 2020/2021 and is planning to apply for funding to complete another approximately 5,000 feet in the fall of 2021.
- PID plans to install an additional 600 feet of pipe along its Highline Ditch in early 2021 for a cost of about $30,000.
- MFWC plans to reline its main canal as part of its upcoming project to consolidate its points of diversions and add a fish screen.
- RD 1004 is searching for a grant funding option to extend the existing concrete lining of its main canal by approximately 3 miles. This project is proposed to be completed by the end of 2022 assuming a funding agreement with DWR is obtained by March of 2021.
- PCGID is investigating financing options to continue its canal concrete floor project in the future.

3.4.2.6 Construct Regulatory Reservoirs – *Not Applicable*

Water levels are maintained in the conveyance and drainage canals across each of the participating SRSCs' districts to provide regulatory storage for supplying peak demands. Therefore, explicit regulatory reservoirs are not necessary. This portion of the BMP is not applicable.

3.4.2.7 Increase Flexibility in Water Ordering by, and Delivery to, Water Users – *Implemented*

Each of the SRSCs maintains a high level of flexibility in their water ordering and delivery to customers. In all cases, customers may request water deliveries or changes with 1 t 2 days advance notice or less. Ditch tenders are provided with cell phones and direct radio connections to SCADA systems (where applicable) to accommodate delivery flexibility. All SRSCs allow customers to leave messages for water orders if staff are not available to answer the call at the time it is placed. Many have ditch tenders who work weekends and holidays, in addition to the regular work week. The majority of lands within the SRSCs' boundaries are planted to rice which, due to the irrigation and cultural practices specific to this crop, does not require more than 1 to 2 days for planning. Therefore, this BMP is considered implemented at this time. Increasing flexibility is re-evaluated as improvements are made to each of the SRSCs' delivery systems and as resources allow. See Attachment J; SRSC "agricultural water order" forms are included for each individual SRSC.

3.4.2.8 Construct and Operate District Spill and Tailwater Recovery Systems – *Implemented*

The specific facilities of each SRSC are described within Chapter 2. Generally, the Sacramento Basin may be characterized as a "flow-through" system, in that the vast majority of the water that is not consumptively used eventually returns to the river or is available for diversion by downstream water users. Water in excess of crop irrigation needs is returned to the river via drains that carry surface runoff away from fields. Water may also percolate into the ground, where it recharges groundwater supplies. Groundwater levels remain high in the Sacramento Valley. In some areas, groundwater is tributary or adds to river flows during normal or wet years. Excess groundwater may also enter nearby drains and return to the river system as drain water.

All of the water returned to the river system is reused by downstream water users or is used to meet Delta outflow requirements. Therefore, the actions of upstream users can have a considerable effect on agricultural users and other entities located downstream. Although water from the river is used efficiently, the timing of diversions and return flows may affect water availability at other locations within the system, necessitating effective water management.

Agricultural water requirements are met through both surface water and groundwater supplies, as well as reused or recirculated tail or drain water. Each subbasin may meet its specific requirements using the optimal combination of sources, depending on specific needs and characteristics of the particular subbasin. The Sacramento River and its tributaries are the primary sources of surface water for users in the Sacramento Valley. All sources must be recharged by precipitation, which can vary significantly from year to year. Flows within the Sacramento River are also influenced by the operation of the Shasta, Keswick, and Oroville Dams, and other climatic and infrastructure requirements. Water rights and contractual allocations also dictate use of surface water.

Drain water provides an important source of water in many areas of the Sacramento Valley. It is provided by runoff from fields and groundwater seepage into surface water drains. The source of this water is mainly water originally diverted from the Sacramento River upstream of the drain water users. Although not a "new" source of water, reuse of drain water allows water users to manage the timing and quantity of water delivered, providing flexibility and maximizing water use efficiency within the region. Because of the extensive reuse of tail and drain water by and between SRSCs and others, water use efficiencies within the Sacramento River Basin and its subbasins have been estimated to be as high as 90 percent. Conservation programs have been developed by several SRSCs, many of which rely on recirculation and reuse of drain water and reduced river diversions. In several cases, during the irrigation season some SRSCs operate mainly as closed systems, recapturing and recirculating tailwater within their systems until the end of the irrigation system. In other cases, tailwater from one SRSC supplements the supply available to another

SRSC or other water users. As an example, tailwater from GCID, PCGID, PID, and other diverters from the Sacramento River drains into the Colusa Basin Drain providing the majority of the water supply available to over 50,000 acres of lands within the Colusa Drain Mutual Water Company. This BMP is considered implemented.

3.4.2.9 Plan to Measure Outflow

Table 3-6 summarizes the current status of outflow measurement programs for each of the participating SRSCs.

Table 3-6. Outflow Measurement by District

Outflow	ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
Total Number of Surface Outflow Locations/Points	Exempt	2	2	11	5	1	1	2	8
Total Number of Subsurface Outflow Locations/Points	Subsurface outflow occurs in all of the SRSCs' service areas through percolation of applied surface water beyond the root zones and seepage from the distribution and drainage systems. This subsurface outflow is unmeasurable but contributes to groundwater recharge and subsurface flows within the Sacramento River and its subbasins.								
Number of Measured Outflow Point	N/A	0 Investigating options, requires structure to maintain fill pipe for measurement	0	11 Note: Davis Weir measures total outflow from GCID as well as others	0 Note: Closed system during irrigation season (no outflow occurs)	0	Calculated based on water level data recorded at 15-minute intervals	1 metered 1 estimated	8

3.4.2.10 Optimize Conjunctive Use of Surface and Groundwater – *Implemented/Ongoing*

Agricultural water requirements are met through both surface water and groundwater supplies, as well as reused or recirculated drain water. Each subbasin may meet its specific requirements using the optimal combination of these sources, depending on basin-specific needs and characteristics. The Sacramento River and its tributaries are the primary sources of water for users in the Sacramento Valley. All sources must be recharged by precipitation, which can vary significantly from year to year. Flows within the Sacramento River are also influenced by the operation of the Shasta, Keswick, and Oroville Dams, and other climatic and infrastructure requirements. Water rights and contractual allocations also dictate the use of surface water in any given year and change the SRSCs' reliance on groundwater for that year. Although SRSCs primarily rely on surface water, groundwater is also used to augment surface supplies, particularly during dry periods. Major aquifers in the Sacramento Basin include the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. In general, groundwater is a minor source of supply because of relatively higher pumping and equipment costs. Although the vast majority of the water that is not consumptively used by the SRSCs eventually returns to the river, water may also percolate into the ground (largely through unlined canals), where it recharges groundwater supplies. Groundwater levels remain high in the Sacramento Valley. In some areas, groundwater is tributary or adds to the river flows during normal or wet years. Excess groundwater may also enter nearby drains and return to the river system as drain water. Therefore, this BMP is considered implemented.

Currently, the SRSCs are developing their GSPs in coordination with their Groundwater Sustainability Agencies. As part of these processes, future conjunctive use projects or efforts may be identified to further optimize the conjunctive use of surface water and groundwater.

3.4.2.11 Automate Distribution and/or Drainage System Structures – *Implemented*

Each of the participating SRSCs has implemented automation on their respective conveyance and drainage systems to increase distribution system flexibility and reduce spill to the extent feasible. As described under BMP B9, in many cases, spill from the SRSCs' services areas provide some or a majority of the water supply to downstream water users. The majority of the SRSCs' systems are unlined canals that contribute to conjunctive use and groundwater recharge. The SRSCs continue to evaluate their distribution systems and drainage systems and will evaluate future projects to maintain and/or expand the use of automation where determined to be feasible in the future. For example, SMWC recently had ITRC conduct a study on its main canal to evaluate potential system improvements, including additional automation. If any such projects are identified, the SRSCs will evaluate available funding sources to implement such projects.

3.4.2.12 Facilitate or Promote Water Customer Pump Testing and Evaluation – *Implemented Regionally*

While the SRSCs only have purview for their conveyance systems, districts also provide their landowners and water users with information regarding programs available to assist in system efficiencies, such as pump testing and evaluation. For example, information about the Advanced Pumping Efficiency Program (APEP), an educational and incentive program intended to improve overall pumping efficiency and encourage energy conservation in California, is disseminated to water users/landowners on request and regularly via the SRSCs' individual and regional websites, landowner meetings, annual notices, and newsletters, as previously described under Critical BMP A3 and Exemptible BMP B3. Also, the Water Conservation Coordinators are available to assist farmers that are interested in pump testing and evaluation. See also Attachment I, Notices of District Education Programs and Services Available to Customers.

3.4.2.13 Mapping – *Implemented*

Each of the SRSCs has mapping of the irrigation districts, including their distribution and drainage systems. Some of the SRSCs have developed and updated these maps through programs with DWR. Currently, many of the SRSCs are adding to and updating their mapped systems through development of their GSPs in coordination with their Groundwater Sustainability Agencies. In addition, the SRSCs have access to publicly available mapped data sets such as multiple groundwater data sets from DWR through its SGMA Data Viewer, California Statewide Groundwater Elevation Monitoring program, and Water Data Library. Soils maps and information are also publicly available and used by the SRSCs when needed through the U.S. Department of Agriculture NRCS's Web Soil Survey. Many of these data sets, in addition to other natural and cultural resources mapping applications, have been combined through the California Natural Resources Agency's Open Data platform whose mission is to restore, protest, and manage the state's natural, historical, and cultural resources. Therefore, this BMP is fully implemented.

3.4.3 Provide a 5-year Budget for Implementing BMPs

Table 3-7 provides district budgets by BMP category for the current year. Tables 3-8 through 3-11 identify preliminary budgets by category through the following 4 years, recognizing that priorities may shift each year and/or be affected by revenue (and grant funding availability in some instances) due to water year type and other.

Table 3-7. Amount Spent during Current Year

Year 1 BMP #	BMP Name	Budgeted Expenditure (not including staff time)								
		ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
A1	Measurement	N/A	$45,000	$45,000	$130,000		$25,000	$25,000	X	$60,000
A2	Conservation Staff	N/A			$10,000		X	X		
A3	On-farm Evaluation/Water Delivery Information	N/A					X	X	X	
	Irrigation Scheduling	N/A					X	X	X	
	Water Quality	N/A					X	X	X	
	Agricultural Education Program	N/A						X		
A4	Quantity Pricing	N/A						X	X	
A5	SRSCs' Pumps	N/A	$28,500	$72,242	$800,000		$25,000	$55,000		
B1	Alternative Land Use	N/A						X		
B2	Urban Recycled Water Use	N/A								
B3	Financing of On-farm Improvements	N/A								
B4	Incentive Pricing	N/A						X		
B5	Line or Pipe Canals/Install Reservoirs	N/A	$30,000	$30,000					$1,000,000	
B6	Increase Delivery Flexibility	N/A						$15,000		$1,500,000
B7	District Spill/Tailwater Recovery Systems	N/A			$100,000			$25,000		
B8	Measure Outflow	N/A						X	X	
B9	Optimize Conjunctive Use	N/A						$5000		
B10	Automate Canal Structures	N/A							$680,000	
B11	Customer Pump Testing	N/A						$2,500		
B12	Mapping	N/A						X		
	Total	N/A								

Table 3-8. Amount Spent during Second Year

Year 2 BMP #	BMP Name	Budgeted Expenditure (not including staff time)								
		ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
A1	Measurement	N/A	$20,000	$20,000	$130,000		$25,000	$50,000	X	$30,000
A2	Conservation Staff	N/A			$10,000		X			
A3	On-farm Evaluation/Water Delivery Information	N/A					X		X	
	Irrigation Scheduling	N/A					X		X	
	Water Quality	N/A					X		X	
	Agricultural Education Program	N/A								
A4	Quantity Pricing	N/A							X	
A5	SRSCs' Pumps	N/A	$18,000	$18,000	$700,000		$20,000	$50,000		
B1	Alternative Land Use	N/A								
B2	Urban Recycled Water Use	N/A								
B3	Financing of On-farm Improvements	N/A								
B4	Incentive Pricing	N/A								
B5	Line or Pipe Canals/Install Reservoirs	N/A							$350,000	$4,000,000
B6	Increase Delivery Flexibility	N/A								$2,000,000
B7	District Spill/Tailwater Recovery Systems	N/A								$500,000
B8	Measure Outflow	N/A							X	
B9	Optimize Conjunctive Use	N/A						$5,000		
B10	Automate Canal Structures	N/A						500,000	$100,000	
B11	Customer Pump Testing	N/A								
B12	Mapping	N/A								
	Total	N/A								

Table 3-9. Amount Spent during Third Year

Year 3 BMP #	BMP Name	Budgeted Expenditure (not including staff time)								
		ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
A1	Measurement	N/A	$20,000	$20,000	$130,000		$35,000	$250,000	X	$40,000
A2	Conservation Staff	N/A			$10,000		X			
A3	On-farm Evaluation/Water Delivery Information	N/A					X		X	
	Irrigation Scheduling	N/A					X		X	
	Water Quality	N/A					X		X	
	Agricultural Education Program	N/A								
A4	Quantity Pricing	N/A							X	
A5	SRSCs' Pumps	N/A	$20,000	$20,000	$20,000		$30,000	$85,000		
B1	Alternative Land Use	N/A								
B2	Urban Recycled Water Use	N/A								
B3	Financing of On-farm Improvements	N/A								
B4	Incentive Pricing	N/A								
B5	Line or Pipe Canals/Install Reservoirs	N/A							$50,000	$4,000,000
B6	Increase Delivery Flexibility	N/A								
B7	District Spill/Tailwater Recovery Systems	N/A			$100,000			$85,000	$50,000	$300,000
B8	Measure Outflow	N/A							X	
B9	Optimize Conjunctive Use	N/A								
B10	Automate Canal Structures	N/A						$500,000	$50,000	$80,000
B11	Customer Pump Testing	N/A								
B12	Mapping	N/A						$5,000		$20,000
	Total	**N/A**								

Table 3-10. Amount Spent during Fourth Year

Year 4 BMP #	**BMP Name**	**Budgeted Expenditure (not including staff time)**								
		ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
A1	Measurement	N/A	$20,000	$20,000	$130,000		$35,000	$125,000	X	$30,000
A2	Conservation Staff	N/A			$10,000		X			
A3	On-farm Evaluation/Water Delivery Information	N/A					X	$25,000	X	
	Irrigation Scheduling	N/A					X		X	
	Water Quality	N/A					X		X	
	Agricultural Education Program	N/A								
A4	Quantity Pricing	N/A							X	
A5	SRSCs' Pumps	N/A	$20,000	$20,000	$30,000		$30,000	$50,000		
B1	Alternative Land Use	N/A								
B2	Urban Recycled Water Use	N/A								
B3	Financing of On-farm Improvements	N/A								
B4	Incentive Pricing	N/A								
B5	Line or Pipe Canals/Install Reservoirs	N/A							$350,000	
B6	Increase Delivery Flexibility	N/A						$5,000		
B7	District Spill/Tailwater Recovery Systems	N/A						$50,000	$500,000	$150,000
B8	Measure Outflow	N/A							X	
B9	Optimize Conjunctive Use	N/A								$200,000
B10	Automate Canal Structures	N/A						$200,000	$500,000	
B11	Customer Pump Testing	N/A								
B12	Mapping	N/A								$20,000
	Total	**N/A**								

Table 3-11. Amount Spent during Fifth Year

Year 5 BMP #	BMP Name	Budgeted Expenditure (not including staff time)								
		ACID	PCGID	PID	GCID	RD 1004	MFWC	SMWC	RD 108	NCMWC
A1	Measurement	N/A	$20,000	$20,000	$130,000		$35,000	$200,000	X	$50,000
A2	Conservation Staff	N/A			$10,000		X			
A3	On-farm Evaluation/Water Delivery Information	N/A					X		X	
	Irrigation Scheduling	N/A					X		X	
	Water Quality	N/A					X		X	
	Agricultural Education Program	N/A								
A4	Quantity Pricing	N/A						$5,000	X	
A5	SRSCs' Pumps	N/A	$20,000	$20,000	$15,000		$30,000	$50,000		
B1	Alternative Land Use	N/A								
B2	Urban Recycled Water Use	N/A								
B3	Financing of On-farm Improvements	N/A								
B4	Incentive Pricing	N/A					$5,000	$5,000		
B5	Line or Pipe Canals/Install Reservoirs	N/A							$750,000	
B6	Increase Delivery Flexibility	N/A						$5,000		
B7	District Spill/Tailwater Recovery Systems	N/A			$100,000			$85,000	$500,000	$150,000
B8	Measure Outflow	N/A							X	
B9	Optimize Conjunctive Use	N/A						$25,000		$200,000
B10	Automate Canal Structures	N/A						$200,000	$250,000	
B11	Customer Pump Testing	N/A								
B12	Mapping	N/A								$20,000
	Total	**N/A**								

Section 4
Regional Water Quality Management and Monitoring Program

4. Regional Water Quality Management and Monitoring Program

This section summarizes current regional water quality management efforts including ongoing participating SRSC actions such as tailwater management. It is important to recognize that tailwater is often reused either within a district or by an adjoining district (particularly in the Colusa Subbasin) as a source of supply. The "optimum" tailwater flow is influenced by many factors including hydrology, cropping patterns, and individual cultural farming practices. Use of tailwater allows districts to maximize available water in-lieu of river diversions.

4.1 Water Quality and the Sacramento Valley Water Quality Coalition

The Sacramento Valley Water Quality Coalition (Coalition) was formed in 2003 to enhance and improve water quality in the Sacramento River, while sustaining the economic viability of agriculture, functional values of managed wetlands, and sources of safe drinking water. The Coalition is composed of more than 8,600 farmers and wetlands managers encompassing more than 1.1 million irrigated acres and supported by local farm bureaus, resource conservation districts, County Agricultural Commissioners, and crop specialists with the University of California Cooperative Extension to improve water quality for Northern California farms, cities, and the environment.

The Coalition developed and submitted its initial Regional Plan for Action to the SWRCB and Water Board in June 2003. To implement the Regional Plan for Action and to meet the Water Board's Irrigated Lands Regulatory Program (ILRP), the Coalition prepared and submitted a revised Monitoring and Reporting Program Plan (MRPP) on July 25, 2008 (the initial MRPP was submitted in April 2004 and remained in effect through 2008). To effectively implement the MRPP, the Coalition and 12 (now 13) sub-watershed groups signed a Memorandum of Agreement that defines the respective roles and responsibilities of the sub-watershed groups, as well as Northern California Water Association. Additionally, the Coalition signed a Memorandum of Agreement with the California Rice Commission to coordinate the respective water quality programs in the Sacramento River Basin. In 2015, the Sacramento Valley Water Quality Coalition's Water Quality Management Plan (2009 Management Plan) was reorganized into the Comprehensive Surface Water Quality Management Plan (CSQMP). The CSQMP was updated last in September 2016 and approved by the Central Valley Regional Water Quality Control Board in November 2016.

Although water districts are typically not direct members of the Coalition, many districts and companies have encouraged landowners to join and have assisted in grower education through newsletters and information updates. The Coalition is continuing to pursue partnerships with municipalities and urban areas in the region that are developing stormwater management plans and facing increasingly more stringent effluent limitations.

Monitoring sites evaluated in 2019 included 15 representative sites, 3 integration sites, and 4 special project sites where monitoring requirements were triggered by management plans. Figure 4-1 shows the water and sediment sites that were monitored by the Coalition during 2019.

Beginning in 2015, data compiled from Coalition Member Farm Evaluations have been used to establish goals for additional management practice implementation needed to address potential exceedances of Basin Plan water quality objectives and ILRP Trigger Limits. Results from the 2019 *Annual Monitoring Report* indicate with few exceptions that there are no major water quality problems with agricultural and managed wetland discharges in the Sacramento River Basin. Development of the amended MRPP allowed the Coalition to re-evaluate the waterways, identify drainages with the highest and most inclusive agriculture, and use water quality data from those sites to represent other similar areas. On the basis of the results collected by the Coalition to date, the Coalition proposed a much more focused monitoring program. Similarly, the Coalition proposed to conduct more focused monitoring of most trace elements (arsenic, cadmium, lead, nickel, selenium, and zinc) given monitoring to date has demonstrated that these metals do not exceed objectives and are not likely to cause adverse impacts to aquatic life or human health in waters receiving agricultural runoff in the Coalition watershed. In December 2009, the Water Board approved a 5-year specific MRPP that focuses on surface water quality monitoring and analysis of the pesticides, herbicides, nutrients, and other agricultural products specifically used locally in the sub-watersheds of the Sacramento Valley.

A total of 22 sampling sites were monitored by the Coalition and coordinating subwatershed monitoring programs during 2019; see Table 4-1. Additional sites that have management plan requirements were also monitored. The annual monitoring reports, including the analysis of outflow water, are available for review and included as Attachment O.

Table 4-1. 2019 Sacramento Valley Coalition Monitoring Sites

Sub-watershed	Location	Latitude	Longitude
Butte-Sutter-Yuba	Lower Honcut Creek at Highway 70	39.30915	-121.59542
Butte-Sutter-Yuba	Butte Slough at Pass Road	39.1873	-121.90847
Butte-Sutter-Yuba	Gilsizer Slough at George Washington Road	39.009	-121.6716
Butte-Sutter-Yuba	Lower Snake River at Nuestro Road	39.18531	-121.70358
Butte-Sutter-Yuba	Sacramento Slough bridge near Karnak	38.785	-121.6533
Butte-Sutter-Yuba	Pine Creek at Highway 32	39.75338	-121.70358
Colusa Glenn	Walker Creek near 99W and CR33	39.62423	-122.19652
Colusa Glenn	Colusa Basin Drain above KL	38.8121	-121.7741
Colusa Glenn	Rough and Ready Pumping Plant (RD 108)	38.86209	-121.7927
Colusa Glenn	Freshwater Creek at Gibson Rd	39.17664	-122.18915
Goose Lake	Lower Lassen Creek	41.89103	-120.35594
Lake	McGaugh Slough at Finley Road East	39.00417	-122.86233
Lake-Napa	Middle Creek upstream from Highway 20	39.17641	-122.91271
Solano-Yolo	Shag Slough at Liberty Island Bridge	38.30677	-121.69337
Butte-Sutter-Yuba	Lower Snake River at Nuestro Road	39.18531	-121.70358
Butte-Sutter-Yuba	Sacramento Slough Bridge near Karnak	38.785	-121.6533
Butte-Sutter-Yuba	Pine Creek at Nord Gianella Road	39.78114	-121.98771
Colusa Glenn	Freshwater Creek at Gibson Road	39.17664	-122.18915
El Dorado	Coon Hollow Creek	38.75335	-120.72404
Pit River	Pit River at Pittville Bridge	41.0454	-121.3317
PNSNSS	Coon Creek at Brewer Road	38.93399	-121.45184
Sac-Amador	Cosumnes River at Twin Cities Road	38.29098	-121.38044
Sac-Amador	Grand Island Drain near Leary Road	38.2399	-121.5649
Shasta-Tehama	Anderson Creek at Ash Creek Road	40.418	-122.2136

Table 4-1. 2019 Sacramento Valley Coalition Monitoring Sites

Sub-watershed	Location	Latitude	Longitude
Solano	Shag Slough at Liberty Island Bridge	38.30677	-121.69337
Solano	Ulatis Creek at Brown Road	38.307	-121.794
Yolo	Willow Slough Bypass at Pole Line	38.59015	-121.73058
Upper Feather	Middle Fork Feather River above Grizzly Creek	39.816	-120.426

Changes in practices and implementation of additional management practices to minimize discharges of waste contributing to exceedances have been ongoing since the ILRP was initiated. As a result of the outreach and education efforts of the Coalition and its members and partners, specific trackable goals (Management Practice Implementation and Performance Goals [MPIPG]) for a number of pesticide and toxicity management plans were developed and submitted to the Regional Water Board beginning in 2011. Although most of these MPIPGs were not comprehensively reviewed by the Water Board, implementation of management practices to meet these goals was initiated in the subwatersheds in anticipation of Regional Water Board approval. Assessment of progress toward specific implementation goals will continue to be conducted regularly in coordination with the Regional Water Board as necessary, and as documented in individual approved MPIPG documents and required by the current Waste Discharge Requirement (WDR) and approved CAQMP until these pre-2014 management plans are completed.

4.1.1 Sacramento Valley Management Plan

Meeting water quality objectives is the ultimate goal and measure of effectiveness of the implemented management practices and progress for the Management Plan. Water quality monitoring to measure this progress is ongoing and assessed annually and has resulted in the completion of 41 Management Plans to date. Progress is measured by the completion and ongoing work on specific Management Plan tasks and deliverables summarized in the 2019 Annual Monitoring Report and included as Attachment O.

To address specific water quality exceedances, the Coalition developed a Management Plan (http://www.svwqc.org/) in 2009. The Management Plan was approved by the Regional Water Board in 2009, reorganized into the CSQMP in 2015, and approved by the Regional Water Board in 2016. The implementation of the CSQMP is the primary method of addressing exceedances observed in the Coalition's surface monitoring.

This Management Plan includes the following elements, as specified in the ILRP:

- Overall Approach
- Registered Pesticides
- Toxicity in Water and Sediment
- Pathogen Indicators
- Legacy Organochlorines Pesticides
- Trace Metals
- Salinity
- Dissolved oxygen and pH
- List of Exceedances Requiring Management Plan Development and Implementation
- Site-specific Management Plan Implementation

The Coalition's WDRs, Order No. R5-2014-0030, specify the requirements for separate Surface Water Quality Management Plans (SQMPs), and also allow the Coalition the option of submitting separate

SQMPs when they are triggered or submitting an updated CSQMP on an annual basis that identifies any new SQMPs triggered during the preceding monitoring year (October 1 through September 30). SQMPs includes the following elements, consistent with guidance proposed in the Monitoring Reporting Program (MRP) approved by the Water Board in March 2014 (Order No. R5-2014-0030):

- Executive Summary
- Location map(s) and a brief summary of management plans covered by the report
- Updated table that tallies all exceedances for the management plans
- A list of new management plans triggered since the previous report
- Status update on preparation of new management plans
- A summary and assessment of management plan monitoring data collected during the reporting period
- A summary of management plan grower outreach conducted
- A summary of the degree of implementation of management practices
- Results from evaluation of management practice effectiveness
- An evaluation of progress in meeting performance goals and schedules
- Any recommendations for changes to the management plan

4.1.2 Diazinon Management Plan

Prior to submitting the Sacramento Valley Management Plan, the Coalition submitted its Diazinon Runoff Management Plan for Orchard Growers in the Sacramento Valley to the Water Board on January 19, 2006. The plan was approved by the Water Board in March 2006. In fulfillment of the requirements set forth in the plan, the Coalition submitted three Annual Reports summarizing the 2005–2006, 2006–2007, and 2007–2008 monitoring objectives, location and results, outreach efforts, grower survey follow-up, and management practices effectiveness. None of the samples obtained in 2005–2006 or 2006–2007 exceeded the diazinon objective. In 2007–2008, the Coalition again monitored two storm series of events. During the second series of storm events, diazinon exceedances were detected in the Colusa Basin Drain. No exceedances were identified in the other four drainages. To date, the Coalition has been unable to identify the source of the exceedance. The Coalition will continue to monitor for diazinon as part of the Coalition's MRP.

4.1.3 Groundwater

Groundwater quality in the Sacramento Valley is generally excellent (DWR Bulletin 118-2003). The Sacramento Valley is pursuing active groundwater management, which includes the protection of sustainable groundwater supplies. As the Water Board's regulatory programs evolve to include groundwater quality, the Coalition is implementing foundational actions necessary to compile and characterize existing groundwater quality data, and identify and prioritize areas to undertake special projects to improve groundwater quality and to implement a plan of action to improve groundwater quality in the region.

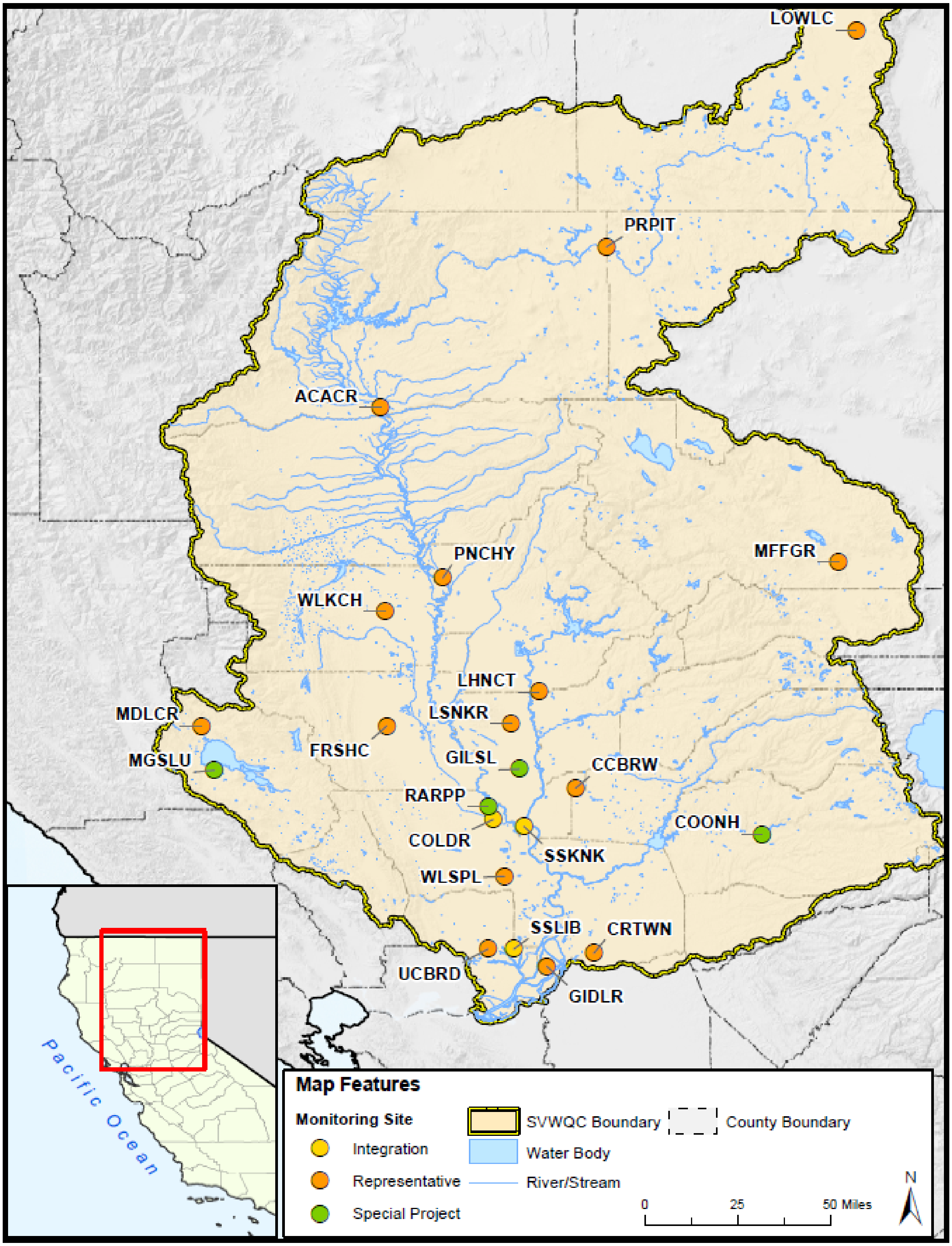


Figure 4-1. 2019 Coalition Monitoring Sites

Section 5
Regional Plan Coordination

5. Regional Plan Coordination

Quarterly conference calls or meetings will be attended by the representatives listed in Table 5-1. Any issues that may not affect an individual SRSC, but may affect the region or subbasin will be addressed at this time. A current list of conservation coordinators for each participating SRSC will be provided with the Regional Plan annual update.

Table 5-1. Regional Plan Conservation Coordinators

District/Company	Conservation Coordinator	Phone	E-mail
ACID	Jered Shipley	530-365-7329	gm@acidistrict.org
GCID	Greg Krzys	530-934-8881	gkrzys@gcid.net
PID	Lance Boyd	530-934-4801	lboyd52@aol.com
PCGID	Lance Boyd	530-934-4801	lboyd52@aol.com
RD 108	William Vanderwaal	530-812-6276	wvanderwaal@rd108.org
RD 1004	Terry Bressler	530-458-7459	rd1004@comcast.net
MFWC	Andy Duffey	530-696-2456	aduffey@succeed.net
SMWC	Roger Cornwell	916-765-0187	rcornwell@sutterbasinwater.com
NCMWC	Brett Gray	916-826-7672	bgray@natomaswater.com
Regional Plan Coordinator	Holly Dawley	530-934-8881	hdawley@gcid.net

Section 6
References

6. References

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Sacramento Valley Regional Water Management Plan Attachments

Draft

March 2023

Sacramento River Settlement Contractors

Jacobs

The following attachments to the Sacramento Valley Regional Water Management Plan are provided:

Attachment A – Maps
Attachment B – Rules and Regulations
Attachment C – Measurement Device Documentation
Attachment D – Sample Bills
Attachment E – Water Shortage Plans
Attachment F – Groundwater Management Plans
Attachment G – Groundwater Banking Plan
Attachment H – Placeholder – not used
Attachment I – Notices of District Education Programs Available to Customers
Attachment J – Water Order Form
Attachment K – Soil Maps
Attachment L – Placeholder – not used
Attachment M – Water Balance Summary Tables
Attachment N – Communications Examples
Attachment O – Final Sacramento Valley Water Quality Coalition 2019 Annual Monitoring Report

Attachment A
Maps

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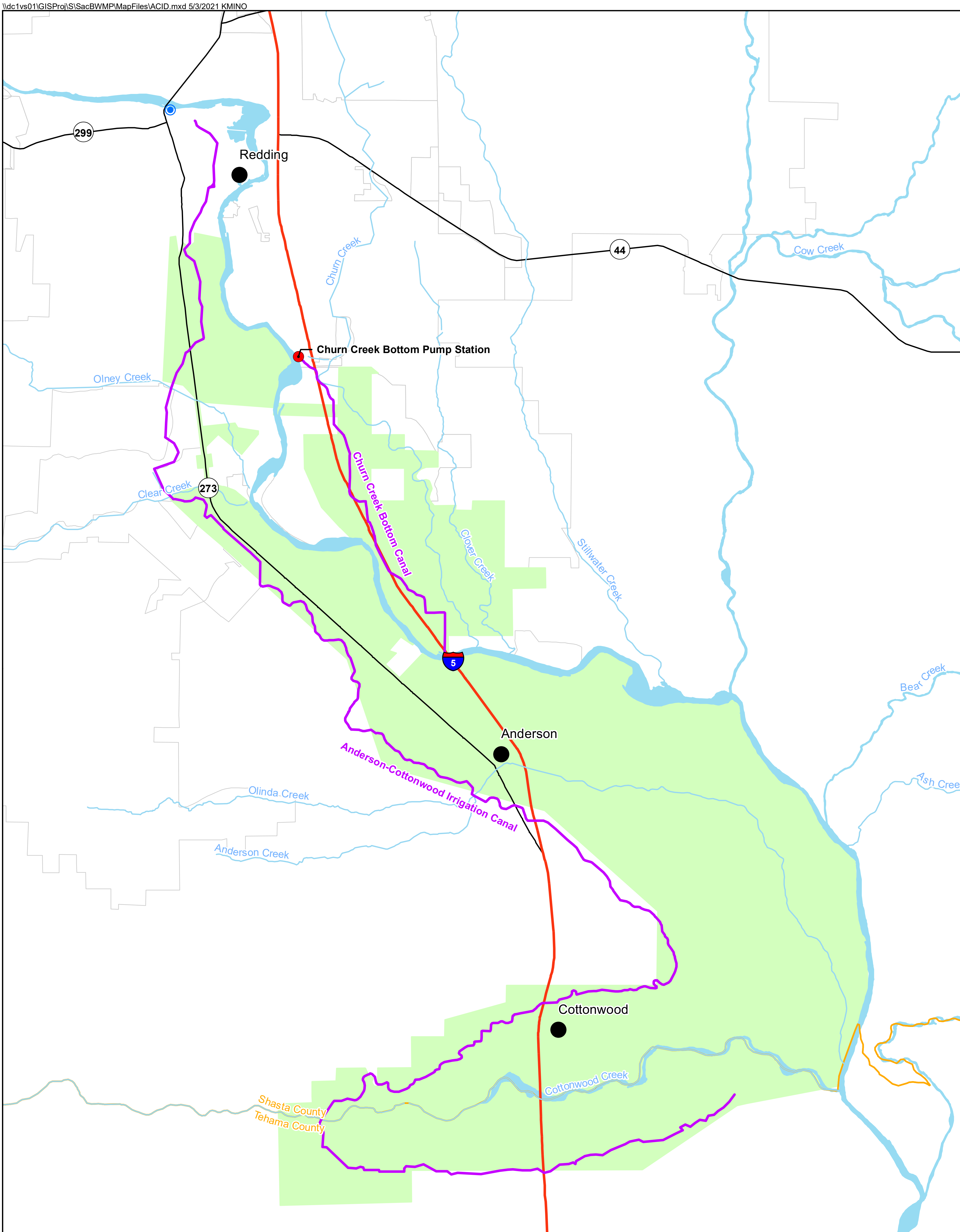

Notes:
Missing Drain Pump Stations
ACID Diversion Dam and ACID Diversion Tunnel was "Faked" in the original map
Dashed purple line of ACID (from Canal to Sac River) was "Faked" in othe original map
"Faked" = No actual geospatial data

LEGEND
- PUMP STATION
- GRAVITY SURFACE DIVERSION
- CANAL/LATERAL
- ACID BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 3,750 7,500 15,000 Feet

1 inch = 7,500 feet

ANDERSON-COTTONWOOD IRRIGATION DISTRICT
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

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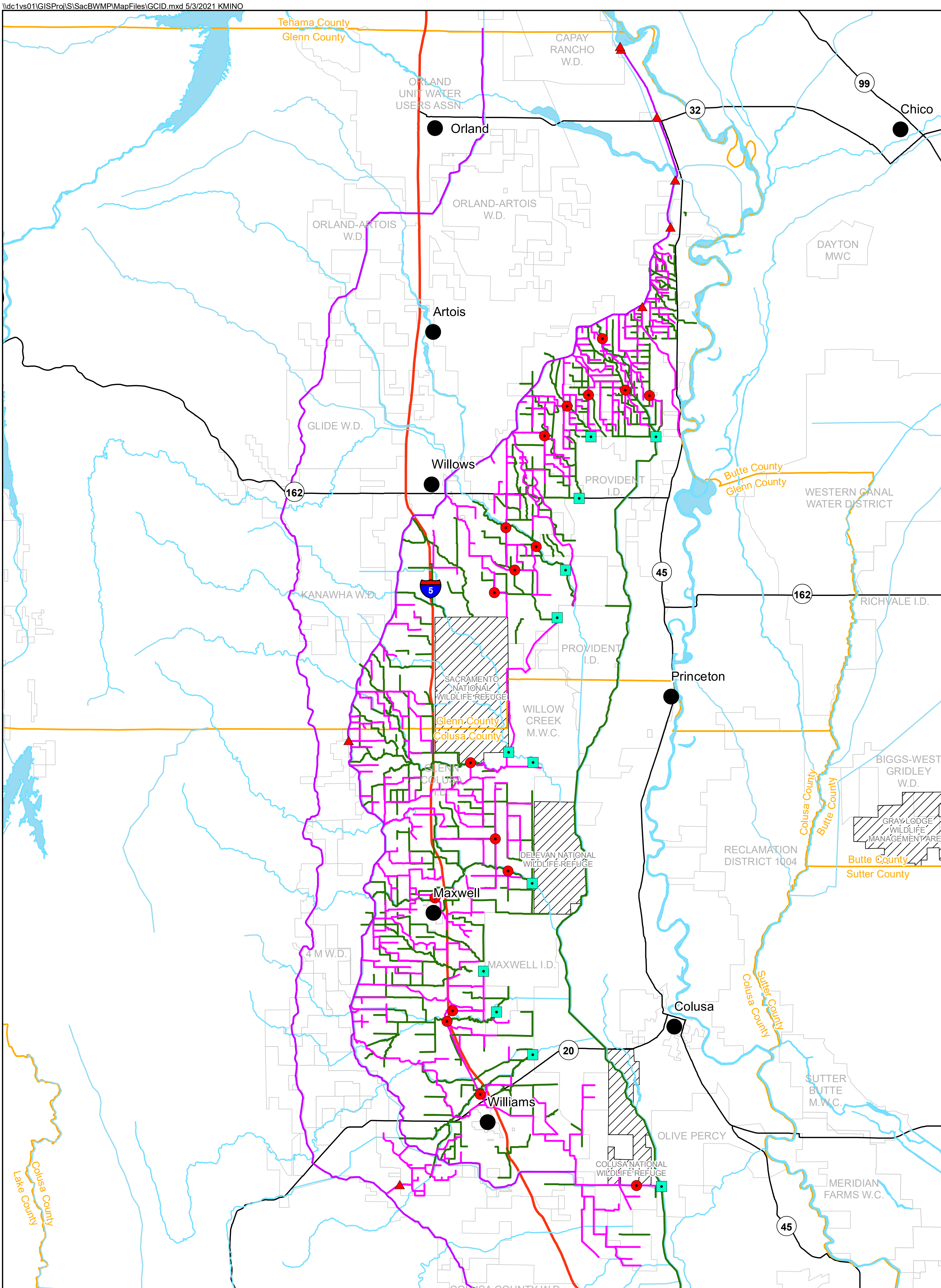

LEGEND

- WATER INTAKE POINTS
- DRAIN OUTFLOW SITES
- DRAIN LIFT PUMPS
- CANAL
- LATEARL
- DRAIN
- GCID BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 10,000 20,000 40,000 Feet

1 inch = 20,000 feet

GLENN-COLUSA IRRIGATION DISTRICT
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

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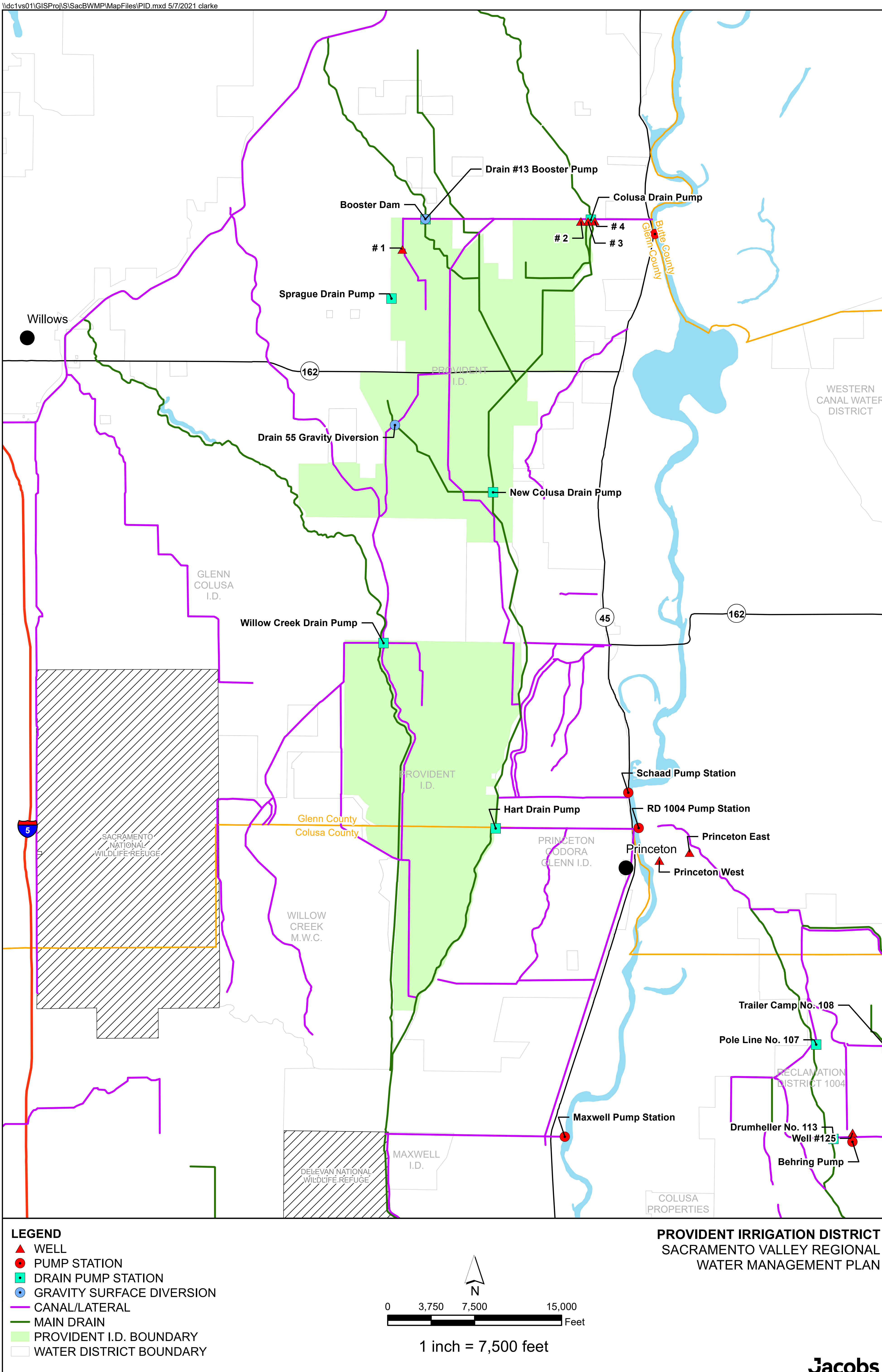

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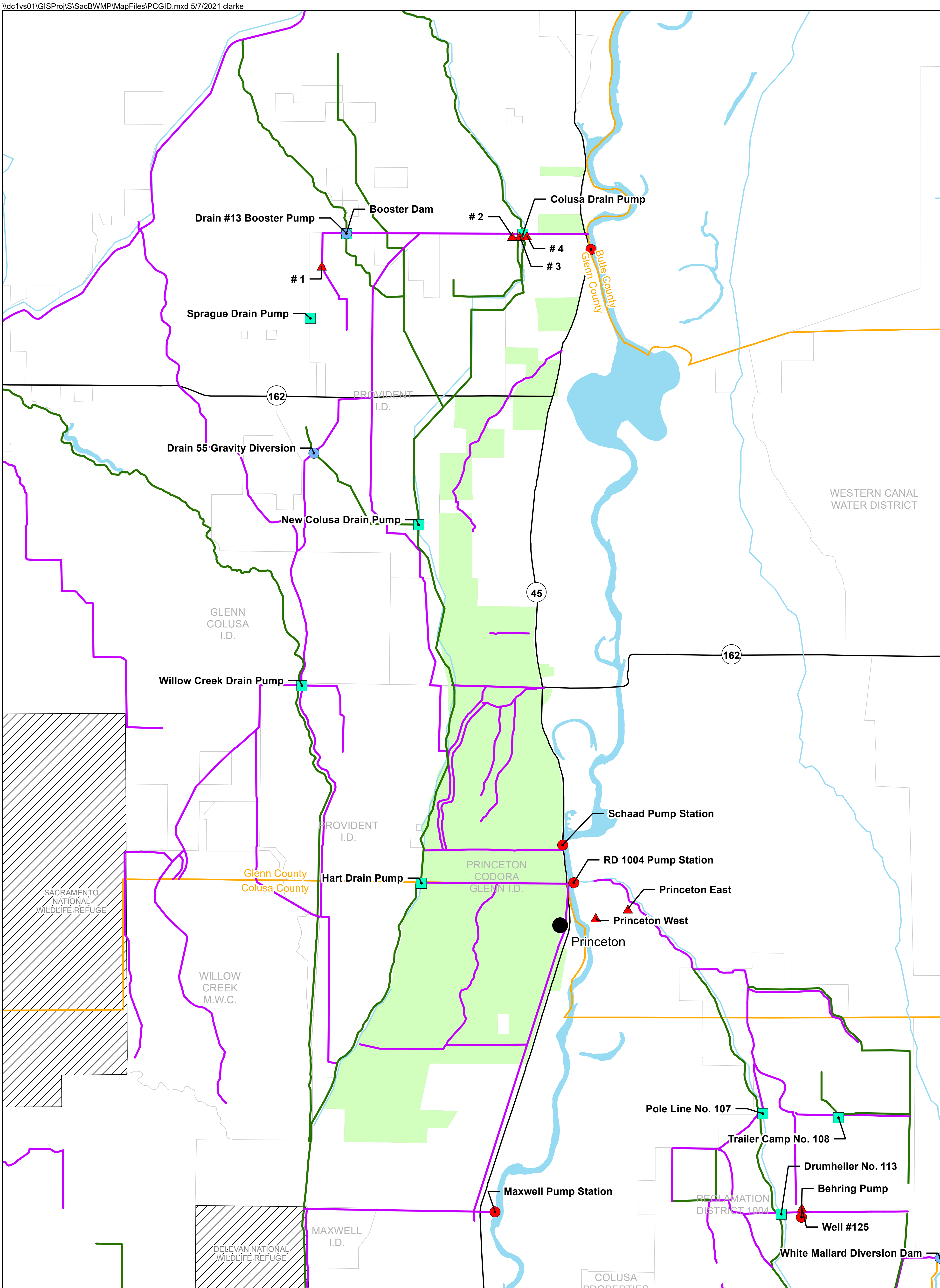

LEGEND

- WELL
- PUMP STATION
- DRAIN PUMP STATION
- GRAVITY SURFACE DIVERSION
- CANAL/LATERAL
- MAIN DRAIN
- PRINCETON I.D. BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 3,750 7,500 15,000 Feet

1 inch = 7,500 feet

PRINCETON-CODORA-GLENN IRRIGATION DISTRICT
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

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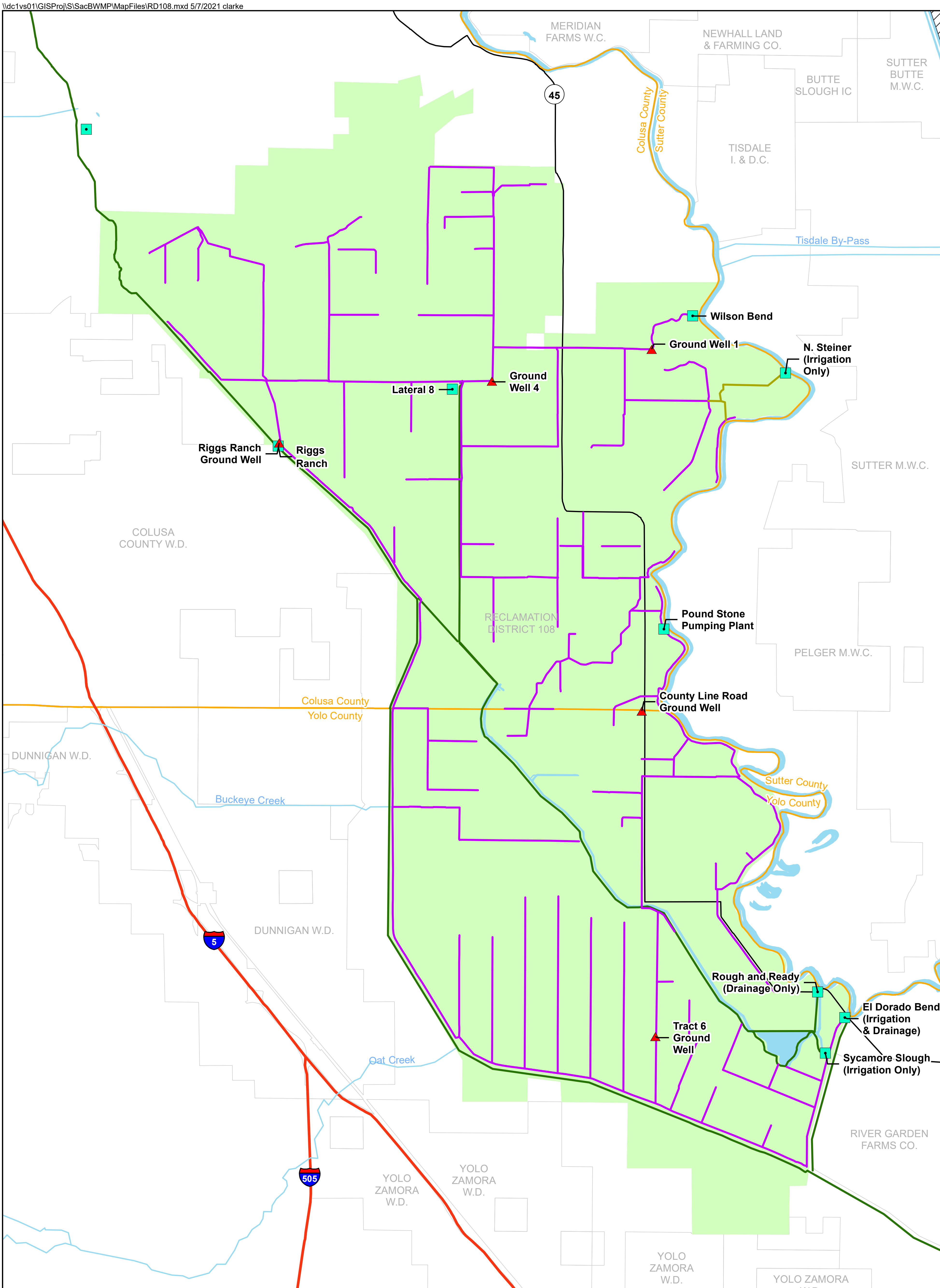

LEGEND
- WELL
- PUMP STATION
- PIPELINE
- CANAL/LATERAL
- DRAIN
- RD 108 BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 3,750 7,500 15,000 Feet

1 inch = 7,500 feet

RECLAMATION DISTRICT NO. 108
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

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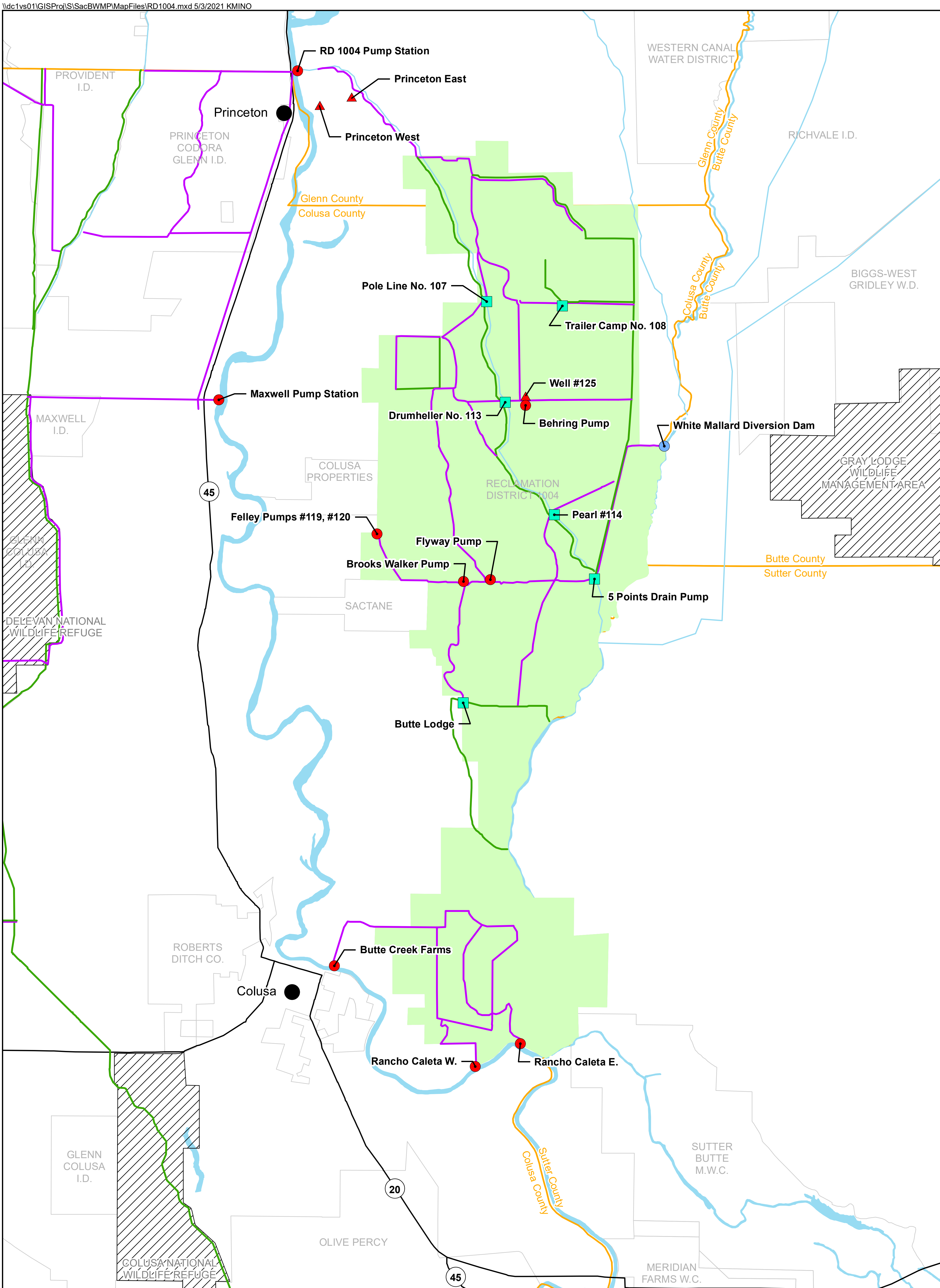

LEGEND

- WELL
- PUMP STATION
- DRAIN PUMP STATION
- GRAVITY SURFACE DIVERSION
- CANAL/LATERAL
- DRAIN
- RD 1004 BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 3,750 7,500 15,000 Feet

1 inch = 7,500 feet

RECLAMATION DISTRICT NO. 1004
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

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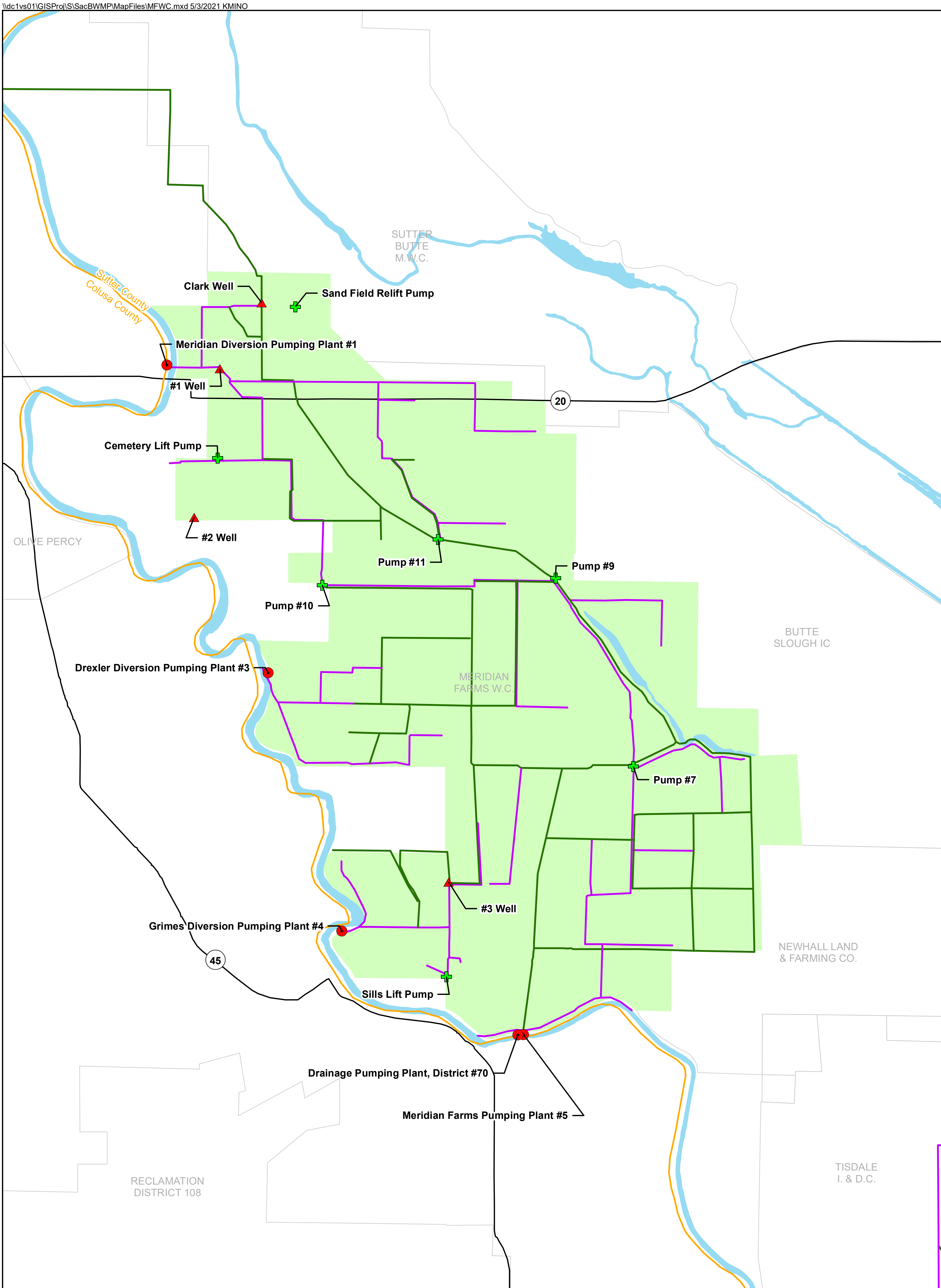

LEGEND

- WELL
- PUMP STATION
- PUMP
- CANAL/LATERAL
- DRAIN
- MERIDIAN FARMS WC BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 2,000 4,000 8,000 Feet

1 inch = 4,000 feet

MERIDIAN FARMS WATER COMPANY
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

Jacobs

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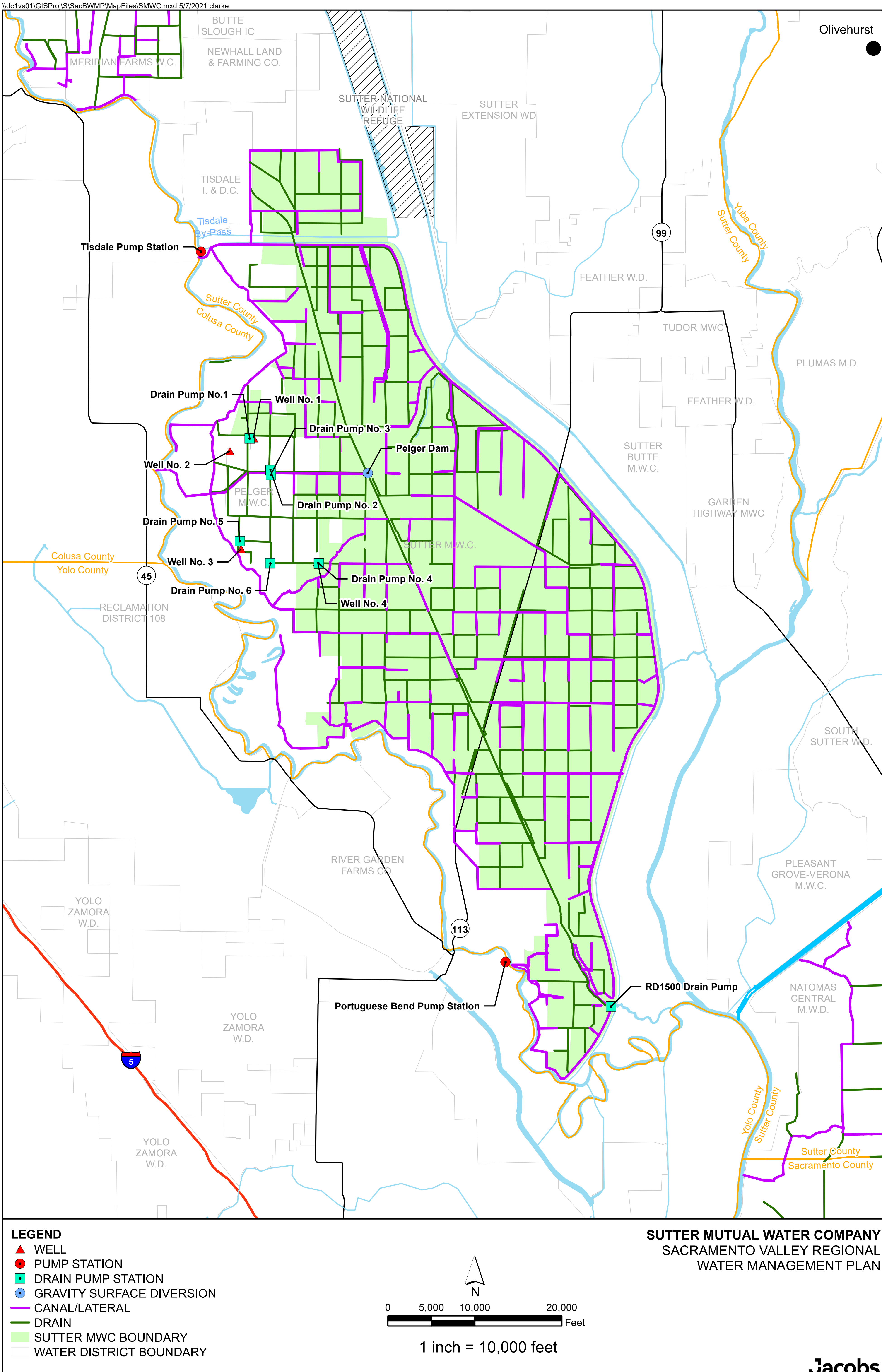

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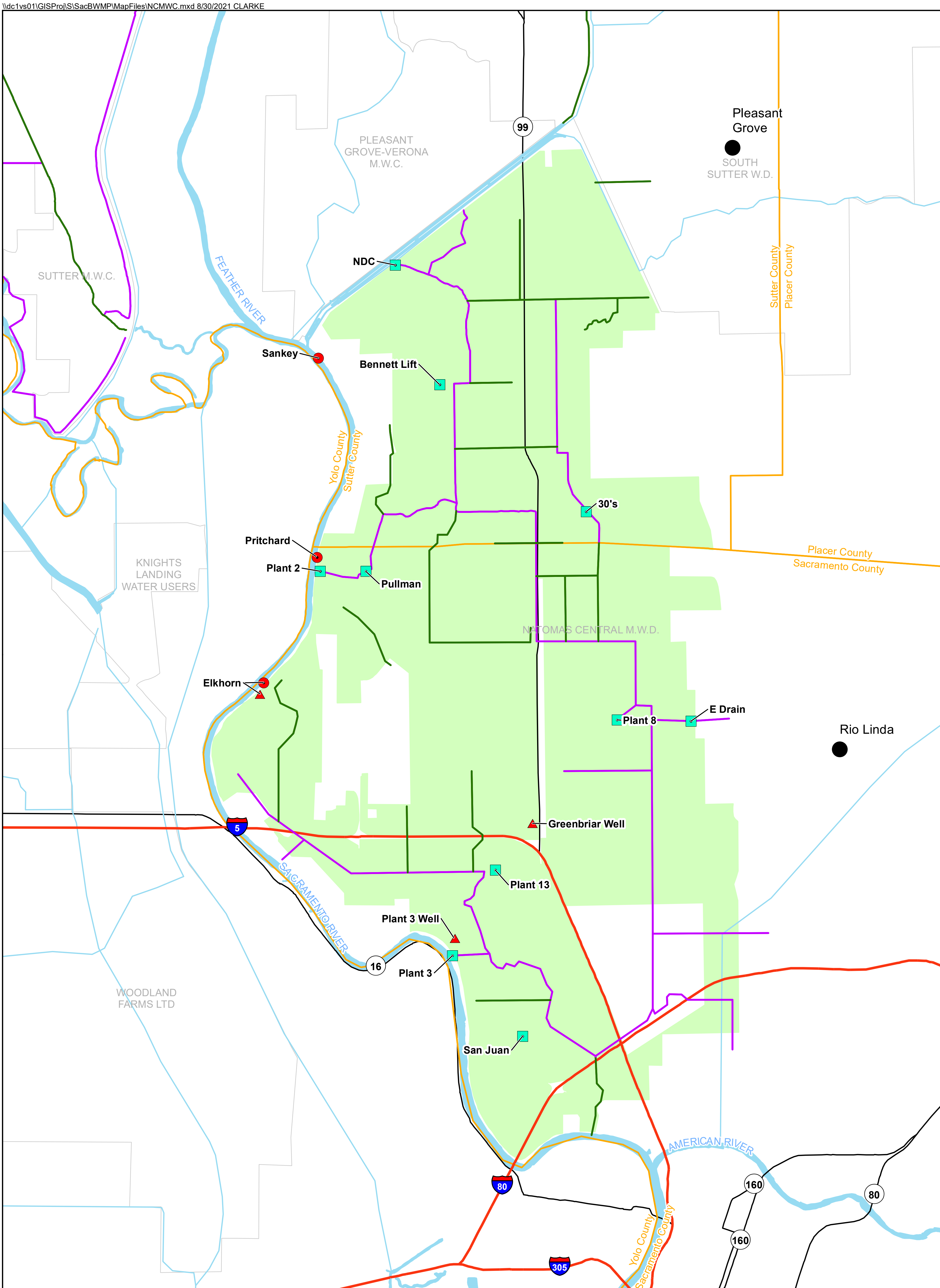

LEGEND
- WELL
- PUMP STATION
- DRAIN/LIFT PUMP
- CANAL/LATERAL
- DRAIN
- NATOMAS CENTRAL MWC BOUNDARY
- WATER DISTRICT BOUNDARY

N

0 3,750 7,500 15,000 Feet

1 inch = 7,500 feet

NATOMAS CENTRAL MUTUAL WATER COMPANY
SACRAMENTO VALLEY REGIONAL
WATER MANAGEMENT PLAN

Jacobs

Attachment B
Rules and Regulations

Anderson-Cottonwood Irrigation District (ACID)

(Not required.)

Glenn-Colusa Irrigation District (GCID)

GOVERNING THE USE

AND

DISTRIBUTION OF WATER

WITHIN THE

GLENN-COLUSA IRRIGATION DISTRICT

ADOPTED

January 23, 2014

RULES AND REGULATIONS

GOVERNING THE USE

AND

DISTRIBUTION OF WATER

WITHIN THE

GLENN-COLUSA IRRIGATION DISTRICT

ADOPTED
January 23, 2014

PREAMBLE

These Rules and Regulations have been adopted by the Board of Directors under the authority of the California Water Code, and are a part of the law governing this District, and its landowners and water users. These Rules and Regulations have been adopted to ensure the orderly, efficient and equitable distribution, use and conservation of the District's water resources.

INDEX

DEFINITIONS

APPLICATION
The annual written application for water referred to in Rule 8.

BOARD
The Board of Directors of the District.

CHARGES
Include water tolls and rates and may include any indebtedness for any service rendered by the District. See Rate Schedule available in the District office.

CONSUMER
Includes water user or user of other services of the District.

CONDUITS
Includes canal, laterals, ditches, drains, flumes, pipes, measuring and control devices therein and their appurtenances.

DISTRICT
The Glenn-Colusa Irrigation District.

EQUIPMENT
Vehicles, construction and maintenance equipment used to facilitate the conveyance and delivery of water.

FACILITIES
Infrastructure of the District, including: conduits, structures, weirs, wells, trash screens, pumps, gates, electrical and telemetry equipment, roadways, and their appurtenances, etc.

GENERAL MANAGER
The General Manager of the Glenn-Colusa Irrigation District appointed by the Board, or the General Manager's designated representative.

LIFT PUMPS

Pumping plants lifting water from District conduits or Reclamation District 2047 drains within the District, into private fields, private conduits or improvement district conduits or conduits held in trust for improvement district. The term does not include the District pumping plants operated by it to pump water from drains into the gravity system.

RULES

Includes regulations.

OPERATE

Includes use, maintain and repair.

OUTSIDE DISTRICT

Refers to land not within the District boundaries.

WITHIN DISTRICT

Refers to land legally included within the District boundaries.

WORKS

Includes structures, dams, wells, conduits, pumps, power plants and all lines, telephone lines and their appurtenances.

RULES AND REGULATIONS

Governing the Distribution and Use of Water

Adopted January 23, 2014

AUTHORIZATION

The following *Rules and Regulations* have been adopted by the Glenn-Colusa Irrigation District Board of Directors under the authority of the California Water Code Section 22257[1] that states in part, "Each District shall establish equitable rules for the distribution and use of water which shall be printed in convenient form for distribution in the District." These *Rules and Regulations* are a part of the law governing the Glenn-Colusa Irrigation District, and its landowners and water users, *and* are intended to ensure the orderly and efficient use, and equitable distribution and conservation of the District's water resources.

These *Rules and Regulations* supersede in their entirety the District's previously approved *Rules and Regulations* dated February 21, 2012, and will be distributed to all landowners and water users.

RULE 1: CONTROL OF THE SYSTEM

All matters relating to the distribution of water and the maintenance of the District's conduits and facilities are under the exclusive management and control of the General Manager, and no other person except employees and assistants authorized by the General Manager will have any right to operate or interfere with the water system and facilities in any manner, except as provided in Rule 12 of the *Rules and Regulations*.

RULE 2: DISTRICT EMPLOYEES

The District's General Manager is authorized to employ and delegate authority to the number of assistants and other employees deemed necessary to properly operate the District, subject to the approval of the Board of Directors.

RULE 3: OWNERSHIP OF WATER

All surface water within the District and all groundwater developed or purchased by the District is the property of the District, and is subject to diversion and use by the District. No landowner or water user acquires any proprietary right to these waters by reason of such use, nor does any landowner or water user acquire any right to resell the water purchased or used, or the right to use it on other premises or for a purpose other than that stated in their water application.

The District expressly asserts the right to recapture, reuse, and resell all surface water that drains into the District from lands outside the District boundary, or drains from the place of use described in the water application, and asserts its right to use all surface waters and groundwater developed or purchased by the District.

RULE 4: WATER USE

The District was organized for the purpose of supplying irrigation water services for the production of agricultural crops. In addition, the District may serve water for flooding of waterfowl ponds, irrigation of habitat land, and aquaculture purposes; however, the District makes no guarantee of the character or quality of water delivered. Water uses for other purposes shall be provided only upon consideration and approval of the Board of Directors. The District may serve water for flooding or irrigation of non-crop fields, but only when, in the opinion of the Water Operations Superintendent, or the assistant(s), such service will not interfere with or harm agricultural operations, through seepage or overflow from conduits.

RULE 5: WATER SERVICE SEASON

Water service from the District is derived from the District's Sacramento River Settlement Contract surface water diversions from April 1 through October 31, and the State issued appropriative water rights permit for winter surface water diversions from the Sacramento River from November 1 through March 31, subject to the following qualifications:

(a) The water conveyance system will be subject to shut down and limited water deliveries as specified in the District's *Winter Maintenance Shutdown Policy* each year to allow for required construction and maintenance projects to be completed.

(b) "Acts of God" and unavoidable maintenance and construction activities may cause interruptions in service at any time during the water service season for the period of time required to make repairs or complete required maintenance work.

Under normal water conditions, the water season will commence on March 1 of each year and end January 7 of the following year. Crops requiring water prior to March 1, but not before February 21 for either frost protection or crop stand establishment only, will be charged a separate rate set by the Board of Directors.

RULE 6: CRITICAL YEAR ALLOCATION AND WATER MANAGEMENT POLICY

Glenn-Colusa Irrigation District (District) holds a Sacramento River Settlement Contract (SRSC) with the United States Bureau of Reclamation for the annual diversion of up to 720,000 acre-feet of Base Supply and up to 105,000 acre-feet of Project Water as defined under the SRSC. In all year types except Shasta Critical (Critical), the District's surface water supply is adequate to meet all of the irrigation demands of the water users within the District's boundaries. Under the terms of the District's SRSC, in Critical years (generally defined as years in which the annual unimpaired inflow into Shasta Lake is less than 3.2 million acre-feet), the District's total supply is reduced by 25% to 618,750 acre-feet. On average, each water year has roughly an 8% chance of being critically dry (1 out of 12 years); however, the last Critical year was in 1994. Under current cropping patterns, the District demand for irrigation water in Critical years typically exceeds the available supply by 50,000 acre-feet to 100,000 acre-feet.

The District has developed the following *Critical Year Allocation and Water Management Policy* in order to maximize the available water to its water users during Critical years. Any water that is excess to the needs within the District may be made available to others in accordance with the District's *Water Transfer Policy*.

Based upon the foregoing, the District's policy for the allocation and apportionment of water during Critical years is as follows:

(a) Critical Year Water Rates
In Critical years, the District will confirm a per acre-foot rate for water by dividing the District's crop revenue need (crop revenue need is equal to budgeted Critical year capital and operation and

maintenance expenses, less anticipated revenue from refuge wheeling, standby charges and other non-operating revenues) by the total available Critical year water supply.

(b) Establishment of Annual Water Requirements for Crops
Applied water unit duties will be established for the estimated applied water use for each type of crop grown in the District.

(c) Primary Apportionment of Available Supply
In Critical years, the District will estimate the total water supply available for the irrigation season by taking the SRSC contract supply less any shortages, adding recaptured water supplies, and then deducting conveyance losses and anticipated outflow. This calculated volume of water will be the amount the District will apportion ratably to deeded lands within the District in accordance with Water Code §22250. Primary apportionments will be mailed to District landowners as soon as practical after the District is reasonably sure of the amount of water it will receive for the April 1 through October 31 Contract period.

(d) Purchase of Primary Apportionments
Landowners and water users will have until the deadline date set by the Board to purchase any or all of their primary apportionments at the Critical year water rate per acre-foot established by the District. 40% of the per acre-foot rate established by the Board, pursuant to Paragraph A above, is due upon purchase of the primary apportionment, with 30% due on June 1 and 30% due on August 1. The landowner or water user who makes the down payment will be billed for the remaining 60% as those payments become due, and the owner of the land that received the allocation will ultimately be responsible in the event of non-payment. The purchase of water in Critical years is non-refundable, regardless of whether the water is used.

(e) Assignment of Right
Apportionments to landowners may be assigned to others, in whole or in part, for use within the District (Water Code § 22251) using the District's Assignment Form, provided that the water involved in the assignment has first been purchased in accordance with the deadlines established in this policy.

(f) Secondary Apportionment of Available Supply
A secondary apportionment will be made for any water that is not sold by the deadline for the purchase of primary apportionments. The remaining water will be apportioned on a pro-rata basis to all landowners that (1) made a purchase of primary apportionment and (2) indicated on their apportionment payment form a desire to receive a secondary apportionment should it be available. The deadline for the purchase of secondary apportionments will be set by the Board.

(g) Water Application Process
The Board will establish a deadline for landowners and water users to file water application(s) for the year. The applications will indicate which crops will be grown with their available supply, where those crops will be located, and which lands will be left fallow. Each cropped acre will be “charged” against water users’ available supply in accordance with the crop unit duties established by the District.

(h) Critical Year Conservation Plan
In Critical years, under current cropping patterns, the demand for irrigation water exceeds the available supply by approximately 100,000 acre-feet if normal year conservation practices are utilized instead of moderate conservation measures. . In order to maximize the use of the limited supply, the District will require moderate conservation measures, including limited re-flooding of rice and a strict no-spill policy during the months of July and August.

(i) District Groundwater
The District owns a number of groundwater wells that may be used at the Board’s discretion (subject to receiving the necessary environmental clearances) to supplement the District’s available water supply in a Critical year. If the Board elects to use the wells, they will set the price per acre-foot for such supplemental groundwater supplies in order to recover at least the estimated operation, maintenance and capital costs to produce such groundwater. Available District groundwater will be offered for sale to interested parties, at the price set by the Board.

(j) Commingling of Groundwater - Private Wells
In order to facilitate the ability of GCID water users with access to private wells to use well water to irrigate additional District lands

during a Critical year, the District will facilitate the commingling of private well water with District surface water. Commingling is subject to operational considerations and the terms of the *Joint Water Service Agreement for the Commingling of Well Water and District Surface Water*, which contains metering requirements and certain groundwater well standards.

(k) Wheeling of Groundwater – Private Wells
Water users with private wells who request to utilize the District's conveyance facilities to move their groundwater from one location within the District to another may do so subject to operational considerations, conveyance capacity, and the terms of the District's *Wheeling Policy.*

RULE 7: ENFORCEMENT OF APPORTIONMENT

To enforce Rule 6 of the *Rules and Regulations*, the District may do any or all of the following:

(a) Refuse to serve irrigable lands applied for if required fallowed lands have not been designated and prepared to prevent the flow of water on to the designated fallow acreage.

(b) Shut off or reduce the flow of water to any landowner or tenant irrigating excess acreage or wasting water as described in the District's *Water Management and Conservation Policy*. Draining rice fields or spilling to lower levels in rice checks shall be deemed a waste of water, unless adequate advance notice is given to the District to permit reduction of inflow into the field and substantial lowering of the water in the checks prior to the start of the draining or spilling.

(c) Charge and collect as part of the water charge, a penalty as determined by the Board for any crops growing on designated fallowed lands.

(d) For lands in which the delivery of water is determined by the District to be excessive and may end up requiring more water than the landowner's allocation amount, the District may install a measurement device and measure the flow of water onto the land and turn off service when the landowner's share has been delivered, based on the measured amount and the estimated amount prior to the period in which the measurement commenced. The landowner's share shall be determined as provided in Rule 6 of the *Rules and Regulations*.

(e) Land for which the District has not received a water application may be irrigated with water pumped from private wells, provided that the groundwater is not mingled with District supplied water in ditches or in the field. If such mingling occurs, the entire water supply shall be deemed to be supplied by the District, unless a written agreement between the District and landowner is executed prior to the mingling, and such agreement assures the District of the amount, adequacy, and dependability of the water to be supplied from private wells.

RULE 8: APPLICATIONS FOR WATER

On or before the last business day in March, or such other date as the Board may designate, each landowner and tenant seeking to irrigate land within the District must file an application for water at the District office in Willows. This application for water must be submitted on the Water Application form provided by the District. Water may not be used for any purpose other than that specified in the Water Application. Specific information required to complete the Water Application includes the crop(s) to be irrigated or water application(s) to be made, the corresponding acreage of each crop or water application(s), the name of the landowner, the name of the tenant or tenants, and the location and description of the land. All Water Application forms must be signed by the landowner, and all appropriate fees must be paid prior to receiving water deliveries.

Water Applications received after the closing time specified for receipt of applications will have a penalty of five percent (5%), or a greater amount as set by the Board of Directors, added to the water charges. Under certain circumstances, late applications may require the consideration and approval of the Board of Directors prior to acceptance by the District. In years of water shortage, and in accordance with Water Code section 22252.1, the Board generally will not accept late applications. Landowners and water users who apply water to land prior to executing a Water Application with the District will have a penalty of ten percent (10%) added to the water charges on any and all land within the parcel(s) and field(s) where water was applied. This provision will not apply to minor adjustments in acreage planted in a field for which an application was filed.

RULE 9: *RULES AND REGULATIONS* INCORPORATED IN WATER APPLICATIONS

These *Rules and Regulations* are incorporated in the Water Applications of the District, as a part of that contract, as if set forth in full. If it is necessary for the District to commence legal action to enforce these *Rules and Regulations*, the District is entitled to recover the reasonable value of staff time spent in enforcing the *Rules and Regulations*, and the reasonable value of attorney services incurred, as well as all other costs incurred by the District.

RULE 10: ACCESS TO LANDS

The authorized agents and employees of the District will have reasonable access, at all times, to all lands within the District's boundaries, regardless of whether they are irrigated or not irrigated, for the purposes of maintaining, operating, or inspecting the conduits; and for conveying water in such facilities; and for the purpose of assessing compliance with water management and conservation requirements, and confirming and measuring the acreage of crops or applications of water on lands irrigated or to be irrigated.

RULE 11: DELIVERY OF WATER

The District will employ its water operations staff to operate the water conveyance system as it deems necessary to control water flow and distribution, minimize seepage, control erosion, and provide reasonable irrigation water delivery service to its landowners and water users. The normal workday for the water operations staff begins at 7:00 a.m. and ends at 3:30 p.m., seven days per week. Refer to the *Water Management and Conservation Policy* for specific information regarding delivery of water. At the District's discretion, or when conditions warrant, water department personnel will control, limit or cutback the amount of flows entering agricultural lands. The reasons for such actions could include, but are not limited to:

(a) Limited supplies of water.

(b) Exceeding the capacities of either the lateral system or the canal conveyance system.

(c) High volumes of water entering the fields that cannot be controlled in a timely manner, or can cause damage to the surrounding area.

Water must be taken continuously by the user throughout the period of delivery, including both day and night.

Where deemed desirable or necessary by the District's Water Operations Department, water deliveries will be made on a rotation basis.

The District reserves the right to measure deliveries to any and all water users.

RULE 12: TAMPERING WITH FACILITIES

Landowners or water users who, by opening, closing or otherwise interfering with the regulation of delivery gates, structures, or devices, cause any fluctuations in the flow of water in the District's water distribution system or cause any overflows, breaks or damage of any kind, will be responsible for the expense and damage caused and may be liable to others who may be adversely affected. In addition to liability for damages, tampering with the District's facilities may result in the "locking-up" of the facility to prevent tampering, termination of water service, or any other action authorized by the *Rules and Regulations*.

Where water control devices are regulated in accordance with specific instructions from an authorized District representative or in cases of an emergency when immediate adjustment or other corrective action will prevent overflows, breaks, crop loss or other property damage, the person making such adjustments or taking corrective action will not be deemed to be in violation of this rule. Any such emergency action or adjustment must be reported to the water operator or water supervisor immediately.

RULE 13: SAFE OPERATING LEVELS IN CANALS AND LATERALS

The water level in any District canal or lateral will not be raised to an unsafe elevation for the purpose of providing gravity service to high elevation lands or delivery facilities. The General Manager will determine the safe operating elevations for providing gravity service.

RULE 14: WATER CONSERVATION

All landowners and water users are subject to the special water management and conservation rules adopted pursuant to the District's *Water Management and Conservation Policy*. The *Water Management and Conservation Policy* references and is part of the District's *Rules and Regulations.*

RULE 15: WASTE OF WATER

If, in the opinion of the General Manager, a landowner or water user is wasting water, either willfully, carelessly, negligently, or due to defective private conduits, the District may refuse, discontinue or limit the delivery of water until the wasteful conditions are remedied. Wasteful water use practices include, but are not limited to the following:

(a) Allowing water to flow onto roads, vacant land, or land previously irrigated.

(b) Flooding land to an unreasonable depth, or using an unreasonable amount of water in order to cover other high elevation portions of such land.

(c) Using water on land that has been improperly prepared for the efficient use of water.

(d) Allowing an unnecessary amount of water to drain or spill from any irrigated field.

The District reserves the right to refuse delivery of water when, in the opinion of the General Manager, the proposed use, or method of use, will require excessive quantities of water that constitute a waste of water.

RULE 16: UNAUTHORIZED USE OF DISTRICT WATER

Lands Outside the District - Landowners and water users seeking to irrigate land partially within and partially outside of the District boundary may not apply District water on the contiguous land outside the District when the corresponding water application was solely for the land located within the District unless approved by the Board of Directors. Landowners and water users may not apply District water on "island lands," not in the District, unless approved by the Board of Directors, as provided for in the annual water rate sheet. If the application of water to contiguous land outside the District is not approved, the landowners or water users must make such physical changes in their fields or irrigation systems, as the General Manager deems necessary, to prevent the flow of District water onto the outside lands.

Lands Within the District - Landowners and water users may not divert, intercept, impound, or otherwise use District water on any land within the District, without filing a Water Application. This prohibition applies regardless of whether the water is diverted from a canal or lateral, taken from or impounded in a natural channel or drain, or whether it is waste, spill, seepage, runoff, or other water.

Unanticipated/Unforeseen Causes - If the General Manager determines that the unauthorized uses of water described above occurred solely due to causes that could not be foreseen or anticipated, then no unauthorized use of District water will be deemed to occur.

Violation and Enforcement

(a) Notice of Violation - Notice of a violation of Rule 16 of the *Rules and Regulations* shall be promptly provided by the District to the responsible landowner(s). The District will attempt to notify the landowner(s) by telephone so the violation can be corrected immediately, and further violations avoided. In addition, written notice will be mailed to the landowner(s) and/or attached to the landowner(s) delivery gate, as soon as possible after the violation is observed.

(b) Enforcement - To enforce Rule 16 of the *Rules and Regulations,* and prevent unauthorized uses of District water, the District may, at the District Manager's discretion, impose any or all of the following conditions:

i) Charge and collect as part of the water charge for any unauthorized use of water, a charge equal to three times the regularly established District water charge for the crops growing on the subject lands. This charge shall be based upon the full irrigation season rate for the crops involved, and shall not be prorated;

ii) Charge and collect an additional ten percent (10%) charge on the amount assessed pursuant to Rule 8 of the *Rules and Regulations*, for failure to submit an application for water for the subject lands;

iii) If the subject lands are irrigated with groundwater, the District may require the delivery to the District, by well operations, of the amount of water which the District estimates was not pumped during the relevant time period, with an additional ten percent (10%) for losses. If there is insufficient pumping capability or the District is unable to use the pumped replacement water during the irrigation season when the violation occurred, the pumped replacement water shall be delivered at the beginning of the following irrigation season;

iv) Place the subject lands on up to five years of probation for continuing District water use. Probationary conditions may include periodic inspections of the subject lands by District personnel, to ensure strict compliance with all District rules and regulations. The cost of such inspections shall be borne by the landowner(s) of the subject lands;

v) Refer the matter and all investigative materials developed by the District to the District Attorney and/or other law enforcement authorities; and

vi) Pursue any form of civil or administrative proceeding to enforce the District's *Rules and Regulations* and/or to recover any losses and damages resulting from an unauthorized use of District water.

vii) Notice of Enforcement Conditions - Written notice of the enforcement conditions imposed pursuant to subsection (b) shall be delivered by certified mail to landowner(s) of the subject lands. Any charges assessed pursuant to Rule 8 of the *Rules and Regulations* must be paid within ten days of the billing date. Failure to pay such charges in a timely manner shall result in an additional charge of ten percent (10%) on the amount charged, and may result in the District's termination of water deliveries to the landowner(s).

viii) Payment Under Protest - Payment under protest of any charges assessed pursuant to Rule 16 of the *Rules and Regulations* will be permitted; however, the Board of Directors may elect not to hear such protests before the end of the irrigation season. Any protests must be received promptly, in writing, no later than 30 days after the mailing of the District's notice of enforcement conditions. All protest must include a detailed written account of the alleged violation of Rule 16 of the *Rules and Regulations*, and any reasons why the enforcement conditions should not be imposed. Protesting or objecting parties are reminded that because efficient water use is so critical to the ability of the District to facilitate maximum planning under existing delivery constraints, the Board will strictly enforce its rules and regulations prohibiting unauthorized uses of District water.

RULE 17: ABANDONED USE OF WATER

Any landowner or water user who has filed an application for water who, subsequently, desires to abandon any use of water must deliver to the District a written notice of such intention. The Board of Directors will review requests to abandon the use of water and consider adjustments to the water charges pursuant to their application.

RULE 18: WATER RATES AND CHARGES

Setting Water Rates and Charges - The water rates for irrigation water service, and other charges authorized by the California Water Code, will be set by the Board of Directors each year before the water application due date. These rates and charges will become due and payable as of the date or dates set each year by the Board of Directors.

The District has the right to conduct surveys to determine the acreage on which water was used, allowed to stand, and over which it was permitted to flow or drain. The charges for water will be based on the gross acreage covered with water, regardless of acreage actually planted.

The Board of Directors will determine the rates, charges, and terms of payment for water to be used for non-agricultural purposes, on a case-by-case basis.

The District may charge higher rates for water service to any lands that are outside the District boundary, and are not subject to assessment by the District, than is charged for similar service to lands that are within the District.

Delinquent Payments - All water rates and charges will become delinquent 15 days after they are due and payable, and will be collected pursuant to the California Water Code. If the charges are not paid prior to such delinquency, the District will add and collect an interest charge of 1.5% per month on all delinquent payments. This interest charge will commence at the date of the delinquency and will be compounded until paid, or to the time the unpaid and delinquent charges are added to the District's annual assessment as provided by the California Water Code. The District will not prorate the delinquent rates and charges.

Unpaid Charges and Refusal of Service - All charges for service remaining unpaid on the last business day in September, each year, will be added to and become a part of the annual assessment levied by the District pursuant to the California Water Code. The District will require full payment to accompany new water applications for service to lands on which delinquent assessments, that include unpaid water charges, are outstanding at the time the new application is made.

The District reserves the right to refuse or discontinue service to any water user who is in default in the payment of District charges, including, but not limited to assessments, standby charges, and water charges, and to any lands on which such charges are delinquent, unless and until such defaulted payment is paid in full. This applies to all applicants for water service on lands that are delinquent, regardless of whether the applicant is the same person who owned or farmed the land when the delinquent water charges were incurred.

RULE 19: EVALUATION OF WATER USE AND APPLICATION REQUIREMENTS

From time to time, the District may evaluate water use and water application requirements for the various crops irrigated in the District. At the discretion of the Board of Directors, this information may be used to develop average annual water requirements for the various crops and water uses in the District.

RULE 20: DIVISION OF LAND

The District must be provided notice by the landowner(s) of any proposed divisions of land within the District. The District will specify the facilities that must be installed at the landowner's expense to provide continued water service to all of the parcels, and drainage from all of the parcels formed by the division, without additional cost to the District. The District will refuse service to each and every parcel formed by a division, unless the District's requirements have been fully performed.

RULE 21: UNAUTHORIZED INSTALLATION OF GATES, STRUCTURES, AND FACILITIES IN DISTRICT CONDUITS

No opening will be made, or structures or facilities constructed in any District conduit, without the authorization of the General Manager. All such facilities must be constructed to the District's standards, under the supervision of the District, and at the sole expense of the landowner or water user. Any alterations in previously authorized work must meet the requirements of the District, and be approved by the General Manager prior to implementation.

The landowner or water user will be responsible for the cost of any additional facilities that the General Manager determines are necessary to make the requested installations functional.

Any facilities constructed in the District's conduits or associated rights-of-way at the landowner's or water user's expense will, at the option of the District, become the property of the District.

RULE 22: PRIVATE LIFT PUMPS

The elevation of certain lands within the District prevents water service by gravity flow and, as a result, lift pump equipment and associated facilities must be employed to serve this high elevation land. These lift pump facilities are considered private facilities, and all costs of installation, maintenance, and operation of lift pumps or private conduits that deliver water to lift pumps will be borne by the landowner or water user obtaining water through such facilities.

All pumping facilities on District rights-of-way must meet District standards, and be approved by the District prior to installation. All landowners and water users who pump from District canals and laterals for the purpose of irrigating land that is too high to be served by gravity water will be governed in all respects by the *Rules and Regulations* applicable to landowners and water users under gravity service.

RULE 23: CANAL AND LATERAL BANK ROADS

District canal and lateral bank roads are maintained for the use of the authorized agents, employees, and officials of the District, in the discharge of their official duties. All other uses of the District canal and lateral bank roads are at the sole risk of the user, and such use is prohibited where signs, gates, chains, or other barricades so indicate.

The District's canal and lateral bank roads must not be blocked by landowners, water users, or their contractors by parking sprinkler booster pumps or chemical mixing/applicator equipment on canal and lateral bank roadways, installing fences, or other impediments to travel, operation, and maintenance of District facilities.

RULE 24: DAMAGE TO DISTRICT FACILITIES AND RIGHTS-OF-WAY

The District will not permit damage to occur to any District facilities, as a result of:

(a) The operation of any equipment.

(b) Damage by livestock, poultry or waterfowl.

(c) Damage or destruction of facilities caused by burning.

(d) Depositing rubbish, prunings, abandoned equipment, etc., in or on any such facilities or rights-of-way.

Landowners, water users, or other parties responsible for such damages will pay to the District, all expenses incurred in repairing the damage, or removing the rubbish, signs, fences or structures, including the reasonable value of staff time and attorneys' fees expended in enforcing this provision.

RULE 25: RESPONSIBILITY FOR THE OPERATION AND MAINTENANCE OF PRIVATE CONDUITS

The District will not have responsibility for the operation and maintenance of private conduits, except where the District assumes operation and maintenance responsibility of private conduits pursuant to the District's *Water Distribution System Operation and Maintenance Policy*. All private conduits must be kept free from weeds and other obstructions, and must be of sufficient capacity and properly constructed and maintained to carry the flow of water applied for without danger of breaks, overflow or undue seepage. Further, all private conduits must be operated and maintained consistent with the District's *Water Distribution*

System Operation and Maintenance Policy. The General Manager may discontinue the delivery of water to any private conduit not meeting these requirements, and may require such conduits to be cleaned, repaired or reconstructed before water delivery is resumed. A water user's failure to comply with such directives by the General Manager will relieve the District of any liability or responsibility for the discontinuation of water deliveries.

Nothing contained in these *Rules and Regulations* will be construed as an assumption of liability on the part of the District, its directors, officers, agents or employees for any damage resulting from the improper construction, maintenance or use of any private conduit or by reason of permitting the flow of water in the private conduits.

RULE 26: DRAINAGE MAINTENANCE

Each landowner, where applicable, shall:

(a) Maintain each drain under its ownership or control, not identified as a District responsibility in the District's *Water Distribution System Operation and Maintenance Policy*;

(b) Maintain each drain under its ownership or control in a condition that adequately conveys agricultural runoff flows, does not cause flooding, minimizes seepage onto adjacent property, and does not constitute a waste of water;

(c) Maintain crossing pipelines and bridges, in or adjacent to drains, that are used for private access across the drains and are not a documented responsibility of the District; and

(d) Discharge water to the drainage system in a safe manner so as not to cause flooding or seepage to downstream properties or waste water.

The District shall assume responsibility for and maintain drains within the District's boundaries consistent with the District's *Water Distribution System Operation and Maintenance Policy.*

RULE 27: DISTRICT CONDUITS ARE NOT FOR RECREATION OR OTHER UNAUTHORIZED USES

The District's conduits will be used solely for the purpose of conveying water for the uses established by the Board of Directors, and for conveying irrigation drainage water. The use of District conduits for recreation or other unauthorized purposes is prohibited. Landowners and water users are urged to assist the District in preventing the use of District conduits and their banks for recreation, swimming, fishing, play or other unauthorized purposes.

RULE 28: CONTRACTS FOR DISTRICT SERVICES

All private work will be performed at the convenience of the District and must not interfere with the District's operation and maintenance responsibilities. Only private work directly related to irrigation water conveyance or drainage will be considered valid justification for the performance of any private work. In all cases where a landowner or water user requests to have private work performed by the District, an estimate of the cost of the work will be prepared and submitted to the landowner or water user. If the estimate is acceptable to the landowner or water user, an Agreement for Services and Materials (ASM) will be prepared by the District. The ASM will acknowledge that the landowner or water user agrees to pay for the work, and further agrees that the cost, if not paid, may be added to the District assessment on the landowner's or water user's land.

RULE 29: NON-LIABILITY OF THE DISTRICT

Private Conduits - The District will not be liable for any damage of any kind resulting directly or indirectly from any private conduit, as a result of the water flowing in any private conduit due to lack of capacity, or for negligent, wasteful or other use or handling of water by the landowner or water user.

Delivery of Water - Most of the water furnished by the District is pumped and flows through many miles of open conduits, and is subject to pollution, shortages, fluctuation in flow, and interruption in service. District employees will not and are not authorized to make any agreements binding the District to serve an uninterrupted, constant supply of water, or guaranteeing a certain quality of water. All water furnished by the District is for irrigation purposes only; landowners and water users putting District water to other uses do so at their own risk, and assume all liability for, and agree to hold the District and its directors, officers, agents and employees free and harmless from liability and damages that may occur as a result of defective water quality, water shortages, fluctuation in flow and interruptions in service. The District sells water as a commodity only, and not as a guaranteed service. The District will not be liable for defective quality of water, shortage of water, either temporary or permanent, or for failure to deliver water.

Pumping - Operation of private lift pumps by landowners or water users of District water is done at their own risk, and the District assumes no liability for damages to pumping equipment or other damages resulting from turbulent water, shortage or excess of water, or other causes, including fluctuations in the flow or elevation of water. It is the responsibility of the landowner or water user to provide appropriate devices to protect pumps from damage.

RULE 30: ENFORCEMENT OF RULES AND REGULATIONS

Failure to comply with the requirements of these *Rules and Regulations*, or any interference by any landowner, water user, or their contractors, or employees with the rights, duties, or obligations of the District and its employees, will entitle the District to terminate water service to the lands of such landowner or water user until such landowner or water user fully complies with all requirements of these *Rules and Regulations*, and will entitle the District to take other enforcement action deemed necessary by the Board of Directors, in accordance with the California Water Code.

APPENDIX A

"IRRIGATION DISTRICT LAW" (Excerpts)
(California Water Code)

Section 21385

"The board except as otherwise specifically provided has the power and it shall be its duty to manage and conduct the business and affairs of the district."

Section 25806

"(a) In case any charges for water and other services or either remain unpaid, the amount of the unpaid charges may, in the discretion of the district:

(1) If unpaid at the time specified for delivery of the assessment book to the collector, be added to and become a part of the annual assessment levied upon the real property upon which the water for which the charges are unpaid was used and upon the real property subject to the charges for any other district services and shall constitute a lien on that real property. However, if, during the year preceding the date on which the first installment of real property taxes which evidence the charges appears on the roll, any real property to which the lien would attach has been transferred or conveyed to a bona fide purchaser for value, or if a lien of a bona fide encumbrancer for value has been created and attaches thereon, then the lien which would otherwise be imposed by this subdivision shall not be added to and become part of the annual assessment nor shall it attach to the real property.

(2) Be secured at any time by filing for record in the office of the county recorder of any county, a certificate specifying the amount of the charges and the name and address of the person liable therefor.

From the time of recordation of the certificate, the amount required to be paid together with interest and penalty constitutes a lien upon all real property in the county owned by the person or afterwards, and before the lien expires, acquired by him or her. The lien has the force, priority, and effect of a judgment lien and shall continue for 10 years from the date of the filing of the certificate unless sooner released or otherwise discharged. The lien may, within 10 years from the filing of the certificate or within 10 years from the date of the last extension of the lien in the manner herein provided, be extended by filing for record a new certificate in the office of the county recorder of any county and from the time of the filing the lien shall be extended to the real property in such county for 10 years unless sooner released or otherwise discharged.

When the charges have become delinquent, they may be collected in the manner provided for the collection of delinquent assessments in Chapter 5 (commencing with Section 26075) and Chapter 6 (commencing with Section 26225) of Division 11 of Part 10.

(b) Where the county assumes the responsibility of assessment and collection pursuant to Chapter 7 (commencing with Section 26500), the amount of the unpaid charges may be added to, and become part of, the annual assessment levied upon the real property upon which the water for which the charges are unpaid was used and upon the real property subject to the charges for any other district services and shall constitute a lien on that real property upon recordation of the order confirming the assessment in the office of the county recorder of the county in which the real property is situated. However, if, during the year preceding the date on which the first installment of real property taxes which evidence the charges appears on the roll, any real property to which the lien would attach has been transferred or conveyed to a bona fide purchaser for value, or if a lien of a bona fide encumbrancer for value has been created and attaches thereon, then the lien which would otherwise be imposed by this subdivision shall not attach to the real property and the costs of the water and services or either, as confirmed, relating to the property shall be transferred to the unsecured roll for collection."

Section 25807
"If the annual district assessment is payable in two installments the unpaid charges may be added to and become a part of the first installment."

Section 22255
"When its board deems it in the best interest of the district, the district may regulate the amount of water used to irrigate crops within the district when seepage from the irrigation would damage adjacent land inside or outside of the district or may require as a condition precedent to the delivery of water the construction of adequate drainage facilities to prevent damage to the adjacent land. Whenever the board finds, with respect to land for which there is no existing system for the application of water for the irrigation thereof, that the character of the soil or elevation

of the land to be supplied water from the district water supply is such that the application of such water thereto by flooding is likely to require the use of excess quantities of water or to create a hazardous seepage or drainage problem. The board may limit the application of such water to that land to application through overhead sprinkling systems so designed and operated to prevent the use of excess quantities of water, or the creation of a hazardous seepage or drainage problem."

Section 22257
"Each district shall establish equitable rules for the distribution and use of water, which shall be printed in convenient form for distribution in the district. A district may refuse to deliver water through a ditch which is not clean or not in suitable condition to prevent waste of water and may determine through which of two or more available ditches it will deliver water.

A district may close a defective gate in community water distribution system used for irrigation purposes and may refuse to deliver water through the defective gate if the landowner fails to repair the gate or outlet to the satisfaction of the district within a reasonable time after receipt of notice from the board through its authorized water superintendent, manager or ditch tender to repair the gate or outlet. Rules and regulations adopted pursuant to this section may include, with respect to land for which there is no existing system for the application of water for the irrigation thereof, the limitation of the use of water for irrigation furnished by the district to an overhead sprinkling system where such method of irrigation will conserve water and prevent excess seepage or the creation of drainage problems."

Section 22282.1
"A district may refuse service to any land if outstanding charges for services already rendered such land have not been paid within a reasonable time."

APPENDIX B

LAWS OF THE STATE OF CALIFORNIA RELATED TO THE CALIFORNIA WATER CODE

Water, Ditches, etc., Penalty for Trespass or Interference

Penal Code Section 592(a)
"Every person who shall, without authority of the owner or managing agent, and with intent to defraud, take water from any canal, ditch, flume, or reservoir used for the purpose of holding or conveying water for manufacturing, agricultural, mining, irrigation, or generation of power, or domestic uses, or who shall without like authority, raise, lower or otherwise disturb any gate or other apparatus thereof, used for the control or measurement of water, or who shall empty or place, or cause to be emptied or placed, into any such canal, ditch, flume, or reservoir any rubbish, filth or obstruction to the free flow of water is guilty of a misdemeanor."

Penal Code Section 607
"Every person who willfully and maliciously cuts, breaks, injures or destroys, or who, without the authority of the owner of managing agent, operates any gate or control of any bridge, dam, canal, flume, aqueduct, levee, embankment, reservoir, or other structure erected . . . to store or conduct water for . . . reclamation, or agricultural purposes . . . or any embankment necessary to the same, or either of them, or willfully or maliciously makes, or causes to be made any aperture or plows up the bottom or sides in the dame, canal, flume, aqueduct, reservoir, embankment, levee, or structure, with intent to injure or destroy the same . . . is guilty of vandalism under Section 594 . . ."

Levees, Banks of Waterways and Pipeline Rights of Way

Section 21116 Vehicle Code
(a) No person shall drive any motor vehicle upon a roadway located on a levee, canal bank, natural watercourse bank, or pipeline right-of-way if the responsibility for maintenance of the levee, canal bank, natural watercourse bank, or pipeline right-of-way is vested in the state or in a reclamation, levee, drainage, water or irrigation district, or other local agency, unless such person has received permission to

drive upon such roadway from the agency responsible for such maintenance, or unless such roadway has been dedicated as a public right-of-way.

(b) For this section to be applicable to a particular levee, canal bank, natural watercourse bank, or pipeline right-of-way, the state or other agency having responsibility for maintenance of the levee, canal bank, natural watercourse bank, or pipeline right-of-way, shall erect or place appropriate signs giving notice that permission is required to be obtained to drive a motor vehicle thereon and giving notice of any special conditions or regulations that are imposed pursuant to this section and shall prepare and keep available at the principal office of the state agency or other agency affected or of the board of such agency, for examination by all interested person, a written statement, in conformity with the existing rights of such agency to control access to the roadway, describing the nature of the vehicles, if any, to which such permission might be granted and the conditions, regulations, and procedure for the acquisition of such permission adopted pursuant to this section."

APPENDIX C
WATER DATA

1 Acre Foot Supplies a Family of 5 for 1 Year

1 Acre Foot is 1 Acre Flooded 1 Foot Deep

1 Acre Foot = 325,900 Gallons

1 Acre Foot = 43,560 Cubic Feet

1 Cubic Foot = 7.48 Gallons (62½ lbs.)

1 Cubic Foot per Second (CFS) = 450 Gallons per Minute

For 24 Hours = 1.983 Acre Feet

1 CFS = 646,317 Gallons per Day

200 CFS = 90,000 Gallons per Minute

1,000,000 Gallons = 3.07 Acre Feet

GLENN-COLUSA IRRIGATION DISTRICT
STATISTICAL DATA

Main Canal Capacity	3,000 cfs
Main Canal Length	65 miles
Lateral and Pipelines	608 miles
Constructed Drains and Creek Channels	534 miles
Total District Acres	176,200 acres
Irrigable Acres	139,020 acres
Sacramento River Water Rights	720,000 acre-feet
CVP Water USBR	105,000 acre-feet
Average annual drain water recapture	205,000 acre-feet

WATER ELEVATION FOR MAIN CANAL CHECKS
U.S.C. & G.S.

Mile Post	Operating	Maximum
7.23	Stony Gates	142.00
12.91	Jacinto	138.70
17.68	Willard	137.30
21.75	Tuttle	134.10
24.00	Walker Check	132.50
26.21	Willows	130.20
31.45	Spooner	128.10
34.49	Norman	126.10
41.34	Funks	123.75
44.95	Stone Corral	121.50
48.74	Abel	119.75
49.95	Lurline	117.60
53.70	Freshwater	116.40
56.45	Salt Creek	114.10
60.87	Zumwalt	111.40
62.40	Husted	109.40
62.57	Freeway	106.00
64.96	Lateral 64.1	68.00

GLENN-COLUSA IRRIGATION DISTRICT
WATER TRANSFER POLICY

Glenn-Colusa Irrigation District (GCID or District) will consider transfers of water from the District on a case-by-case basis, and in accordance with the following policy, which restates and supersedes, in its entirety, the District's previously operative Water Transfer Policy, as adopted on September 20, 2013.

1. Goal of GCID Water Transfer Policy

The overall goal of this Policy is to protect, preserve, beneficially use and manage GCID's surface and groundwater supplies for the direct benefit of all landowners within the District, while indirectly benefitting the local, regional and state economies, and the environment. As water transfer opportunities arise, the District will offer its landowners the option to participate in the District's water transfers on a purely voluntary basis.

2. Background

The District enjoys some of the most senior water rights on the Sacramento River and its tributaries dating back to 1883. Today, the District's surface water rights are the basis of the District's 1964 Sacramento River Settlement Contract with the United States Bureau of Reclamation ("USBR"), as renewed in 2005, for a term of 40 years, and providing for the District's diversion of 825,000 acre-feet of surface water from the Sacramento River during the months of April through October each year.

The District's water rights are held "in trust" by the District collectively for the mutual benefit of all landowners (and lands) within the District. No single landowner owns a right to, or an allocation of a share of the District's water supply. Instead, each landowner has a right to deliveries of water from the District during the periods that water is available. The District continues to make every effort to ensure that water is reasonably and beneficially used within the District and to maintain the economic viability of the lands within the District, and of the District itself. Water transfers conducted by the District should therefore benefit all landowners in the District, and the District itself, while also providing benefits to landowners within the District who take direct actions to make water available to transfer.

In recent years, there has been growing statewide pressure on senior water rights holders in the Sacramento Valley, like GCID, to voluntarily transfer water to meet local, regional, and statewide needs. In this regard, voluntary transfers can provide for the temporary reallocation of water between willing sellers and willing buyers for appropriate compensation while recognizing the importance of prior rights in water. Both the California Water Code and the Central Valley Project Improvement Act (CVPIA) recognize the importance of water transfers and encourage water transfers in accordance with their requirements.

GCID has worked diligently to develop water conservation practices that can keep agricultural land in production while providing surplus water for in-basin water transfers; has coordinated with landowners within the District to develop conjunctive use practices that should also allow for water transfers both in and out of basin; and has allowed landowners to temporarily fallow (idle) lands or shift crops, which also makes water available for transfer both in and out of basin.

3. Water Supply

Water transfers will generally be limited to those years when the District has 100% of its water supplies available under its Sacramento River Settlement Contract; however, the District may approve water transfers from the District in years when its water supply is reduced under the Settlement Contract, provided that the water needs within the District have been addressed as set forth in Section 8.d of this Water Transfer Policy.

4. Board Approval Required

The Board of Directors shall make all final decisions with respect to water transfers involving the District. In making these decisions, the Board of Directors shall act based upon the best interests of the District, and will consider but shall not be bound by the criteria contained in this Water Transfer Policy. The General Manager will negotiate the price and terms of water transfers with potential Buyers, and all water transfer agreements between the District and Buyers shall be subject to final approval by the District Board of Directors.

5. Transfers Must Be District to District and No Resale by Buyers

Water transfers from the District, that rely in any manner on the District's water rights or Sacramento River Settlement Contract for the source of the transfer water, shall only be effectuated through water transfer agreements between the District and other water districts/agencies/non-governmental organizations. Transfers between individual landowners in the District to common landowners or other landowners in other Districts will not be allowed.

In addition, all water transfer agreements with Buyers shall include a provision prohibiting any resale of the transfer water outside the service area or boundary of the Buyer without the written permission of GCID. Such permission will not be unreasonably withheld by GCID. Any profits derived from such resale, other than administrative costs associated with the transaction, shall be tendered to GCID by Buyers.

6. Types of Transferrable Water

a) Project Water. The District's Settlement Contract provides for GCID's diversion of 105,000 acre-feet of Project water, as uniquely defined in the contract, for use in the critical months of July and August to supplement the District's base supply water during the irrigation season. Subject to the provisions of the CVPIA, a portion of this Project supply may be transferred into other months for irrigation use, or can be transferred outside of the District, subject to certain limitations and USBR approval. This Project water would only be available to other USBR contractors within the Sacramento Valley hydrologic region. There are significant limitations on a District landowner's potential rights and ability to transfer the landowner's allocated portion of the District's Project supply.

b) Land Idling and Crop Shifting. Land idling would make water available for transfer as a result of landowners not planting a crop, thus making the water that the crop would have consumed (through evapotranspiration) available. Crop shifting involves paying farmers to substitute a crop with one that uses less water, whereby the surplus water derived from the shifting becomes available for transfer. In either case, actions taken by the landowner will result in a portion of the District's water supply being available, and the District must enter into agreements for the transfer of the water supply to another water agency buyer, as well as obtaining approval from the USBR and other involved agencies.

   All District landowners will be eligible to undertake voluntary land idling and crop shifting actions for the purposes of water transfers by the District. Landowners participating in a land idling or crop shifting transfer will also be responsible for meeting requirements as mandated by local, state, and federal agencies related to economic and environmental impacts that may result from the transfer. Landowners will be required to implement and comply with any monitoring and mitigation plan requirements imposed by any agencies approving the transfer. The amount of water made available through land idling generally may not exceed 20% of the water that would have been applied within the District in that year, in the absence of the water transfer(s) undertaken that year. To the extent land idling participation exceeds this general 20% limitation; the District will allocate participation in the program in a fair and equitable manner.

c) Groundwater Substitution. Groundwater substitution transfers occur when a landowner foregoes a surface water delivery from the District, and pumps an equivalent amount of groundwater from the landowner's private well as an alternative supply. In this case, actions taken by the landowner to pump will result in a portion of the District's water supply being available, and the District must enter into agreements for the transfer of the water supply to another water agency buyer, as well as obtaining approval from the USBR and other involved agencies. To the extent that the interest in groundwater substitution exceeds certain limits, the District will allocate groundwater substitution participation in a fair and equitable manner. Landowners will also be responsible for meeting requirements as mandated by local, state, and federal agencies related to economic and environmental impacts that may result from the transfer. Landowners will be required to develop a monitoring and mitigation plan should it be required. All District landowners with private groundwater wells who are able to meet these requirements will be eligible to undertake groundwater substitution actions for the purposes of water transfers by the District.

7. Priorities of Water Transferred

a) In-Basin Agricultural Transfers. In-basin transfers refer to those transfers that occur within the same counties of origin or hydrogeologic region, e.g. the Sacramento Valley. GCID may transfer water in-basin however, such transfers will occur only on a district-to-district basis, with preference given to other CVP settlement or water service contractors for irrigation and agricultural purposes of use.

b) Environmental Transfers. In next order of priority, GCID will market surplus water for environmental purposes. This water may be marketed to environmental groups, environmental agencies, e.g., the California Department of Fish and Wildlife (CDFW), the United States Fish and Wildlife Service (USFWS), or the USBR/Department of Water Resources (DWR), depending upon the nature of the transfer at issue and the number of willing environmental buyers.

c) North-of-Delta Transfers. GCID will next market water to urban water agencies north of the Delta.

d) South-of-Delta Transfers. GCID will next market water to agricultural or urban water agencies south of the Delta, or to the USBR/DWR for delivery to their contracting agencies south of the Delta.

8. Transfer Process, Pricing and Payments to Landowners

a) On or about March 1 of each year, the District will notify landowners if water transfers within and outside of the District are being contemplated. If water transfers are planned, the District will provide landowners an Expression of Interest form to complete in order to participate in making water available for transfers. Landowners must complete and return the form to the District, by the date set by the District in order to participate in the District's water transfer program.

b) Establishment of Sale Price. When the District's water supply has been finalized, the District Board of Directors will set an Initial Sale Price per acre-foot transferred, for consideration by interested landowners who intend to make water available for the District's Water Transfer Pool via groundwater substitution, land idling or crop shifting. Participating landowners will be paid no less than the Initial Sale Price for each acre-foot transferred. Landowners may rescind their Expression of Interest form if they consider the sale price offered by the District to be too low.

c) 100% Contract Supply Year Procedure. In 100% supply years under the District's Settlement Contract, the District will compare the amount of water to be made available for transfer under the pending Expression of Interest Forms to the demand for water transfers out of the District. If the supply of water exceeds the demand, the District will prorate participation in making water available. The landowners with pending Expression of Interest Forms will then execute agreements with the District setting forth the terms of participation in making water available for transfer and payment.

d) Critical Year Procedure. The purpose of the Critical Year Procedure is to ensure that no District landowner or water user is unreasonably adversely affected as a result of any District water transfer in critical dry years. If the year is deemed to be a Shasta Critical year under the District's Settlement Contract, the District will first offer water users within the District the opportunity to buy water from the Water Transfer Pool at the established Initial Sale Price. Interested in-District water users will execute an agreement with the District and pay the Initial Sale Price per acre-foot purchased.

If the in-District demand for water from the Water Transfer Pool exceeds the supply made available under the pending Expression of Interest Forms, the District will prorate the supply to all in-District water users purchasing water from the Water Transfer Pool. If the supply of water in the Water Transfer Pool exceeds the in-District demand, any additional supply will be made available for water transfers out of the District. The landowners with pending Expression of Interest Forms will sign agreements with the District setting forth the terms of participation in making water available for transfer and payment.

e) Revenue Split Beyond Minimum Sale Price. Revenues from the sale of water from the Water Transfer Pool beyond the Initial Sale Price will be shared between participating landowners and the District. The District will retain the next $XXX per acre-foot above the Initial Sale Price. If the out of District buyer's sale price per acre-foot is more than the Initial Sale Price plus $XXX, the remaining revenue will be shared between the landowners and the District in a percentage to be decided by the District Board of Directors.

9. Water Transfer Revenue

Any revenues retained by the District for water transfers will generally be applied as follows, unless otherwise determined by the Board of Directors:

a) Landowner Payments. For land idling or crop substitution, the District will pay to landowners an amount that in-part is based on the foregone costs and benefits as if the land would have been farmed. The price from year to year will vary depending on the price that water transfer buyers are willing to pay. For groundwater substitution transfers, landowners within the District utilizing their own private wells will be paid a price commensurate to the actual cost to pump groundwater and deliver it to a District facility, and a reasonable cost for the amortized capital installation cost and operations and maintenance.

b) District Operational Costs. District water rates are based on the premise of most of the irrigable lands within the District being irrigated and farmed each year, except for the periodic idling due to crop rotation or resting the land. If land is idled as a direct result of a water transfer program, the District shall retain a portion of the transfer revenue from the land participating in the transfer to pay for the water rates as if the land were farmed. The District will use these funds to ensure its annual budget is "made whole" from lands participating in a transfer, and that no cost-shift occurs to lands remaining in production.

c) District Reserves. The District will retain a portion of transfer revenues, which will be placed into the Water Supply Protection and Regional Sustainability Reserve and apportioned and utilized in accordance with the District's Reserve Policy. This retention is in direct recognition that the District holds the water rights associated with the transfer "in trust" for all lands within the District, as well as a recognition of the benefits accruing to the groundwater system through recharge from the District's canal and drain system, and the deep percolation of the District's surface water during crop irrigation.

d) Monitoring/Mitigating Third Party Impacts and Regional Sustainability. As determined by the District, funds from a transfer may be used to pay for additional monitoring and/or mitigation that may be required to address potential impacts resulting from a transfer. Any funds retained by the District for past, present, and future groundwater recharge and sustainability purposes will be used to protect, enhance, and ensure the long term reliability of this resource as described in GCID's Conjunctive Use Policy. Funds retained for this item will be placed in the Water Supply Protection and Regional Sustainability Reserve for specific purposes as identified in the District's Reserve Policy.

10. Compliance with Applicable Law, and Completion of Environmental Documentation

GCID will comply with any applicable local, state, and federal laws pertaining to water transfers, and the District's approval and implementation of any water transfer shall be contingent upon the completion and adoption of any necessary environmental documentation under the California Environmental Quality Act and National Environmental Policy Act.

Provident Irrigation District (PID)

PROVIDENT IRRIGATION DISTRICT
Rules for Distribution and Use of Water
Adopted July 9, 2002

The Board of Directors of Provident Irrigation District have adopted these Rules and Regulations under authority of the provisions of California Water Code Section 22257, that provides for a district to establish and distribute a set of equitable rules for the distribution and use of water.

Rule 1. Control of System

The maintenance, and operation of the canals, drains and works of the District shall be under the exclusive management and control of the District Manager, appointed by the Board of Directors and no other person, except his employees and assistants shall have any right to interfere with said canals, drains and works in any manner, except in case of an order from the Board of Directors.

Rule 2. Ditchtenders and Other Employees

The District Manager will employ such ditchtenders and other assistants as he may deem necessary for the proper operation of the system subject to the approval of the Board of Directors. Each ditchtender shall have charge of his respective Section, and shall be responsible to the District Manager. From the rulings and the action of the ditchtender an appeal may be made to the District Manager. From the action of the District Manager an appeal may be made to the Board of Directors at any meeting of such Board.

Rule 3. Distribution of Water

All waters shall be apportioned ratably to each landowner upon the basis of the ratio which the last assessment against his land for District purposes bears to the whole sum assessed upon the lands of the District, or in such other manner as is allowed by law, to such landowners making application therefor, and making payments of the tolls and charges fixed by the Board. Upon failure of any landowner to make application for water, the water that would otherwise be allotted to such landowner may be alloted by the District to other landowners who make application therefor.

Any landowner may make application for additional water over and above the amount to which he is entitled under his assessment and if such application cannot be granted for the full amount applied for, such water as may be available shall be pro-rated between such applications in proportion to their said assessments in the District.

Rule 4. Application for Water

At such time as may be ordered by resolution of the Board of Directors, each landowner or tenant shall file an application for water on a form provided by the District, setting forth the crops and acreage of each he is intending to irrigate. The application shall further contain the name of the owner of the land to be farmed, name of the tenant or tenants, acreage to be farmed within the District, amount and location of acreage for which the water is required and such other matters as the Board of Directors may desire. By making said application the applicant grants a right to the District for the irrigation season to control all ditches and laterals, and to install, maintain, control and regulate all meters, measuring devices, delivery gates or other structures in any ditch, canal or lateral necessary and on which the District does not otherwise have such rights, for the distribution, measurement and control of water, and to go upon the applicant's land for the purpose of measuring the area irrigated.

Any land that is farmed by a tenant is subject to the imposition of a claim by the District for any unpaid District rates, charges or assessments.

Rule 5. Delivery of Water

All orders for delivery or for shut-off of water must be made to the District's office by 2:00 p.m. on the day prior to the desired delivery or shut-off. The District will attempt to make delivery the same day, or by the next day for orders received after 2:00 p.m. The District's distribution system, however, is not designed to provide full service to every landowner simultaneously. Therefore, there may be times when water deliveries must be rotated, and that rotation will be imposed as equitably as possible by the District Manager. The District shall not be responsible for loss or damages incurred by reason of delays or interruptions in delivery of water service.

Water must be used continuously by the water user throughout the period of delivery, both day and night.

The District shall deliver no water unless proof of payment therefore required by these Rules and Regulations is made.

Rule 6. Measurements and Measuring Devices

The District shall be entitled to place such meters or other measuring devices, turnouts, gates, or other structures in the ditches, canals and laterals as it may consider necessary or proper.

Rule 7. Time for Fixing Rates of Tolls and Charges

The rates of tolls and charges for the use of water and other purposes may be fixed and determined annually by the Board of Directors. The rates of tolls and charges are payable at the District office.

If an applicant requests only a single irrigation, the entire amount of tolls and charges shall be paid before water is delivered. Should an applicant require a subsequent irrigation, the entire amount of tolls and charges for that subsequent irrigation shall be paid before water is delivered. Where more that one irrigation or continuous irrigation (such as for rice) during a season will be required, the applicant shall pay a minimum of one-fourth of the tolls and charges upon filing his application and before water delivery is commenced. The remainder of the tolls and charges shall be paid, one-fourth each, on or before the first day of June, July and August.

All water tolls and charges shall become delinquent fifteen days after the same are due and payable. If not paid prior to such delinquency, an interest charge of 1 ½% per month shall be added. If delinquent water tolls and charges are not fully paid on or before the last Monday of December, an additional 10% penalty shall be added thereto and shall be and become part of such tolls and charges, in addition to the interest on delinquent payments, and such penalty will also bear interest thereafter.

In addition to any other rights under law, the District may secure any unpaid tolls and charges in accordance with California Water Code Section 25806, that allows, in the District's discretion, for such charges to be added to the next assessment on the land, or to be secured by the filing of a certificate of lien in the office of the county recorder of any county. Landowners should understand that one or more of these processes could ultimately result in their loss of title to their land.

If any applicant for or user of water or the land upon which the water is to be used is fifteen or more days delinquent in the payment of any District tolls or charges, or any installments thereof, water delivery to such applicant or land shall be refused or discontinued until such tolls or charges or installments thereof, plus interest and penalties as provided for in these Rules and Regulations, are paid. If water service has commenced for the irrigation season, but is to be discontinued under the terms of this Rule, the landowner, and tenant, if any, who signed the application for water for the year, will first be afforded the right to a hearing before the District Manager or Board of Directors, as set forth in a written notice to be given to the landowner and tenant. Addition of delinquent water toll or tolls to the assessment against the lands using such water shall not be considered as payment thereof. The District's option to discontinue water service is in addition to all other rights of enforcing payment of District tolls and charges, and shall not be construed as limiting the rights of the District to otherwise enforce collection of its tolls and charges.

If at any time during an irrigation season, a landowner or water user has been more than thirty days delinquent in the payment of district tolls or charges, the District will require that one hundred percent of the following irrigation season's estimated water tolls and charges for the land on which the prior year's tolls or charges were delinquent be deposited at the time an application for water service is filed for that subsequent irrigation season.

Rule 8. District Owned Property

The lands owned or controlled by the District may be leased or rented under such terms and conditions as may be prescribed and ordered by the Board of Directors from time to time; provided however, that unless different rules, regulations and rates are fixed, then these rules, regulations and rates shall apply to water service to be delivered to such District-owned land.

Rule 9. Acreage Surveys

If the District finds it necessary to survey land for the purpose of determining the acreage planted and for which water was delivered, it will include all lands within the exterior boundaries of the area on which water has been allowed to stand, or use such other standards for measurement as are commonly used in the area in which the land is situated.

Rule 10. Abandoned Use of Water

Whenever the use of water is abandoned on any lands, such lands shall be required to pay the full installments of water tolls and charges due and payable at the time the District receives notice of such abandonment.

Rule 11. Condition of Ditches

Upon the application of a landowner or water user for the delivery of water, it shall be the duty of the District Manager to certify whether or not the applicant's ditches are in proper condition to receive water.

As provided in California Water Code Section 22257, all ditches must be kept free from weeds and other obstructions and shall be of sufficient capacity and properly constructed and maintained so as to carry water without danger of serious breaks or waste, and if not so unobstructed, constructed and maintained the District Manager may shut off delivery of water thereto. The District Manager will examine all ditches and may order them to be cleaned, repaired or reconstructed if necessary, before water is turned in. Refusal to comply with this rule will be sufficient cause for refusal to turn in water. Nothing herein shall be construed as an assumption of liability on the part of the District, its Directors, officers or employees for any damages occasioned through the improper construction, maintenance or use of any ditch or ditches or by reason of permitting the flow of water or turning water therein.

Rule 12. Waste of Water

Any landowner or water user wasting water either wilfully, carelessly, or on account of defective ditches will be refused the use of water until such conditions are remedied. Without limiting the foregoing, the District and its Board of Directors reserve the right to refuse or to limit delivery of water to any lands when it appears to the satisfaction of the Board of Directors that its proposed use, or method of use, will require such excessive quantities of water as will constitute waste or will damage adjacent land by seepage.

When it appears to the satisfaction of the Board of Directors that service of water to certain lands will probably result in seepage damage to adjacent lands the Board may require as a condition precedent to the delivery of water a written guarantee on the part of the landowner desiring service that he will protect the District and hold it free and harmless from liability for any such damage.

Rule 13. Shortage of Water

When, through lack of water, lack of ditch capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof the full supply of water required by the water users, such supply as can be delivered will be equitably pro-rated until such time as delivery of a full supply can be given. A pro-rata delivery means a simultaneous flow available at a point nearest the District system for the use of each and every landowner or water user in as nearly an exact proportion as can be determined of the total amount available or that can be delivered, based on the individual's right to receive water as fixed by acreage, crop to be irrigated, ditch capacity, or otherwise. The method may be applied to all, or a part of the system.

Rule14. Use of Laterals and Distribution Ditches

No District owned or operated lateral shall be used as a distribution ditch to directly irrigate alfalfa, clover, corn or similar strip check grown crop.

Rule 15. Complaints

All complaints as to service, lack of water, or other unsatisfactory conditions should be made immediately, in writing, addressed to the District office.

Rule 16. Access to Land and Ditches

The District and its agents shall have free access at all times to all lands irrigated from the canal system and to all canals, laterals and ditches for the purpose of inspection, examination, measurements, surveys or other necessary purposes of the District, with the right of installation, maintenance, control and regulation of all meters or other measuring devices, gates, turnouts, or other structures necessary or proper for the measurement and distribution of water.

The District assumes no liability for damages to persons or property occasioned through defective ditches, laterals, meters or measuring devices.

Rule 17. Use of District Right-of-Way

No trees or crops shall be planted on any District right-of-way, and all such trees or crops growing therein shall belong absolutely to the District. The District Manager may, upon such terms and conditions as he deems appropriate, grant permission in writing for annual crops to be planted in a District right-of-way. Such plantings shall be entirely at the risk of the landowner or tenant planting such crops.

Rule 18. Obstructions on Right-of-Way

No fences or other obstructions shall be placed across, upon or along any canal bank or District right-of-way without the written permission of the Board of Directors, subject to such conditions as the Board deems appropriate. Any obstructions placed without permission as herein required shall be removed by the District and the expense of such removal shall be assessed against the landowner.

Rule 19. Drains

Before allowing water to drain or waste into the drains constructed by the District, all landowners and water users must construct, install and maintain all necessary structures so as to protect such drains from erosion and damage. Such work must be done to the satisfaction of the District Manager.

Each landowner shall construct and maintain adequate drainage facilities to prevent damage to adjacent land.

Rule 20. Gates, Structures and Main Canal

No opening shall be made or structures placed in or on any District right-of-way, nor shall anyone alter District facilities without the written permission of the District Manager. All such structures or alterations must be constructed according to requirements of the District, at the expense of the landowner or water user, must be maintained in a condition satisfactory to the District Manager and must not be changed without the written permission of the District Manager.

If a landowner or water user desires to have work done at his expense by the District, the District will prepare an estimate in advance if the landowner or water user requests it. The total cost of all work shall be paid within 30 days of completion of the project.

Rule 21. Damage to Laterals

Any person causing damage to or permitting livestock to cause damage to any District right of way or facilities shall be required to reimburse this District for all expense incurred in repairing the same.

Rule 22. Enforcement of Rules

Refusal to comply with the requirements, any violations of any of these Rules and Regulations, or any interference with the proper discharge of the duties of any person employed by the District, shall be considered sufficient cause for shutting off the water, and water will not again be furnished until in the opinion of the District Manager full compliance has been made with all requirements herein set forth.

Rule 23. Non-Liability of District

The District will not be liable for any damage of any kind or nature resulting directly or indirectly to any private ditch or the water flowing therein or by reason of lack of capacity therein, or for negligent, wasteful or other use or handling of water by the users thereof. The District's responsibility shall absolutely cease when the water leaves the District's facilities, and the District will not be liable for shortage of water, either temporary or permanent, failure to deliver such water, or for the quality thereof.

Rule 24. Presumption of Knowledge by Landowners

All landowners in the District shall be conclusively presumed to have knowledge of these Rules and Regulations, of the provisions of the California Irrigation District Law, and of all proceedings had, and all orders and decisions made and entered in the District's records, including those already appearing therein and those that may hereafter be entered therein; and all such landowners are bound by them.

Rule 25. Borrowing Equipment

Tools or equipment will not be loaned unless the borrower first secures a properly signed order for same at the District office.

Rule 26. Rebates

Refunds or rebates for water applied for but not used will only be considered in the discretion of the Board of Directors and none will be granted unless application therefore is made within the current year during which payment was made.

The foregoing Rules and Regulations were adopted ____________________________, superceding all former Rules and Regulations.

Princeton-Codora-Glenn Irrigation District (PCGID)

PRINCETON-CODORA-GLENN IRRIGATION DISTRICT
Rules for Distribution and Use of Water
Adopted: July 10, 2002

The Board of Directors of Princeton-Codora-Glenn Irrigation District have adopted these Rules and Regulations under authority of the provisions of California Water Code Section 22257, that provides for a district to establish and distribute a set of equitable rules for the distribution and use of water.

Rule 1. Control of System

The maintenance, and operation of the canals, drains and works of the District shall be under the exclusive management and control of the District Manager, appointed by the Board of Directors and no other person, except his employees and assistants shall have any right to interfere with said canals, drains and works in any manner, except in case of an order from the Board of Directors.

Rule 2. Ditchtenders and Other Employees

The District Manager will employ such ditchtenders and other assistants as he may deem necessary for the proper operation of the system subject to the approval of the Board of Directors. Each ditchtender shall have charge of his respective Section, and shall be responsible to the District Manager. From the rulings and the action of the ditchtender an appeal may be made to the District Manager. From the action of the District Manager an appeal may be made to the Board of Directors at any meeting of such Board.

Rule 3. Distribution of Water

All waters shall be apportioned ratably to each landowner upon the basis of the ratio which the last assessment against his land for District purposes bears to the whole sum assessed upon the lands of the District, or in such other manner as is allowed by law, to such landowners making application therefor, and making payments of the tolls and charges fixed by the Board. Upon failure of any landowner to make application for water, the water that would otherwise be allotted to such landowner may be alloted by the District to other landowners who make application therefor.

Any landowner may make application for additional water over and above the amount to which he is entitled under his assessment and if such application cannot be granted for the full amount applied for, such water as may be available shall be pro-rated between such applications in proportion to their said assessments in the District.

Rule 4. Application for Water

At such time as may be ordered by resolution of the Board of Directors, each landowner or tenant shall file an application for water on a form provided by the District, setting forth the crops and acreage of each he is intending to irrigate. The application shall further contain the name of the owner of the land to be farmed, name of the tenant or tenants, acreage to be farmed within the District, amount and location of acreage for which the water is required and such other matters as the Board of Directors may desire. By making said application the applicant grants a right to the District for the irrigation season to control all ditches and laterals, and to install, maintain, control and regulate all meters, measuring devices, delivery gates or other structures in any ditch, canal or lateral necessary and on which the District does not otherwise have such rights, for the distribution, measurement and control of water, and to go upon the applicant's land for the purpose of measuring the area irrigated.

Any land that is farmed by a tenant is subject to the imposition of a claim by the District for any unpaid District rates, charges or assessments.

Rule 5. Delivery of Water

All orders for delivery or for shut-off of water must be made to the District's office by 2:00 p.m. on the day prior to the desired delivery or shut-off. The District will attempt to make delivery the same day, or by the next day for orders received after 2:00 p.m. The District's distribution system, however, is not designed to provide full service to every landowner simultaneously. Therefore, there may be times when water deliveries must be rotated, and that rotation will be imposed as equitably as possible by the District Manager. The District shall not be responsible for loss or damages incurred by reason of delays or interruptions in delivery of water service.

Water must be used continuously by the water user throughout the period of delivery, both day and night.

The District shall deliver no water unless proof of payment therefore required by these Rules and Regulations is made.

Rule 6. Measurements and Measuring Devices

The District shall be entitled to place such meters or other measuring devices, turnouts, gates, or other structures in the ditches, canals and laterals as it may consider necessary or proper.

Rule 7. Time for Fixing Rates of Tolls and Charges

The rates of tolls and charges for the use of water and other purposes may be fixed and determined annually by the Board of Directors. The rates of tolls and charges are payable at the District office.

If an applicant requests only a single irrigation, the entire amount of tolls and charges shall be paid before water is delivered. Should an applicant require a subsequent irrigation, the entire amount of tolls and charges for that subsequent irrigation shall be paid before water is delivered. Where more that one irrigation or a continuous irrigation (such as for rice) during a season will be required, the applicant shall pay a minimum of one-fourth of the tolls and charges upon filing his application and before water delivery is commenced. The remainder of the tolls and charges shall be paid, one-fourth each, on or before the first day of June, July and August.

All water tolls and charges shall become delinquent fifteen days after the same are due and payable. If not paid prior to such delinquency, an interest charge of 1 ½% per month shall be added. If delinquent water tolls and charges are not fully paid on or before the last Monday of December, an additional 10% penalty shall be added thereto and shall be and become part of such tolls and charges, in addition to the interest on delinquent payments, and such penalty will also bear interest thereafter.

In addition to any other rights under law, the District may secure any unpaid tolls and charges in accordance with California Water Code Section 25806, that allows, in the District's discretion, for such charges to be added to the next assessment on the land, or to be secured by the filing of a certificate of lien in the office of the county recorder of any county. Landowners should understand that one or more of these processes could ultimately result in their loss of title to their land.

If any applicant for or user of water or the land upon which the water is to be used is fifteen or more days delinquent in the payment of any District tolls or charges, or any installments thereof, water delivery to such applicant or land shall be refused or discontinued until such tolls or charges or installments thereof, plus interest and penalties as provided for in these Rules and Regulations, are paid. If water service has commenced for the irrigation season, but is to be discontinued under the terms of this Rule, the landowner, and tenant, if any, who signed the application for water for the year, will first be afforded the right to a hearing before the District Manager or Board of Directors, as set forth in a written notice to be given to the landowner and tenant. Addition of delinquent water toll or tolls to the assessment against the lands using such water shall not be considered as payment thereof. The District's option to discontinue water service is in addition to all other rights of enforcing payment of District tolls and charges, and shall not be construed as limiting the rights of the District to otherwise enforce collection of its tolls and charges.

If at any time during an irrigation season, a landowner or water user has been more than thirty days delinquent in the payment of district tolls or charges, the District will require that one hundred percent of the following irrigation season's estimated water tolls and charges for the land on which the prior year's tolls or charges were delinquent be deposited at the time an application for water service is filed for that subsequent irrigation season.

Rule 8. District Owned Property

The lands owned or controlled by the District may be leased or rented under such terms and conditions as may be prescribed and ordered by the Board of Directors from time to time;

provided however, that unless different rules, regulations and rates are fixed, then these rules, regulations and rates shall apply to water service to be delivered to such District-owned land.

Rule 9. Acreage Surveys

If the District finds it necessary to survey land for the purpose of determining the acreage planted and for which water was delivered, it will include all lands within the exterior boundaries of the area on which water has been allowed to stand, or use such other standards for measurement as are commonly used in the area in which the land is situated.

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Whenever the use of water is abandoned on any lands, such lands shall be required to pay the full installments of water tolls and charges due and payable at the time the District receives notice of such abandonment.

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Upon the application of a landowner or water user for the delivery of water, it shall be the duty of the District Manager to certify whether or not the applicant's ditches are in proper condition to receive water.

As provided in California Water Code Section 22257, all ditches must be kept free from weeds and other obstructions and shall be of sufficient capacity and properly constructed and maintained so as to carry water without danger of serious breaks or waste, and if not so unobstructed, constructed and maintained the District Manager may shut off delivery of water thereto. The District Manager will examine all ditches and may order them to be cleaned, repaired or reconstructed if necessary, before water is turned in. Refusal to comply with this rule will be sufficient cause for refusal to turn in water. Nothing herein shall be construed as an assumption of liability on the part of the District, its Directors, officers or employees for any damages occasioned through the improper construction, maintenance or use of any ditch or ditches or by reason of permitting the flow of water or turning water therein.

Rule 12. Waste of Water

Any landowner or water user wasting water either wilfully, carelessly, or on account of defective ditches will be refused the use of water until such conditions are remedied. Without limiting the foregoing, the District and its Board of Directors reserve the right to refuse or to limit delivery of water to any lands when it appears to the satisfaction of the Board of Directors that its proposed use, or method of use, will require such excessive quantities of water as will constitute waste or will damage adjacent land by seepage.

When it appears to the satisfaction of the Board of Directors that service of water to certain lands will probably result in seepage damage to adjacent lands the Board may require as a condition precedent to the delivery of water a written guarantee on the part of the landowner desiring service that he will protect the District and hold it free and harmless from liability for any such damage.

Rule 13. Shortage of Water

When, through lack of water, lack of ditch capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof the full supply of water required by the water users, such supply as can be delivered will be equitably pro-rated until such time as delivery of a full supply can be given. A pro-rata delivery means a simultaneous flow available at a point nearest the District system for the use of each and every landowner or water user in as nearly an exact proportion as can be determined of the total amount available or that can be delivered, based on the individual's right to receive water as fixed by acreage, crop to be irrigated, ditch capacity, or otherwise. The method may be applied to all, or a part of the system.

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All complaints as to service, lack of water, or other unsatisfactory conditions should be made immediately, in writing, addressed to the District office.

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The District and its agents shall have free access at all times to all lands irrigated from the canal system and to all canals, laterals and ditches for the purpose of inspection, examination, measurements, surveys or other necessary purposes of the District, with the right of installation, maintenance, control and regulation of all meters or other measuring devices, gates, turnouts, or other structures necessary or proper for the measurement and distribution of water.

The District assumes no liability for damages to persons or property occasioned through defective ditches, laterals, meters or measuring devices.

Rule 17. Use of District Right-of-Way

No trees or crops shall be planted on any District right-of-way, and all such trees or crops growing therein shall belong absolutely to the District. The District Manager may, upon such terms and conditions as he deems appropriate, grant permission in writing for annual crops to be planted in a District right-of-way. Such plantings shall be entirely at the risk of the landowner or tenant planting such crops.

Rule 18. Obstructions on Right-of-Way

No fences or other obstructions shall be placed across, upon or along any canal bank or District right-of-way without the written permission of the Board of Directors, subject to such conditions as the Board deems appropriate. Any obstructions placed without permission as herein required shall be removed by the District and the expense of such removal shall be assessed against the landowner.

Rule 19. Drains

Before allowing water to drain or waste into the drains constructed by the District, all landowners and water users must construct, install and maintain all necessary structures so as to protect such drains from erosion and damage. Such work must be done to the satisfaction of the District Manager.

Each landowner shall construct and maintain adequate drainage facilities to prevent damage to adjacent land.

Rule 20. Gates, Structures and Main Canal

No opening shall be made or structures placed in or on any District right-of-way, nor shall anyone alter District facilities without the written permission of the District Manager. All such structures or alterations must be constructed according to requirements of the District, at the expense of the landowner or water user, must be maintained in a condition satisfactory to the District Manager and must not be changed without the written permission of the District Manager.

If a landowner or water user desires to have work done at his expense by the District, the District will prepare an estimate in advance if the landowner or water user requests it. The total cost of all work shall be paid within 30 days of completion of the project.

Rule 21. Damage to Laterals

Any person causing damage to or permitting livestock to cause damage to any District right of way or facilities shall be required to reimburse this District for all expense incurred in repairing the same.

Rule 22. Enforcement of Rules

Refusal to comply with the requirements, any violations of any of these Rules and Regulations, or any interference with the proper discharge of the duties of any person employed by the District, shall be considered sufficient cause for shutting off the water, and water will not again be furnished until in the opinion of the District Manager full compliance has been made with all requirements herein set forth.

Rule 23. Non-Liability of District

The District will not be liable for any damage of any kind or nature resulting directly or indirectly to any private ditch or the water flowing therein or by reason of lack of capacity therein, or for negligent, wasteful or other use or handling of water by the users thereof. The District's responsibility shall absolutely cease when the water leaves the District's facilities, and the District will not be liable for shortage of water, either temporary or permanent, failure to deliver such water, or for the quality thereof.

Rule 24. Presumption of Knowledge by Landowners

All landowners in the District shall be conclusively presumed to have knowledge of these Rules and Regulations, of the provisions of the California Irrigation District Law, and of all proceedings had, and all orders and decisions made and entered in the District's records, including those already appearing therein and those that may hereafter be entered therein; and all such landowners are bound by them.

Rule 25. Borrowing Equipment

Tools or equipment will not be loaned unless the borrower first secures a properly signed order for same at the District office.

Rule 26. Rebates

Refunds or rebates for water applied for but not used will only be considered in the discretion of the Board of Directors and none will be granted unless application therefore is made within the current year during which payment was made.

The foregoing Rules and Regulations were adopted ____________________________, superceding all former Rules and Regulations.

Reclamation District No. 108 (RD 108)

RULES AND REGULATIONS

COVERING THE DISTRIBUTION OF WATER

IN

RECLAMATION DISTRICT NO. 108

AND FIXING CHARGES AND RATES FOR THE SAME

ADOPTED NOVEMBER 8, 1989

Pursuant to Section 50911 (a) of the Water Code of the State of California

BOARD OF TRUSTEES

Lewis Bair
General Manager

Kathryn Chandler
Assistant Manager

Headquarters on Wilson Bend Road at Wilkins Slough
P.O. Box 50
Grimes, CA 95950
(530)437-2221 fax (530)437-2248

RULES AND REGULATIONS
GOVERNING THE DISTRIBUTION OF WATER IN
RECLAMATION DISTRICT NO. 108
AND FIXING CHARGES FOR THE SAME

RULE 1 – CONTROL OF SYSTEM

The operation of all irrigation works owned or operated by Reclamation District No. 108 shall be under the exclusive management and control of the Manager of the District. No other person shall have any right to operate or interfere in any manner with said irrigation works, except for duly appointed assistants of the Manager or when specifically authorized by resolution of the Board of Trustees of the District.

RULE 2 – EMPLOYEES

Subject to the approval of the Board of Trustees, the Manager shall employ such assistants as may be necessary for the proper operation and maintenance of the irrigation works of the District. In such operation and maintenance, all employees shall be guided by these Rules and Regulations and by such technical and other instructions and advice as may be given by the Engineer of the District for the purpose of carrying out the policies of the Board of Trustees and providing efficient and economical services.

RULE 3 – DISTRIBUTION OF WATER

The District will deliver water into the various irrigation canals and laterals included in its adopted project at such levels as are feasible and practicable with the facilities existing at the time these Rules and Regulations are made effective and such other facilities as may thereafter be added by resolution of the Board of Trustees. Except as hereinafter provided in case of a shortage of water or in case of noncompliance with these Rules and Regulations, water will be delivered into the irrigation canals and laterals in sufficient quantity to meet the reasonable needs of all qualified irrigators.

RULE 4 – APPLICATIONS FOR WATER

Prior to the first delivery of water to each tract of land each season and prior to the pumping of any water from the works of the District to lands not susceptible to gravity irrigation, an application for water shall be filed with the Manager or authorized assistant on a form provided by the District. All applications shall be signed by and shall show the name and address of the party (applicant) to be billed for irrigation services, and such other information as the Manager may require from time to time.

In all instances, the landowner shall be responsible for all charges for water used upon his or her land and, when the application for water is made by a tenant, the applicant, and all other tenants making use of such water, shall be jointly and severally liable with the landowner for all water charges.

RULE 5 – CHARGES FOR WATER

The Board annually shall adopt a schedule of rates to be charged by the District for irrigation water service.

RULE 6 – TIME OF PAYMENT

Payment of the seasonal charge for the irrigation of each tract of rice shall be made in three equal installments; the first prior to the initial delivery of water to the tract, the second on or before the first day of July and the third on or before the fifteenth day of August.

Payment of the charges for water for each irrigation of lands and corps utilizing a single irrigation or a series of separate irrigations during the season shall be made not later than the start of each separate irrigation.

For special cases, payment of the seasonal charge for water shall be made in such installments of such amounts as the Manager may determine to be necessary in each case so as to insure that all water so delivered is paid for in advance.

If any installment is not paid by the due day set forth above, it shall be considered delinquent and a penalty of five percent (5%) shall be added to the balance. There shall also be added at the end of each thirty (30) day period following date of delinquency, interest at the rate of one percent (1%) on the delinquent principal amount until the full amount including principal, penalty and interest is paid. The District may in addition thereto, immediately discontinue the delivery of water and refuse further delivery of water for the irrigation of said land until charges are paid in full.

RULE 7 – SHORTAGE OF WATER

Whenever a general shortage of water appears imminent, the Board of Trustees shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary; local or similar shortages, the Manager is authorized to place in effect such variations in service as in his judgment the occasion requires.

RULE 8 – WASTE OF WATER

Any water user who deliberately, carelessly or otherwise wastes water on roads, vacant land or land previously irrigated or who floods certain portions of the land to an unreasonable depth or who uses an unreasonable amount of water in order to irrigate properly other portions or who irrigates land which has been improperly checked for the economical use of water or who allows an unnecessary amount of water to escape from any field will be refused the use of water until such conditions are remedied or will have his use curtailed by the amount of waste, as the Manager may determine.

The District reserves the right to refuse delivery of water to any lands when it appears to the satisfaction of the Manager that its proposed use or method of use would require such excessive quantities of water as would constitute waste.

RULE 9 – MEASUREMENT OF WATER

The Manager and his assistants shall be entitled to place meters or other measuring devices in such canals, laterals, ditches and pipe lines as may be considered necessary or proper, whether such canals, laterals, ditches and pipe lines are owned by the District or by the landowner.

RULE 10 – DETERMINATION OF ACREAGE IRRIGATED

The District will survey each tract of land for the purpose of determining the acreage to be paid for and will include all land within the exterior boundaries of the land area upon which water is allowed to stand. If any such survey shows a change in the acreage, the effect thereof will be included in all subsequent bills.

RULE 11 – ACCESS TO LAND

The Manager, his assistants and all other employees of the District shall have free access at all times to all canals, laterals, ditches and pipe lines and to all lands irrigated from same for the purpose of inspection, examination, measurements, surveys, control of water or other necessary purposes of the District, with the right of installation, maintenance, control and regulation of all meters or other measuring devices, gates and turnouts necessary or proper for the measurement and distribution of water.

RULE 12 – CONTROL OF REGULATION STRUCTURES

Except in cases of actual emergency or to prevent imminent danger of damage to property or when specifically authorized by the Manager, no person other than the Manager or his assistants shall be authorized or permitted to turn water on or off or to change or interfere with any waste, check, head or delivery gate or the irrigation systems or with any measuring devices of the irrigation systems. All violators are subject to prosecution under Section 592 of the Penal Code of California.

RULE 13 – CONDITION OF PRIVATE DITCHES

All private ditches shall be properly constructed and maintained so as to carry water without danger of serious breaks or undue seepage. The Manager is required to examine all such ditches and may order them to be cleaned, repaired or reconstructed, as he deems necessary, before water will be turned into them. Refusal to comply therewith will be sufficient cause for refusal to turn in water. Nothing herein shall be construed as an assumption of liability on the part of the District, its Trustees, officers, or employees for any damage occasioned by improper construction, maintenance or use of any private ditch or ditches or by reason of permitting the flow of water or the turning of water therein.

RULE 14 – DELIVERY GATES OR TURNOUTS

All pipes and crossings shall be constructed by District personnel in accordance with District plans. They become District property and shall be maintained by the District.

All costs of new pipes and crossing shall be paid for by the Landowner. Replacement of existing pipes and crossings are at District expense.

If the Landowner requests a pipe or crossing moved, he pays for the costs. During this process, if the pipe is found to be unusable, the District pays for the pipe.

Damage occurring to existing structures, such as splash board risers, turnouts, or any other District owned property, see Rule 16.

All used materials remain the property of the District.

RULE 15 – RESPONSIBILITY OF THE DISTRICT

The District will not be liable for any damage resulting, directly or indirectly, from the water flowing in or from any private ditch nor for any damage which may result from the flooding of land or other property by water from fields that are being irrigated. District responsibility will cease absolutely when the water is delivered from the canals or laterals of the District.

RULE 16 – LIABILITY OF IRRIGATORS

Every water user and landowner shall be jointly and severally responsible to the District for all damage to District works by his neglect or careless or malicious acts, such repairs will be made at his expense by the District.

RULE 17 – ENCROACHMENTS

No encroachment shall be permitted upon District lands, easements, rights-of-way, including irrigation and drainage ditches, by installation of any structure or other alteration of the District lands, easements or rights-of-ways (excluding, in the case of District owned lands, alterations made pursuant to a lease) except upon application to the District for a permit authorizing such installation or other alterations.

RULE 18 – ABATEMENT OF NUISANCE

No tree or vine pruning, brush, weeds, grass, tules, rubbish, swill, garbage, manure, refuse, dead animals or animal matter from any barnyard, stable, dairy or hog pen, or other materials or substances that will become offensive to the senses or injurious to health or obstruct the flow of the water, or result in the scattering of seeds of noxious weeds, plants or grasses shall be placed or dumped in any canal or lateral belonging to the District, or be placed or left so as to roll, slide, flow or be washed or blown into any such canal or lateral. Any violation of this rule will subject the offender to prosecution. All employees of the District shall promptly report an violation of this rule and the water users of the District are urged to cooperate in its enforcement.

RULE 19 – DRAINAGE WATER FROM SOURCE OUTSIDE DISTRICT SYSTEM

A charge will be made to cover the cost of conveying and disposing of drainage water from each tract of land situated outside the District. This charge shall be established annually by the Board of Trustees.

RULE 20 – ENFORCEMENT OF RULES

Failure to comply with the requirements of any of these Rules and Regulations or violation of any of the provisions hereof or failure to pay any water toll or charge, when due, or interference with the performance of the duties of any official or employee of the District shall be sufficient cause for shutting off the water form any such offender, and water will not again be furnished until, in the opinion of the Manager, full compliance has been made with all of the requirements hereof.

RULE 21 – COMPLAINTS

All complaints as to service, lack of water or other unsatisfactory conditions shall be communicated by the landowner or irrigator directly to the employee of the District in direct charge of the distribution of water. From the ruling or action of such employee, resources may be had to the Manager and from the decision of the Manager to the Board of Trustees at the next regular meeting of the Board.

RULE 22 – DISTRICT FACILITIES

No landowner can remove, modify or replace any District facility without written permission from the Manager.

RULE 23 – AMENDMENTS AND OTHER CHANGES

No cost for work performed by a landowner on District facilities shall be reimbursable unless prior written permission is obtained from the Manager.

A modification to item 2) could be the addition of:

If work is performed in an emergency, reimbursement must be approved by the Board.

RULE 24 – AMENDMENTS AND OTHER CHANGES

These Rules and Regulations are subject to amendment, modification, repeal or other variation at any time or from time to time in the discretion of the Board of Trustees.

Reclamation District No. 1004 (RD 1004)

RULES AND REGULATIONS

GOVERNING THE USE
AND
DISTRIBUTION OF WATER
IN
RECLAMATION DISTRICT NO. 1004
AND FIXING CHARGES PURSUANT TO
SECTION 50911 OF THE CALIFORNIA WATER CODE

Preamble

These Rules and Regulations have been adopted by the Board of Trustees under the authority of the California Water Code, and are part of the law governing this District, and its landowners and water users. These Rules and Regulations have been adopted to ensure the orderly, efficient, and equitable distribution, use and conservation of the District's water resources.

Revision Date

January 2nd, 2018

RD 1004 - BOARD OF TRUSTEES

Edwin Hulbert	**Chairman**	**530-682-7431**
Jack W. Baber	**Vice Chairman**	**530-713-7906**
Jeff Moresco	**Trustee**	**530-682-6820**
Roger Borrell	**Trustee**	**530-632-4170**
Frank Rogers	**Trustee**	**530-308-0050**

DISTRICT EMPLOYEES

Terry Bressler	**District Manager**
Barbara J. Sachs	**Office Manager/Sec. to Board of Trustees**
	Office Assistant
Steve Crawshaw	**Operations Supervisor**
Greg Zwald	**Operations Assistant**
Matt Garrison	**Meter Specialist**

AFTER HOUR EMERGENCIES

District Manager	**530-682-0050**
Operations Supervisor	**530-682-0051**
Asst. Operations	**530-434-3681**

DISTRICT OFFICE
317 4th Street
Colusa, CA 95932
Phone: (530) 458-7459
Fax: (530) 458-4276

DISTRICT SHOP
7625 Gridley-Colusa Hwy
Colusa, CA 95932
Phone/Fax: (530) 458-4220

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RULE 1- CONTROL OF SYSTEM

The operations of the distribution system and irrigation works owned or operated by Reclamation District No. 1004 shall be under the exclusive management and control of the Manager of the District. No other person shall have control of the distribution system and works, except for duly appointed assistants of the Manager or when specifically authorized by resolution of the Board of Trustees of the District.

RULE 2- EMPLOYEES

Subject to the approval of the Board of Trustees, the Manager shall employee such assistants as may be necessary for the proper operation and maintenance of the District. Employees shall be guided by these Rules and Regulations and by such technical and other instructions and advice as may be given by the District's professional staff for the purpose of carrying out the polices of the Board of Trustees and providing efficient and economical service.

It is the specific duty of each employee to maintain cordial relations with all landowners and water users in the District. Every water user is entitled to equitable, courteous and prompt service. Every employee is charged with the duty and responsibility of cooperating with the water users and the Board in a sincere effort to render as satisfactory service as can be reasonably attained. Every water user has a right to such service, and every employee of the District is enjoined to maintain and execute this policy.

RULE 3- DISTRIBUTION OF WATER

The District will deliver water into the various irrigation canals, laterals and drains as shown on the map of District facilities approved by the Board of Trustees at such levels as are feasible and practical with the facilities existing at the time these

Regulations are made effective and such other facilities as may thereafter be added by resolution of the Board of Trustees. Except as hereinafter provided in case of a shortage of water or in case of noncompliance with these Rules and Regulations, water will be delivered into the irrigation canals and laterals in sufficient quantity to meet the reasonable needs of all qualified irrigators. The District does not and cannot guarantee water quality, nor the time or quantity of delivery. THIS WATER IS NOT POTABLE AND MUST BE PURIFIED FOR DOMESTICUSE. The District recommends that the water not be used for domestic purposes.

A water user may have temporary circumstances needing a very limited quantity of water not effectively being taken through the current metered points of delivery. The District Manager will evaluate this special need of water on a case-by-case basis with water only being available during the irrigation season, as it is available, and to be used within the District boundaries. The approved quantity of water will be charged a flat fee determined by the District Manager. No pump with larger than a three inch intake is to be used. A separate fee will be levied for each District numbered property receiving this water for a period of time not to exceed the current irrigation season. The required paperwork and the full amount of the fee will be submitted to the District office for approval prior to the take of water. The water user is to call the District Manager arranging the time water will begin being taken and similarly, when the take will end. At any time during the irrigation season the District Manager may curtail the taking of water with no refund. Any expense for the movement of the needed water from the point of origin to the point of use is at the sole cost of the party requesting the water. The District purveys water from many sources and may contain varying amounts of foreign matter such as chemicals, insecticides, herbicides and fertilizers. Therefore, theDistrict is not to be used as apotable source of water and should be tested if used on any sensitive vegetation.

RULE 4- APPLICATIONS FOR WATER

Prior to delivery of water from the irrigation works of the District to any tract of land each season, an application for water shall be filed with the District Office Manager or authorized assistant on a form provided by the District. All applications shall be signed and shall show the name(s) and address(es) of the party(ies) (applicant) to be billed for irrigation service, and the landowner, if not the applicant, and such other information as the Manager may require from time to time. Fields with multiple water applicants utilizing a common meter shall submit a lead contact name and phone number when applications are submitted. The lead contact shall provide the District office with information requested during the water season as needed. A field containing multiple water applicants utilizing a common meter or multiple fields with different water applicants utilizing a common meter are to agree on water splits at the time applications are submitted. The agreed splits shall be submitted to the District in writing with application and signed by all participating parties.

In all instances, the landowner shall be responsible for all charges for water used upon his or her land. When the applications for water is made by a tenant, the applicant, and all other tenants making such use of water, shall be jointly and severally liable with the landowner for all water charges.

RULE 5- TAKING WATER DELIVERY

In accordance with District rules #4 and #6, customers may not commence taking water until their paperwork is complete, the deposits have been paid and the District has received proper notification and confirmation. These requirements will insure water orders can be filled, diversions match supply and there is no disruption with existing deliveries. If water user pumps with an electric pump and uses a timer on the pump, the timer has to make sure it takes the same amount of water each hour of the day. All water order changes must take place by 1:00 p.m. Major changes in the amount of water being utilized (i.e.5 c.f.s. or more) must be called in to the District Manager by 12:00 noon prior to the change. Small changes of less than 5 c.f.s. must be called in by 9:00 a.m. on the day the change request occurs. However, any change in the amount of water being utilized South of the California Levee needs an additional 24 hours. Water users north of the California Levee are required to notify the District Manager a minimum of twenty-four hours in advance and water users South of the California Levee are required to notify the District manager a minimum of forty-eight hours in advance of water demands and curtailments. Water users commencing service prior to the completion of the required paperwork, payment of the water deposit and authorization from the District Manager will be subject to the turnout(s) being chained and a $300.00 fine per occurrence.

The Board passed a policy that all meter stands must be safe to access, read and clean the meter as well as repair it. The Board has decided that no water will be delivered unless the gate valve is working correctly and the meter stand is safe to access.

If a water user pumps District water with an electric pump which uses a timer on the pump, the pump must take the sam amount of water each hour of the day.

RULE 6- CONTROL OF WATER

All water diverted by the District and delivered within the boundaries of the District, by means of District canals, laterals, drains, including private drains, is and remains the property of the District and is subject to control, diversion, re-diversion, reclamation, reuse, relift, sale and resale, by the District as it sees fit. No landowner or water user within the boundaries of the District acquires any proprietary right to water delivered to himby the

District by reason of such use nor does such landowner or consumer acquire any right to resell and/or relift water provided by the District for purposes of irrigating additional land for which no application has been made and District fees and charges paid. If water is used on lands either within or without the District, which water has heretofore been diverted and/or delivered by the District for use on lands within the District, whether or not that person utilizes water by routing it first through a conduit, flowing it across other lands within the District, recapturing it from drains, or otherwise, said use of water will be subject to the rulesand regulations of the District for the use of such water. All drainage from District lands remain the property of the District and shall not be restricted, diverted or pumped without the written permission of the District Manager. Any delivery or drainage water restricted, diverted or pumped to non-district properties shall subject the tenant/property owner to a minimum fine of $750 per occurrence. Immediate curtailment of water deliveries will occur to the field(s) of origin until the Manager is satisfied that the fees are paid to the District Office. Additional associated charges may include and are not limited to the annual costs per acre imposed on similar District properties for operation and maintenance fees and assessments and the cost of Bureau of Reclamation project water and related component inputs. Per acre charges will be calculated for andencompass the entire property the diversion was made to utilizing Farm Service Agency acreage measurements. Estimates of water usage will be made by District personnel, consistent with the determination of water usage within the District, for purpose of determining acre feet of water delivered. Any commingled water, regardlessof origin, with District water will be considered entirely as District water. The Board of Trustees reserves the right to determine whether any additional charges will be imposed.

RULE 7-SALE OR TRANSFER OF TITLE TO LANDS

When land affected by a Water User application is sold or title otherwise transferred to another party, the District shall be under no obligation to deliver water to such lands until the Water User application is assigned to and assumed by the new landowner. Such assignments and assumption agreements shall be on forms provided by the District, executed and completed in a manner satisfactory to the District.

RULE 8- CHARGES FOR WATER

The Board shall annually adopt a schedule of rates to be charged by the District for water service prior to the water application date.

RULE 9- TIME OF PAYMENT

Payment of the seasonal water charge for the irrigation of each tract of land applied for shall be made prior to delivery of water to the tract, or prior to April 30 whichever is first, or as scheduled by the Board of Trustees, in the form of a deposit based on the acre foot price and unit duty for the particular crop. The acre foot price and unit duty shall be annually adopted by the Board of Trustees.

For special cases, payment of the seasonal charge for water shall be made in such amounts and at such times as the Manager may determine to be necessary in each case so as to insure that all water so delivered is paid for in advance. No water shall be delivered in advance of said deposit. No water shall be served to parcel of land until all Operation/Administration fees, custom work charges, fines, delinquent charges including interest, or any other outstanding District obligations have been paid in full. No water shall be delivered until any Federal, State or County documents, required by the District, are accurately completed and submitted to the District office.

Any Federal, State or County documents submitted to the District office deemed to be in error will be correctly resubmitted within sixty (60) days of initial notification. Noncompliance of these terms will subject applicant to fines of $300.00 per document per incident in addition to future water delivery delays. Fine amounts and time demands for documents may be subject to change depending on constraints levied by auditing or enforcing agency.

An additional deposit will be required when the initial deposit has been depleted. The amount of the additional deposit or partial deposit shall be determined by the District Manager. For any additional deposit or any balance due on the account payment (s) must be paid within 10 days of the date notice is mailed to the water user. In the event, the required payment is not made within the 10 day period, water service will be terminated until such time as the deposit and payment (s) have been satisfied in full.

Any and all person (s) responsible for causing the District not to have enough Non-Excess, Eligible Land shall be jointly and severally responsible for the additional costs of the Full Cost Water plus any penalties, interest and related costs.

The obligation to pay for Full Cost Water, penalties, interest and related cost shall be that of the landowner, even if caused by a tenant, unless the tenant has satisfied this obligation in full.

In the event there are multiple landowners with Excess, Non-Eligible land, the obligation to pay shall be prorated among them on the basis of the number of acre feet of water the District delivered to the Excess, Non-Eligible Land during the year (s) involved. This obligation shall attach to the property and in inure to the detriment of any subsequent landowner. It is enforceable as a lien against the property and will result in a curtailment of water delivery until paid in full.

RULE 10-CHARGE FOR UNAUTHORIZED USE OF WATER

Water Users who take water without prior application, deposit, notification, or authority from the District will incur a minimum charge of $300.00 per occurrence, reimbursing the District for extraordinary expenses caused by such action. Unauthorized water service will be discontinued until compliance with these requirements is met. Water users will provide reasonable notification of the need for additional water as well as reasonable notification when turning water down or off. In all cases, non-notification will result in a charge of $300.00 per occurrence no matter how much water the adjustment may involve. Any violations may be cause for an immediate lockdown whereby future water modifications will be by appointment. Similar charges will apply in lift pump applications where time clocks are utilized. Any adjustments of running time in clock applications, adjustments to boards in weirs, adjustments to screw gates or any other District approved conveying apparatus shall be conveyed to the District Manager in advance or the water user will be subject to a $300.00 charge. Fines will be immediately deducted from any water deposit the offender has with the District.

In a critical dry year, when the District allocates its water supply, a District landowner wishing to transfer water to another District landowner/tenant may do so only by transferring part or all of their water allocation.

RULE 11-SHORTAGE OF WATER

Whenever a general shortage of water appears imminent, the Board of Trustees shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary local or similar shortages the District Manager is authorized to place in effect such variations in service, as, in his judgment the occasion requires.

RULE 12-INTERRUPTION OF WATER SERVICE

The District may temporarily discontinue or reduce the amount of water to be furnished to the Water User for the purpose of investigation, inspection, maintenance, repair or replacement of the District facilities. The District may also temporarily discontinue or reduce water deliveries for vegetation abatement measurements or to the extent required by any environmental regulation that may be imposed upon the District for protection of fish or other environmental concerns. So far as feasible, the District shall give the water user due notice, in advance, of such temporary discontinuance or reduction, except in case of emergency. In no event shall any liability accrue against the District or any of its officers, agents, or employees, for any damage, direct or indirect, arising from such temporary discontinuance or reduction of water deliveries.

RULE 13-WASTE OF WATER

Any water user who deliberately, carelessly or otherwise wastes water or who uses an unreasonable amount of water will be refused the use of water until such conditions are remedied or will have his use curtailed by the amount of waste, as the District Manager may determine.

The District reserves the right to refuse delivery of water to any lands when it appears to the satisfaction of the District Manager that its proposed use or method of use would require such excessive quantities of water as would constitute waste.

The District spill policy is: 1" spill

All return flow from use of district water shall be the property of the District when it reaches a drain or a canal maintained by the District. No drain water shall flow from the entity field into another entity field without first passing through a District approved metering structure. In water short years the District Manager may preapprove water conservation techniques on a case by case basis requiring all parties submit a written plan with an agreement signed by all participating parties.

RULE 14-MEASUREMENT OF WATER

Except as hereinafter provided for Temporary and Special Purpose deliveries of water, all deliveries will be made only through District approved or District owned and operated meters or outlets. The District Manager will provide meter specifications and installation measures. Meters must be installed to the District's specifications at the landowner's expense. Meters will become the property of the District so that they may be properly maintained. Any alteration, modification or removal of said meters shall be done only with the supervision of or by District personnel. No one is to remove or tamper with any metering device at any time. This uniformity will promote reliability of service. If a meter is damaged or becomes inoperable as a result of District operations or District personnel the meter will be replaced by the District at District expense. A meter shall be replaced or repaired at the landowner's expense when the meter is damaged or proven inaccurate as a result of landowner or tenant operations. In the event a landowner's meter is damaged due to actions of another landowner or landowner's tenant the District will charge all repairs to that landowner who was responsible for said damage.

Meters will be routinely tested. The scheduling and method will be at the discretion of the District. Should a water user suspect the inaccuracy of a District meter between scheduled testing intervals, the water user may request testing. If the test indicates that the meter in within 5% (minimum) of accuracy, the water user will pay for the testing. Should the test show that metering is not within 5% of accuracy, the District will pay the cost of testing and make the proper adjustments.

When a meter is discovered as not working as a result of mechanical problems or an obstruction, the amount of water is calculated using the rate of flow in C.F.S. (cubic feet per second) observed the last time the meter was read and working properly. The rate of flow is multiplied by the number of estimated hours it was not working and divided by 12.1, to arrive at the total acre feet used.

RULE 15-DETERMINATION OF ACREAGE IRRIGATED

The District will periodically survey each tract of land by means of aerial photography or other means provided by the appropriate County Farm Service Agency for the purpose of determining the acreage to be used in calculating all District charges. The acreage will include all irrigable land. If any such survey shows a change in the acreage, the effect thereof will be included in all subsequent bills.

RULE 16-ACCESS TO LAND

The Manager, his assistants and all other servants, agents and employees of the District shall have free access at all times to all canals, ditches, laterals, pipes and meters and, to the extent needed to properly manage District operations or enforce these regulations, to the lands irrigated from same for the purpose of inspection, examination, measurements, surveys, control of water or other necessary purposes of the District, with the right of installation, maintenance, control and regulation of all meters or other measuring devices, gates and turnouts necessary for the proper measurement and distribution of water.

RULE 17-CONTROL OF REGULATING STRUCTURES

Except in cases of actual emergency or to prevent imminent danger of damage to property or when specifically authorized by the Manager, no person other than the Manager or his assistants shall be authorized or permitted to turn water on or off or to change or interfere with the District's head gates or delivery gates or the irrigation systems or with any measuring devices of the irrigation systems. All violations are subject to prosecution under Section 592 of the Penal Code of California.

RULE 18-CONDITION OF PRIVATE DITCHES

Upon application of a landowner for the delivery of water, it shall be the duty of the District Manager to certify whether or not the applicant's ditches are in proper condition to receive water. All private ditches shall be properly constructed and maintained so as to carry water without danger of serious breaks or undue seepage. The Manager is required to examine all such ditches and may order them to be cleaned, repaired or reconstructed, as he deems necessary, before water will be turned into them. Refusal to comply therewith will be sufficient cause for refusal to turn on water. Nothing herein shall be construed as an assumption of liability on the part of the District, its Trustees, officers, or employees for any damage occasioned by improper construction, maintenance or use of any private ditch or ditches or other facilities or by reason of permitting the flow of water or the turning of water therein.

RULE 19-DELIVERY GATES OR TURNOUTS

All delivery gates, turnouts and weirs are under the control of the District. The District's employees alone are allowed to open the District's delivery gates, and they alone have full authority to close the same as soon as the requisite amount of water for each irrigator has discharged. Said gates and turnouts may be supplied with locks, the keys to under control of the Manager. All landowner delivery hardware, including but not limited to, screw gates, weirs and piping are to be in satisfactory condition prior to water delivery. District personnel will make every reasonable effort to advise landowners of any observed deficiencies in sufficient time to make necessary repairs. Landowners and or tenants should take note during the season and make repairs of all needed field hardware also including drain pipes and weir boxes in addition to continuous seasonal surveying and repair to perimeter roads that border delivery and drainage laterals reducing unnecessary water losses. Refusal to comply therewith will be sufficient cause for refusal to turn water on or continue to provide water deliveries.

RULE 20-BUILDING DIVERTING GATES AND WEIRS

No openings shall be made or structures placed in any district conveyance or drainage canal until an application in writing has been made to the Board, and permission granted therefore, and without the special permission of the District Manager. All structuresmust be maintained in a condition satisfactory to the

Manager, and must not be removed or altered without the permission of the Manager.

RULE 21-RESPONSIBILITY OF THE DISTRICT

The District will not be liable for any damage resulting, directly or indirectly, from the water flowing in or from any private ditch nor for any damage resulting from the flooding of land or other property, by water from fields that are being irrigated. District responsibility will cease absolutely when the water is delivered from the canals or laterals of the District.

RULE 22-ENCROACHEMENTS

No encroachments shall be permitted upon District lands, easements or rights-of way, including conveyance, drain ditches and ditch banks, by installation of any structure or alteration of the District lands, easements or rights-of-way (excluding, in the case of District owned lands, alterations made pursuant to a lease), except upon application to the District for Board approval authorizing such installation or other alteration. No construction, permanent or temporary of any nature on District easements or rights-of way, including conveyance and drainage ditches and ditch banks will be permitted without prior approval of the District Manager and written authorization from the Board of Trustees. Material needed for coffer dams or other projects by the water users or their agents will not be permitted from the District easement of rights-of-way areas without prior approval of the District Manager.

Plantings and natural growth of vegetation in District easement and rights-of way, including conveyance and drainage ditches and ditch banks must be maintained. Prior consideration should be given to the future growth of this vegetation, planted or natural, to insure safe unobstructed passage of vehicles and equipment. Encroachment of any plantings and/or natural vegetation within this area may be subject to damage from the cleaning and/or maintenance. Reasonable allowance for vegetative growth in these areas will minimize potential damage or loss of wanted cover from maintenance. It is the responsibility of the landowners or their agents to maintain clear unobstructed passage.

Every Water User and landowner shall be jointly and severally responsible to the District for all damage to District works by his neglect, carelessness, or malicious acts, and upon his failure to repair such damage after notification by the Manager or duly authorized assistant thereof, such repairs will be made at his expense by the District.

RULE 23-ABATEMENT OF NUISANCE

No tree or vine trimmings, brush, weeds grass, tulles, rubbish, swill, garbage, manure, refuse, dead animals, or animal matter from any barnyard, stable, dairy or hog pen, or other materials or substances that will become offensive to the senses or injurious to health or obstruct the flow of water, or result in the scattering of seeds or noxious weeds, plants, or grasses shall be placed or dumped in any canal or drain belonging to the District, or be placed or left so as to roll, slide, flow or be washed or blown into any such canal or drain. Any violation of this rule will subject the offender to prosecution. Also, the offender will be responsible for all costs incurred by the District to rectify the violation. All employees of the District shall promptly report any violation of this rule and the water users of the District are urged to cooperate in its enforcement.

RULE 24-WATER DELIVERED IN MAIN CANAL

The District will operate the pumping plant or plants of the District and will deliver the water there from to the main canal of the District known as Drumheller Slough and all existing District laterals, from whence it will be required to be diverted or pumped by each irrigator at his own expense; and it is understood that the District shall be required to deliver water for irrigation into said main canal and all exiting laterals only, and the charges paid by the respective irrigators for water is for the service of the District in delivering said water into said main canal.

RULE 25- ENFORCEMENT OF RULES

Failure or refusal of any landowner or water user or their servants or employees to comply with the requirements of any of these Rules and Regulations or violation of any of the provisions hereof or failure to pay any water toll or charge, when due, or interference with the performance of the duties of any official or employee of the District shall be sufficient cause for shutting off the water from any such offender. Except in cases of emergencies, the Manager will attempt to notify the irrigator in person, by telephone, or in writing prior to shutting off the water supply together with advice as to the violation requiring that termination. Water will not again be furnished until, in the opinion of the Manager, full compliance has been made with all of the requirements hereof.

RULE 26-NON LIABILITY OF DISTRICT

a. Private laterals. The District will not be liable for any damage of any kind or nature resulting directly or indirectly from any private lateral or the water flowing therein, or by reason of lack of capacity therein, or for negligent, wasteful or other use or handling of water by the water user therefrom.

b. Delivery of water. Most of the water furnished by the District is pumped. Then flows through miles of open ditches and is subject to pollution, shortages, fluctuation in flow, and interruption of service. District employees shall not and are not authorized to make any agreements binding the District to serve an uninterrupted, constant supply of water, or guaranteeing a certain quality of water. Water furnished by the District will be on the basis of irrigation deliveries; water users putting District water to other uses do so at their own risk and assume all liability for, and agree to hold the District and its Trustees, officers, agents and employees free and harmless from, liability and damages that may occur as a result of defective water quality, water shortages, fluctuation in flow and interruptions in service. The District sells water as a commodity only and not as a guaranteed service. The District will not be liable for defective quality of watershortage of water, either temporary or permanent, or failure to deliver water.

c. Pumping. Pumping by water users of District water, when permitted by the District Manager, is done at the user's risk, and the District assumes no liability for damages to pumping equipment or other damages resulting from turbulent water, shortage of excess of water, or other causes, including fluctuations in the amount or level of water. It shall be the duty of the landowner or the water user to provide appropriate devices to protect pumps from damage.

RULE 27-DISTRICT CANALS AND FACILITIES ARE NOT FOR RECREATION OR OTHER UNAUTHORIZED USES

The District's canals/laterals and facilities shall be used solely for the purposes of conveying water for use on land, and for conveying drainage water away from the land. The use of District canal/laterals for recreation or other unauthorized purposes is prohibited.

Landowners and water users are urged to prevent the use of District canals/laterals and their banks, as well as any pumping structures and bridges, for recreation, swimming, play or other unauthorized purposes. These areas present hazards, as the water may be cold, swift and deep. Turbulence in and around culverts and pumping facilities also present eminent danger.

RULE 28-COMPLAINTS

All complaints regarding service, lack of water or other unsatisfactory conditions shall be communicated by the landowner or water user directly to the District Manager. It will be the responsibility of the Manager to bring the matter before the Board of Trustees at the next regular board meeting. Decisions may be appealed to the District Board at a regular meeting after appropriate opportunity has been provided the Manager to respond.

RULE 29-TRANSFERRING WELL WATER

RD1004 ditches are for transferring only District water to Landowners fields. If a Landowner wishes to use them to transfer their well water they must first request permission from the Board. The Board may or may not allow this use, and will set the terms and conditions if it does.

If you are thinking you may need to transfer water in a District ditch you should contact the District office and have them place you on the agenda for the next Board meeting.

RULE 30-AMENDENT AND OTHER CHANGES

These Rules and Regulations are subject to amendment, modification, repeal or other variation at any time or from time to time at the discretion of the Board of Trustees.

NOTES:

Meridian Farms Water Company (MFWC)

RULES AND REGULATIONS

MERIDIAN FARMS WATER COMPANY

RULE 1. CONTROL OF SYSTEM

The maintenance and operation of the canals, laterals and irrigation works of the corporation shall be under the exclusive management and control of a manager hired by the Board of Directors.

(a) All canals, gates, weirs and other structures belonging to the Company shall always be under the management and control of the Company and its employees, and must not be interfered with by any other person. No person shall be permitted to change or in any way interfere with any headgate, weir, canal, or any other irrigation works, or interfere with the flow of water therein, except on written permission of the Company. (See rule 17)

(b) Water will be delivered from the main canal or laterals, through delivery boxes or gates provided by the Company. If any bank of any canal of the Company is cut and water take thereby, delivery may be suspended to the person or persons responsible therefore until all damage caused thereby has been repaired or paid for, including the making of payment for the water taken, if not already paid for.

RULE 2. MANAGER, DITCHTENDER AND OTHER EMPLOYEE

The Manager will employ such Ditchtenders and other assistants as he may deem necessary for the proper operation of the system. Each Ditchtender shall have charge of his respective section under direction of the Manager. From the rulings and actions of the Manager or Ditchtenders an appeal may be made to the President. If further arbitration is necessary, appeal may be made to the Board of Directors.

RULE 3. APPLICATION FOR WATER

Between the 1st day of March and the 1st day of April all water users are required to file with the Manager a statement, on form provided by the Company, setting forth the crops and acreage of each parcel they're intending to irrigate. Each statement must contain the name of the owner, name of tenant or tenants, location of acreage, approximate amount to be used and any other matter as the Company may desire.

RULE 4. DELIVERY OF WATER

All demands for water must be made in writing on blanks furnished by the company, and must be delivered to the Ditchtender or Manager at least 48 hours before water is needed. No water will be delivered to the water user until the first payment is made. The Manager may at any time shut off delivery of water as set forth in the following rules. When notified by the Ditchtender that water is available the user must accept delivery forthwith or his right to the use will pass until other users are served and water is again available for his use. Water must be used continuously by the user throughout the period of delivery, both day and night.

RULE 5. RATE SCHEDULE

Water shall be charged for on quantity basis. The quantity shall be based on the amount diverted for the main canal or lateral of the Company.

The rates will be as follows: See following page.

RULE 6. PAYMENTS

The payment shall be made in advance according to the following schedule:

For All Crops:

Upon completion of irrigation, the balance of the total charges are due and payable.

The Manager shall, after ten (10) days notice shut off the water of any user who has not made the payments as set forth above.

(a) Interest at 7% per annum shall be charged on all unpaid balances commencing ten (10) days after due date, until all said charges are paid.
(b) Each Stockholder shall be responsible for all unpaid water charges arising from the use of water on his or her lands.

RULE 7. ASSESSMENTS

Assessments shall be levied upon all the outstanding stock of the Company for the purpose of defraying the costs of administration, operation and maintenance in excess of the amount of money collected by and through tolls as provided by Rules 5 and 6. Said assessment shall be made by the Board of Directors at the regular meeting in November of each year.

RULE 8. ACREAGE SURVEYS

If the Company finds it necessary to survey land for the purpose of determining the acreage planted and for which water was delivered, it will include all lands within the exterior boundaries of the planted area which water has been allowed to stand or flow upon the surface.

RULE 9. WASTE OF WATER

Any user of water, consumer or stockholder wasting water on roads or vacant land or land previously irrigated, either willfully, carelessly, or on account of defective farm service ditches, or who shall flood certain portions of the land to an unreasonable depth or amount in order to irrigate other portions, or whose land has been improperly checked, furrowed or leveled for the economical use of water, or who is causing damage to adjoining lands, through lack of farm service, drains or drainage ditches, will be refused the use of water until such conditions are remedied. The Company reserves the right to refuse delivery of water to any lands when it appears that its proposed use, or method of use, will require such excessive quantities of water, and will cause such damage to adjoining or other lands of the stockholders as will constitute waste. All lands to be flood irrigated shall first be prepared for use of water by the construction of levees or borders following the natural contours of the ground, checks to be spaced at intervals not to exceed thee tenth (3/10) of one foot between borders or levees. Borders and levees shall be of sufficient height and width so as to prevent water from wasting outside of the boundaries of the field to be irrigated.

Other methods of flood irrigation shall be accepted such as terrace basin, gravity checks in alfalfa fields and constant flow furrows in orchards. This paragraph shall be liberally interpreted so long as the water user makes use of a method that controls the water on the land being irrigated and does not permit wanton waste or damage.

RULE 10. SHORTAGE OF WATER

When, for any reason, the full supply of water required cannot be delivered to the users or Stockholders, such supply as can be delivered shall be prorated until such time as delivery of full supply can be resumed. A prorata delivery means a simultaneous flow available at a point in the Company system for the use of each and every consumer or stockholder in proportion to the amount available in that canal, ditch or lateral where service has failed, based on the individual's right to receive, as fixed by stock, acreage, crop, payment or otherwise.

RULE 11. ACCESS TO LAND

The authorized Ditchtender and other agents and employees of the Company shall have free access at all times to all lands irrigated from the canal or lateral systems of the Company, for the purpose of inspection, measurements, surveys or other necessary purposes. Said Company shall have no liability for damage to persons or property of Stockholders occasioned by breaks or failures in ditches, laterals, canals, pumps or pumping plants.

RULE 12. SERVICE DITCHES

At the beginning of each season and before the water shall be turned therein, privately operated canals or laterals must be put in good repair and thereafter kept in such condition, with vegetation removed therefrom, so that water may flow through the same with the least practicable loss. Such work shall be done to the satisfaction of the Manager of the Company.

RULE 13. FARMS DRAINS

Before water will be turned from the canals or laterals of the Company for service to consumers or Stockholders, seep ditches and farms service ditches must be constructed along the toe of slopes of main service laterals of the Company and across and along the boundaries of the fields of the water users to be irrigated in such way and manor as will control the water upon the lands of the user and provide an outlet to the District drainage canals provided for that purpose. All such work shall be done to the satisfaction of the Manager.

RULE 14. SPILL LADDERS

Before allowing water to drain or waste into the drains constructed for the service of the lands of a water user, all con summers or Stockholders must construct, install and maintain such necessary structures as will protect such drains from erosion and damage. Such work to be done to the satisfaction of the Reclamation District No. 70 Trustees.

RULE 15. GATES AND STRUCTURES AND DITCHES

No opening shall be made or structures placed in any Company canal, ditch or lateral or canal banks without written permission of the Manager. All structures must be constructed according to the requirements of the Company and at the expense of the consumer or Stockholder and must be maintained in a condition satisfactory to the Manager and must not be changed without written permission of the Manager. In all cases where a Stockholder or water user desires to have work done at his expense by the Company, an estimate will be prepared and if construction by Company forces is approved, the person making application will deposit, in advance, with the Company, the amount of the estimated cost. If the work costs less than the estimated amount deposited, the difference will be returned by the Company. If the work costs more than the estimate, the Stockholder or consumer making the deposit shall make payment of the difference to the Company.

RULE 16. FENCING RIGHTS OF WAY

The Manager may, upon application of the Stockholder grant in writing the right and privilege to fence the canals, laterals and ditches of the Company with sheep tight fencing and may grant said Stockholders the free use of the banks of said canals, laterals, and ditches for pasture of stock. Pasturing or watering of hogs on ditches is strictly prohibited. This right and privilege may be given for a period no in excess of three years and may be revoked by the Manager at any time, unless all the conditions contained in said written permit are fully and strictly complied with. Renewal of permits may be granted in the same manner as the original applications.

RULE 17. PENALTIES

Failure or refusal to comply with these requirements or nay of the foregoing Rules and Regulations, or any interference with the proper discharge of the duties of any person employed by the Company, shall be considered sufficient cause for shutting off the water, and water will not again be furnished until the opinion of the Manager full compliance has been made with all requirements herein set forth.

RULE 18. LIABILITY

The Company will not be liable for any damage of any kind or nature resulting directly or indirectly form any private ditch of the water flowing therein, or by any reason of lack of capacity therein, or for negligent, wasteful or other use or handling of water by users or Stockholders thereof; its responsibility shall absolutely cease when the water leaves the canals and ditches of the Company, nor will the Company be liable for shortage of water, either temporary or permanent, or for failure to deliver such water.

Sutter Mutual Water Company (SMWC)

SUTTER MUTUAL WATER COMPANY
15094 Cranmore Road P.O. Box 128
Robbins, California 95676
Tel: 530.738.4423 Fax: 530.738.4327

RULES AND REGULATIONS GOVERNING THE DISTRIBUTION, DELIVERY AND MANAGEMENT OF IRRIGATION WATER IN THE SERVICE AREA

(Updated January 2018)

RULE 1 - CONTROL OF WATER SYSTEM

The operation of all irrigation works owned or operated by the Company shall be under the exclusive management and control of the Management of the Company. No other person shall have any right to operate or interfere in any manner with said irrigation works, except for duly appointed assistants of the Management or when specifically authorized by resolution of the Board of Directors of the Company.

RULE 2 - DISTRIBUTION AND DELIVERY OF WATER

Except as hereafter provided in case of a shortage of water or in case of non-compliance with these rules and regulations, the Company will deliver water into various irrigation canals and laterals included in its adopted projects at such levels that are feasible and practical with the facilities existing at the time these Rules and Regulations are made effective and such other facilities as may thereafter be added by a Board of Directors' resolution.

RULE 3 - CROP MAPS

Water users will be required to submit their preliminary cropping plans (maps) for their land holdings within the Company service area on or before the **20th day of March** of each year unless otherwise requested earlier by the Board of Directors and Management of the Company. These maps will be used for budgeting and planning purposes including rate setting and water needs projections. Final crop maps will be required at a later date as determined by the Board of Directors and Management.

RULE 4 - CERTIFICATION OF FINAL CROP MAPS AND WATER ORDERS

Water users shall submit **certification of final crop maps and water orders to the Company' office prior to a user being delivered water or by May 1, of the subject year, whichever is earlier**.

RULE 5 - SHORTAGE OF WATER

Whenever a general shortage of water appears imminent, the Board of Directors shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary, local or similar shortages, the Field Superintendent is authorized to place in effect such variations in service as in his judgment the occasion requires.

RULE 6 - WASTE OF WATER

Any water user who deliberately, carelessly or otherwise wastes water on roads, vacant land or land previously irrigated or who floods certain portions of the land to an unreasonable depth, or who uses an unreasonable amount of water in order to irrigate other portions or who irrigates land which has been improperly checked for the economical use of water, or who allows an unnecessary amount of water to escape from any field or who otherwise engages in the waste or unreasonable use of water will be refused the use of water until such conditions are remedied or will have his use curtailed by the amount of waste, as the Field Superintendent may determine.

The Company reserves the right to refuse delivery of water to any lands when it appears to the satisfaction of the Field Superintendent that its proposed use or method of use would require such excessive quantities of water as would constitute waste or unreasonable use.

The Field Superintendent shall be authorized to shut off water or reduce the flow when a Canal Operator sees that the irrigation is finished, or water is being wasted, after first attempting to advise the person by telephone designated in the water order to be advised.

RULE 7 - ACCESS TO LAND

The Field Superintendent, his assistants and all other employees of the Company shall have free access at all times to all canals, laterals, seep ditches and pipe lines and to all lands irrigated from same for the purpose of inspection, examination, measurements, surveys, control of water or other necessary purposes of the Company, with the right of installation, maintenances, control and regulation of all meters or other measuring devices, gates and turnouts necessary or proper for the measurement and distribution of water.

RULE 8 - CONTROL OF REGULATION STRUCTURES

Except in cases of actual emergency or to prevent imminent danger of damage to property, or when specifically authorized by the Field Superintendent, no person other than the Superintendent or his assistants shall be authorized or permitted to turn water on or off or to change or interfere with any waste, check, head or delivery gate or the irrigation systems or with any measuring devices of the irrigation systems***. All violators are subject to prosecution under Section 592 of the Penal Code of California.***

RULE 9 - LIABILITY OF IRRIGATORS

Every water user and landowner shall be jointly and severely responsible to the Company for all damages to Company works by their negligence or careless or malicious acts, and required repairs will be made by the Company at their expense.

RULE 10 - ENCROCHMENTS

No encroachment shall be permitted upon Company lands, casements, rights-of-way, including irrigation canals and drainage ditches, by installation of any structure or other alteration of the Company lands, easements or rights-of-way (excluding, in the case of district owned lands, alterations made pursuant to a lease) except upon issuance by the Company of a written permit authorizing such installation or other alterations.

RULE 11 - ABATEMENT OF NUISANCE

No tree or vine pruning, brush, weeds, grass, tules, rubbish, swill, garbage, manure, refuse, dead animals, or animal matter from any barn yard, stable, dairy or hog pen, or other materials or substances that will become offensive to the senses or injurious to health or obstruct the flow of the water, or result in the scattering of seeds of noxious weeds, plants or grasses shall be placed or dumped in any canal or lateral belonging to the Company, or be placed or left so as to roll, slide, flow or be washed or blown into any such canal or lateral. Any violation of this rule will subject the offender to prosecution. All employees of the Company shall promptly report any violation of this rule and the water users of the Company are urged to cooperate in its enforcement

RULE 12 - ENFORCEMENT OF RULES

Failure to comply with the requirements of any of this booklet' Rules and Regulations or the violation of any of the provisions hereof, or failure to pay any water toll or charge, when due, or interference with the performance of the duties of any official or employee of the Company shall be sufficient cause for shutting off the water from any such offender, and water will not again be furnished until, in the opinion of the Field Superintendent, full compliance has been made with all of the requirements hereof

RULE 13 – AMENDMENTS AND OTHER CHANGES

These Rules and Regulations are subject to amendment, modification, repeal or other variation at any time or from time to time in the discretion of the Company's Board of Directors.

RULE 14 - WINTER WATER (OFF-SEASON) OPERATIONS

Item 1. The Winter Water operations period is considered October 1 through March 31.

Item 2. A formal written request to the Company is required to receive water during the Winter Water period, except for finishing the irrigation of an existing crop already being served water during the regular irrigation period.

Item 3. A decision regarding written requests shall be made by the Directors and/or Management on a case-by-case basis based on certain general criteria and notification would be made within 14 days of the submitted request.

Item 4. The general criteria on which decisions would be made are as follows:

a) The operational and economic feasibility, i.e.,
1) operational: the pumping level of the river;
(2) economic: the cost of operations respecting the water rate established for the regular water delivery season vs. the actual cost to supply off-season water deliveries.

b) The agronomic and/or agricultural uses and merit.

b) The impact on the maintenance needs and Scheduling of work on the water delivery facilities and/or systems.

d) The relative benefits to water management conservation plans, programs and policies including environmental merits.

RULE 15 - DELINQUENCIES AND UNPAID BILLS

The By-Laws of the Sutter Mutual Water Company provide that charges for water shall be payable when and as water shall be so supplied, and provides further that no person shall be entitled to be supplied with water for any lands on which a lien for any charge fixed by the Board of Directors, due and payable, shall remain unpaid and the Board of Directors may refuse to supply water for such lands until such charge shall have been fully paid. The rules of the Sutter Mutual Water Company provide that if charges for water delivered during any month are not paid by the delinquent date, additional water may not be delivered. Further, one and one half percent (1.5%) interest per month (18%) per annum shall be payable on the delinquent date and each month thereafter until paid.

RULE 16 - GENERAL WATER OPERATIONS

Item 1. Water users can make requests for water deliveries to Canal Operators up to 11:00 a.m. on the day water is needed. Water users are encouraged to request water the **DAY BEFORE** water is needed to allow Canal Operators adequate time to complete morning canal inspections prior to completing delivery changes. The more time Canal Operators are able to inspect their systems the safer the system will be.

Item 2. **For water shut-off, notice can be given to Canal Operators up to 11:00 a.m. on the day of the desired shut off. During the Rice flood up period it is imperative that canal operators be given as much time as possible to start and stop water. Canal operators will be operating the system so that water will not be wasted or abused.**

Item 3. It is understood that water delivery requests are subject to all rules of operation in effect.

Item 4. ***Water users will under no circumstances interfere with gates or flashboards in any structure. To do so is a misdemeanor.***

RULE 17 - SEEP DITCHES

The Company can construct seep ditches at the request of and in cooperation with private landowner(s). Seep ditches are constructed for the purpose of carrying away the flow of seep water from Company irrigation facilities and protecting lands owned or operated by an adjacent private landowner(s). Seep ditches that are used for irrigation purposes shall be at the sole discretion of the user, and the water user shall hold the Company harmless if the ditches are used for irrigation.

RULE 18 - PUMPING FROM DRAINS

The Company has an agreement with Reclamation District No.1500 which allows the Company shareholders to make use of water from the District drainage ditches for irrigation purposes. Pursuant to this agreement, a user (shareholder/ landowner) may pump drain water without further permission from either the District or Company by pumping directly from a drain situated in the Company service area boundaries for use on lands within the Company. The Company is not, however, in control of the quantity of water available in the District drains, and accordingly makes any representation as to the nature and extent or reliability of the water supply available to user from the District drains. The Company is not responsible for any lack of quantity available for irrigation purposes in the District drains, and this risk is solely upon the drain water user.

A water user may request that the Company deliver water from a Company irrigation canal into a District drainage ditch located near the user's parcel, and in such case the user may be assured that the water supply ordered from the Company will be available provided the drain has adequate capacity, usability, and/or delivery structure for such water delivery and subject to diversions from the drain by others.

It is the water user' responsibility to consult with their Canal Operator prior to a water user installing a ditch pump in a District drain. If more than one water user plans to use a common drain for water, the first user in time shall be considered the first user in right to the available water, if any. In any case the Company does not guarantee the availability and/or dependability of such water supply to any user or potential user in this situation.

The Company has no control over the quality of water available in the district drains and accordingly can provide no assurance as to the usability, for irrigation purposes, of the water supply which may be physically available in the drain. The water user must satisfy him or her as to the quality of water available from the drain and its appropriateness for the respective use proposed by the user. The Company is not responsible for any injury which may result from the application of water of inadequate quality by the user from the District drains. The user must solely determine whether that water is of a useful quality.

RULE 19 - ACCURACY OF WATER MEASUREMENTS

The Company will test the accuracy of water flow measurements at the request of the user. Company water delivery records are open for inspection at all times at the Company office. Measurement disputes are open for discussion and resolution at all times with field personnel, administration, management, and/or Board action. Notification of a measurement dispute is to be given to the appropriate field representative in a reasonable time fame following delivery of water.

RULE 20 - DAMAGE CAUSED BY WATER DELIVERY OPERATIONS

Disputes are open for discussion and resolution at all times with field personnel, administration, management, and/or Board action. If a water user believes that damage is being caused by water delivery operations of the company, notice must be given promptly to the field personnel or to the Company office upon discovery of such occurrence so that the Company will have an adequate opportunity to consider correction and take appropriate steps, if needed, to correct any adverse impact. If a water user believes that damage has occurred as a result of previous Company operations, then the Field Superintendent and/or Company office must be notified promptly after discovery of such alleged damage.

RULE 21 - ORDERING WATER BY DELIVERY POINT IDENTIFICATION LABELS

The ordering of water for delivery to fields will be implemented as follows:

Item I. As water orders are requested (or earlier if desired), water users (landowners and/or tenants) will obtain a copy of a map showing all applicable water delivery points to their specific farmlands. Each point is numbered and the number will be the point of reference.

Item 2. ***Company maps are to be used by the water users as reference for identifying (locating) water delivery points and making official water orders with their Canal Operators based on these points.***

Item 3. Copies of such maps can be obtained at the Company office or from the Field Superintendent.

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Item 4. The Company will only officially recognize user water orders by reference to the water delivery point (turnout) locations identified on the provided maps.

Item 5. When making a request for water or ordering water, the user will clearly specify ***(a) the quantity of water in cubic feet per second (Ft3/sec), (b) the time and day the water delivery is needed, and (c) the water deliver) point (turnout) number, representing the water control structure, through which the water will be delivered.***

The implementation of this ordering system is intended to standardize and facilitate water ordering and provide better service to the water user.

RULE 22 - ORDERING WATER WHEN CAPACITY IS NOT CURRENTLY AVAILABLE

Water orders are accepted and placed on a priority list. Priority is then determined by the user's ability and readiness to take water as requested. Field personnel will assess the urgency of cropping needs usually favoring an already established crop or crop that had previously taken water or was in the process of taking water. Unless other factors are deemed to require priority consideration, water request orders and deliveries will be provided on a first-come first-served basis.

RULE 23 - USER READINESS TO TAKE WATER IN THE FIELD FOR DELIVERY

Water will not be delivered to a parcel until and unless the parcel is prepared in a manner deemed ready for delivery of said water. The water user and Canal Operator shall mutually determine the readiness of the parcel to receive water in the requested and/or specified amount.

RULE 24 - PUMPING OF WATER FROM WATER DELIVERY CANALS

There shall be no pumping of irrigation water by a water user from any Company irrigation canal unless permission has been granted by formal board action.

RULE 25 - DRAINING OF WATER FROM RICE FIELDS

All water users in the Company service area should note and understand that it is the Reclamation District No. 1500's policy that any and all rice growers are required to notify the District's Riser Man ***at least 24 hours prior*** to draining water from their particular rice field.

RULE 26 - REGULAR OFFICE BUSINESS HOURS

The Company office will be open for regular business needs on all weekdays from 7:30 a.m. to 4:00 p.m. except for certain designated holidays. The office will normally be closed on weekends unless special circumstances warrant the office to be opened for business.

RULE 27 - WATER OPERATIONS HOURS AND COVERAGE

On ***weekdays***, telephone, mobile, and/or office contact concerning field water operations will be available during regular business hours, except for certain designated holidays or holiday periods.

On ***weekends*** during the irrigation season water operations (including water orders and/or inquiries) will be covered in the field by assigned area Canal Operators who have mobile telephones in their vehicles. Telephone numbers can be obtained from the Company office.

For weekend emergency and/or special needs the Field Superintendent can be contacted on his mobile telephone.

RULE 28 - INSTALLATION OF NEW FACILITIES

When a Shareholder requests the installation of a new turnout gate, pipe or other irrigation facility in or on a Company right-of-way, the request will be received by the Field

Superintendent who will approve or disapprove the request and, if approved, will decide what material will be used and who will pay for the new installation. After the facility has been installed the Company will maintain the facility thereafter at Company expense. The Field Superintendent has the option to obtain approval from the Board of Directors and General Manager, if appropriate.

RULE 29 - RENTAL OF COMPANY EQUIPMENT

At the discretion or under the supervision of the Field Superintendent, in an emergency situation Company equipment (backhoe, tractors, etc.) operated by a company equipment operator can be rented to a Shareholder for work in a Shareholder's field if the equipment is available at the time of the request. The current market rental rate of the equipment and operation will be billed to the Shareholder requesting the equipment.

Common Hydraulic Equivalents

1 Acre Foot (AF)…………………325,851 gallons
1 Acre Foot (AF)……………………43,560 Feet^3
1 Foot^3………………7.48 gallons or 62.5 pounds
1 Cubic foot per second (CFS)…450 gallons per minute
1 CFS……………………………..646,317 gallons day
1 CFS for 24 hours……………………1.9835 AF
1 CFS for 1 year.......................................…...724 AF
1,000,000 gallons……..………………..……3.07 AF
1 AF supplies 2 families of 5 for 1 year.

Sutter Mutual Water Diversion
USBR Contract 14-06-200-815A-R-1
(Acre Feet)

Month	Project Water	Base Supply
April		20,000
May		42,500
June		48,000
July	25,000	28,500
August	24,000	20,000
September	7,500	5,000
October		5,500
Total	56,500	169,500

NOTES

Natomas Central Mutual Water Company (NCMWC)

NATOMAS

Central Mutual
Water Company

Irrigation Policies and Procedures

Updated
April, 2012

IRRIGATION
POLICIES & PROCEDURES

This update to the *Irrigation Policies and Procedures* has been approved by the Natomas Central Mutual Water Company Board of Directors. These *Irrigation Policies and Procedures* are intended to ensure the orderly and efficient use, and equitable distribution and conservation of the Company's water resources. These *Irrigation Policies and Procedures* supersede in their entirety the Company's previously approved *Irrigation Policies and Procedures* and will be distributed to all water users.

Mission Statement:

Committed to providing water services and local resource management that meet the evolving, beneficial uses of shareholders, preserve our agricultural heritage and extend the region's economic and environmental well-being through the protection of historic water rights.

OFFICE HOURS:

Monday through Friday:	7:30 a.m. to 4:30 p.m.
Saturday and Sunday:	Office Closed
After-hours and Emergency Calls:	916-548-1853

TELEPHONE NUMBERS:

Office Number:	916-419-5936
FAX Number:	916-419-8691
Emergency / After-hours Number	916-548-1853
Field Supervisor - Ken McLaughlin	916-752-1555
Northern Ditchtender – John McNeil	916-826-7713
Central Ditchtender – Gilberto Figueroa	916-548-1288
Southern Ditchtender – Steve Hetherington	916-826-7673
Relief Ditchtender – Roberto Leon	916-826-7804
Relief Ditchtender—Jose Vaca	916-549-1968

WATER REQUEST INFORMATION:

FIELD STAFF IRRIGATION HOURS

Weekdays:	7:00 a.m. until 3:30 p.m.
Weekends:	7:00 a.m. until 3:30 p.m.

The field staff is not authorized for any overtime hours unless it involves an emergency situation. Any request that involves after-hours work of the field staff must be requested 24 hours in advance. All such requests must be directed to the Field Supervisor and will be approved at his discretion only.

BEFORE REQUESTING WATER

Before requesting water a Water Application, a Bylaw Acknowledgement and the Bureau Reclamation (RRA) forms will need to be submitted with accurate crop and acreage information on all forms.

NO WATER WILL BE DELIVERED ON PROPERTY WITH AN OUTSTANDING BALANCE ON ITS ACCOUNT.

Please do not place an order for water to be turned on before the field in question is ready to accept irrigation water. An order for water placed before a field is prepared to accept water will ***not be accepted.***

WHEN ORDERING WATER

Water requests must be made before 3 pm for delivery the following day. Water requests will be filled as soon as possible, when water is available. All requests for water will be filled on the basis of when the request was submitted once the preparation of the field has been completed. No same day flow changes will be made unless field staff can accommodate the adjustment with no impact upon other water users, unless it is an emergency situation. The field staff will be required to notify their supervisor of any request that is filled under the emergency rule. Customers who have special requests, i.e. late stops or specific start times, are asked to notify field staff as soon as possible so arrangements can be made. Special requests are not the same as emergency situations.

CHANGES IN GATE SETTINGS

Gate changes or adjustments must be done by or under the direction of the field staff. Gates which are opened or closed without field staff direction will be chained and locked to prevent future unauthorized adjustment. All requests for gate adjustments will be filled as soon as possible. All requests must be submitted before 3 pm for adjustment the following day unless it is an emergency situation. As with water requests, the Field Supervisor will be notified of any request that is granted under the emergency rule. Exceptions will be made if the field staff can accommodate the adjustment with no impact upon other water users.

USE OF DRAIN WATER

The water within all of the drainage canals is the sole property of the Company. The field staff has been directed to maintain the drain canals at a consistent level. The water level for each drainage system is set to maximize the efficiency of the Company pumps which operate out of that system, but prevent drain water from entering fields that are lower than the drain system.

The consistency of this water level is dependent upon the field staff's knowledge of any use of drain water by Non-Company pumps, i.e. owner operated drain pumps and the release of water into the drainage system. To help the field staff prepare for changes in demands from the drain pumps, please alert the service area personnel of any use of drain water by non-company drain pumps and any changes in the amount of tail-water from your property. This will help the field staff prepare for your water usage and help prevent the drain levels from fluctuating unnecessarily.

HERBICIDE/PESTICIDE MANAGEMENT

Pesticide management is an important aspect of water management when the pesticide is applied to irrigated lands within the Natomas Basin. It is essential that all customers adhere to label requirements of any pesticide applied. This is especially true concerning any use near bodies of water, use before or during an irrigation, and the rules governing the 'holding periods" immediately following rice herbicide applications. The misuse of any pesticide could cause issues with discharge and reuse of drain water.

SPILLAGE

Excessive spillage, or dumping of water into the drains, must be avoided to prevent supply constraints, increased energy costs, increased water costs, and drain level fluctuation. Supply constraints coupled with excess spillage, can negatively affect availability of water for others.

The field staff has been directed to correct and report any spillage that looks to be out of the ordinary or excessive. The Company's permits and contract for water are based upon its ability to assure "Reasonable and Beneficial Use of a Public Resource" and its use of a number of "Best Management Practices". Several of those "practices" involve the reduction and/or elimination of spillage from all crops. You will be notified of any spills that are deemed excessive and be asked to reduce the spill.

If management feels that spills continued to be above reasonable levels, it will be forced to reduce or stop the delivery of water to the identified parcel. We don't expect incidents like that to happen, but we need to forewarn everyone.

EXCEPTIONS

Emergencies will always be accommodated as soon as possible. If you have an emergency, please call the office during business hours or the Emergency / After-hours number - 916-548-1853.

AFTER HOURS SERVICE CHARGE

Management will continue to assess the need for instituting an added service charge to accommodate after hours requests for gate changes and/or late evening water "starts" and "stops".

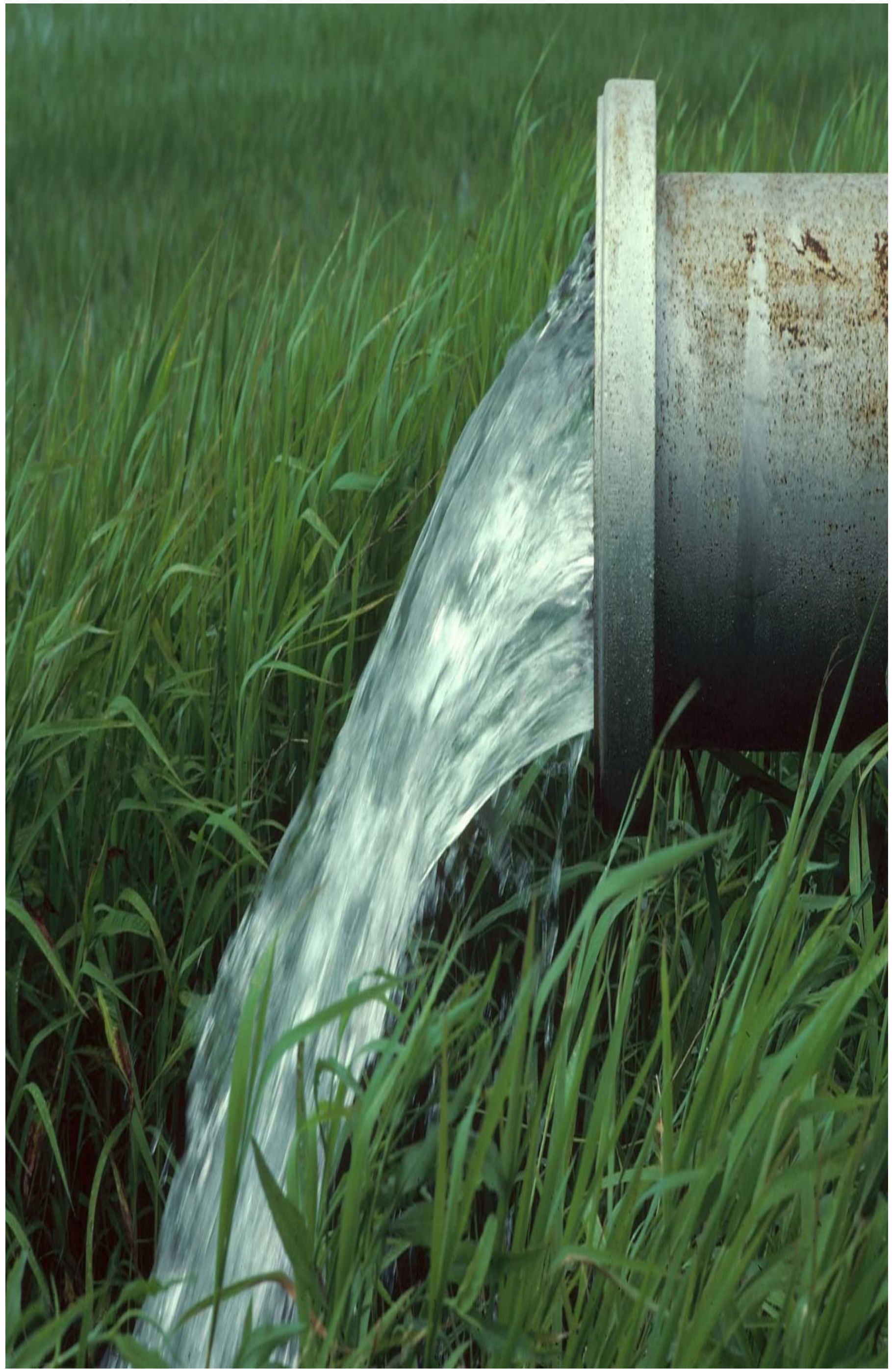
WAITING LIST

Waiting lists may be used when the capacity of Natomas Canal System reaches capacity.
Water requests will be placed on the waiting list until there is capacity to supply the needed water. The order of the waiting list will be based on date and time the water request was received. Waiting lists will be specific to the area of the system with the deficiency. This may lead to a waiting list on one system or lateral and no waiting list on a different system. Field staff will make every attempt to make water deliveries when requested and to keep water deliveries equitable. Copies of the waiting list are kept at the Office and are update by ditchtenders daily.

USE OF COMPANY EQUIPMENT:

The Company will consider renting equipment to shareholders or their agents if the equipment is not scheduled for usage on Company projects. Rental of equipment is at the discretion of the General Manager. Equipment can be rented on an hourly, daily, or weekly basis. Excavators, backhoes and tractors will be rented with an equipment operator.

Arrangements for renting equipment can be made by contacting the office at 916-419-5936. Any questions concerning rental rates will be answered at that time.



OFFICE HOURS:

Monday through Friday:	7:30 a.m. to 4:30 p.m.
Saturday and Sunday:	Office Closed
After-hours and Emergency Calls:	916-548-1853

TELEPHONE NUMBERS:

Office Number:	916-419-5936
FAX Number:	916-419-8691
Emergency / After-hours Number	916-548-1853
Field Supervisor - Ken McLaughlin	916-752-1555
Northern Ditchtender – John McNeil	916-826-7713
Central Ditchtender – Gilberto Figueroa	916-548-1288
Southern Ditchtender – Steve Hetherington	916-826-7673
Relief Ditchtender – Roberto Leon	916-826-7804
Relief Ditchtender—Jose Vaca	916-549-1968

Attachment C
Measurement Device Documentation

Appendix C. Measurement Device Documentation

This attachment includes documentation on the accuracy of the various measurement devices being used and/or proposed for use by the districts. Additional details are available within the document under Section 2 for each district (Water Measurement, Pricing, and Billing) and Section 3.4.1.1. The following documents are enclosed:

- Remote Tracker System Overview
- Irrigation District Turnouts (ITRC December 2010)
- SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts (ITRC August 2012)
- Volumetric Flow Measurement for Irrigation District Turnouts ITRC January 2020.
- Glenn-Colusa Irrigation District SB X7-7 Water Measurement Compliance Program
- Reclamation District No. 108 RemoteTracker Volumetric Accuracy Certification Colusa and Yolo Counties, California
- RD 1004 Specification Sheet M0300 Strap-on Saddle Flow Meter
- RD 1004 Water Specialties Propeller Meter
- RD 1004 Water Specialties Propeller Flow Meter

Remote Tracker System Overview

RemoteTracker

System Overview

The RemoteTracker[1] is an integrated turnout flow measurement, data management and volumetric accounting system developed by H2oTech[2] specifically for agricultural water suppliers in response to CCR 23 §597. The RemoteTracker system is comprised of (1) a wirelessly controlled water velocity sensor, (2) a ruggedized tablet PC in the operator's vehicle and (3) a database running on a file server connected to the internet. The user interface on the tablet PC enables operators to view real time flow data from the wirelessly controlled water velocity sensor via a Bluetooth radio connection while adjusting flows at the turnout gate. Data is automatically transferred over a wireless wide area network (WWAN) to a centralized file server at the District headquarters where it is automatically loaded into a custom database application. The database performs quality control and quality assurance procedures on the data and then develops daily volumes for each customer delivery point (turnout or delivery) within the District.

The wireless water velocity sensor (WWVS) is held in place at a precise location at the pipe outlet by an aluminum or stainless steel mounting bracket. The user interface, shown in Figure 1, was designed with simplicity and ease of use in mind. If 'Auto Locate' is selected, the program automatically populates the three site identification pull-downs at the top of the screen. If the operator needs to select a different site, the pull-downs can be manually changed. The site selection hierarchy is a three digit abbreviation of 'Operator Route' (i.e. ride, beat or division) on the left, a three digit abbreviation of 'Canal' in the middle and site name on the right. The most recently measured flow, and any pending orders are shown on the 'Home' tab. Many useful reports, including (1) Delivery History, (2) Pending Orders, (3) Fulfilled Orders and (4) Canal Management are available on the 'Reports' tab. These reports can be sorted at any spatial or temporal scale. The data sharing and management framework allows water order and delivery data collected by any operator to be automatically available for viewing by other operators or management staff in a matter of minutes.

[1] Patent Pending.

[2] H2oTech is a company based in Chico, California that focuses on the development of innovative technologies to solve water management challenges. Visit www.h2otechonline.com for additional details.

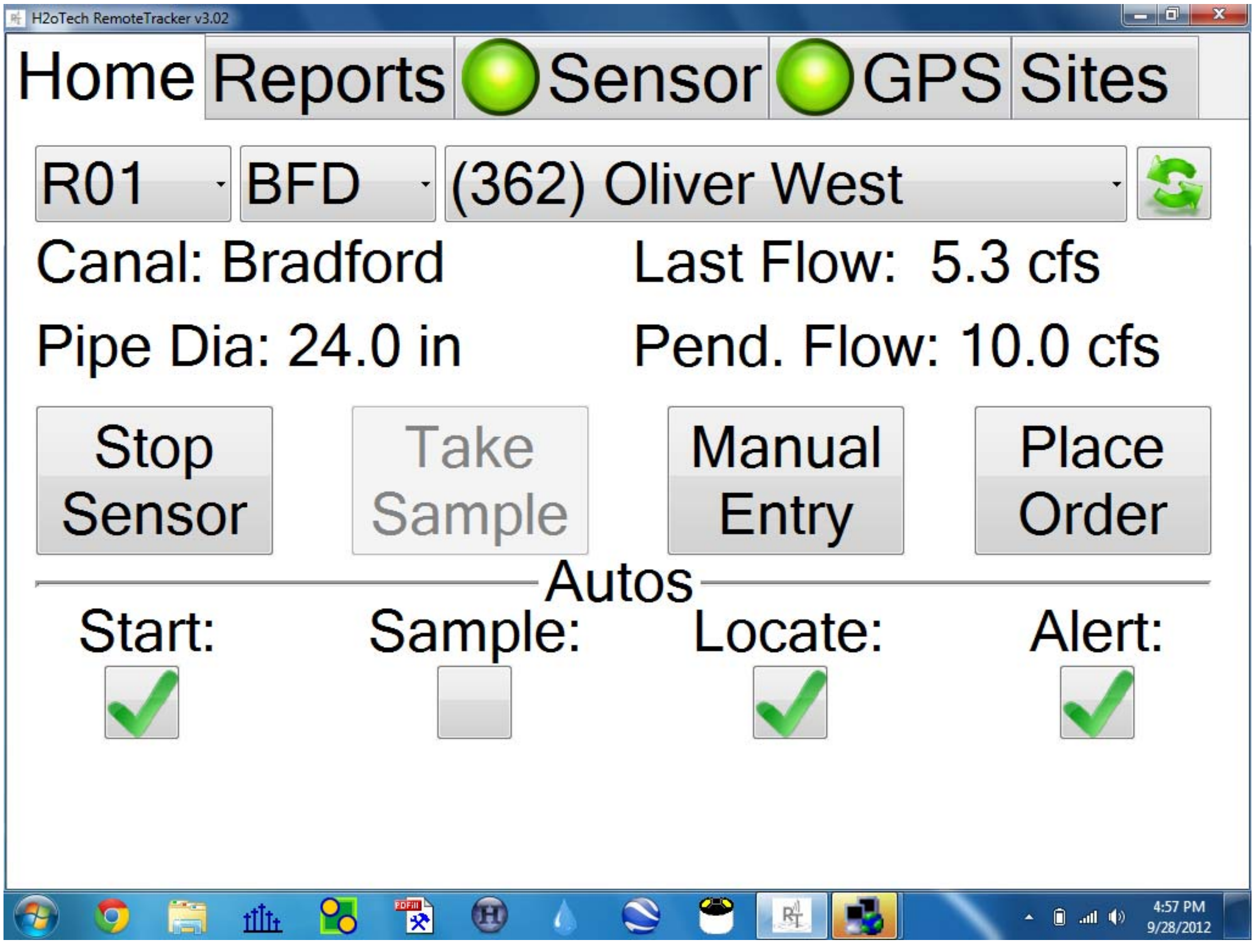


Figure 1. RemoteTracker User Interface - Home Tab Shown

The basic components of the RemoteTracker system are illustrated in Figure 2. Water velocity is collected by a portable acoustic Doppler velocimeter deployed during measurement by hanging it on brackets permanently installed at each turnout. The brackets are precisely positioned such that the sample volume is at the center of the pipe. Data is transmitted via a class 1 Bluetooth radio to a ruggedized tablet PC where it is processed, displayed and stored. Data is then transferred via a WWAN to a file server at the District headquarters. Data from each operator is aggregated with an automated database procedure and then returned to each operator via WWAN, thereby ensuring that delivery and order data is shared and accessible throughout the entire District.

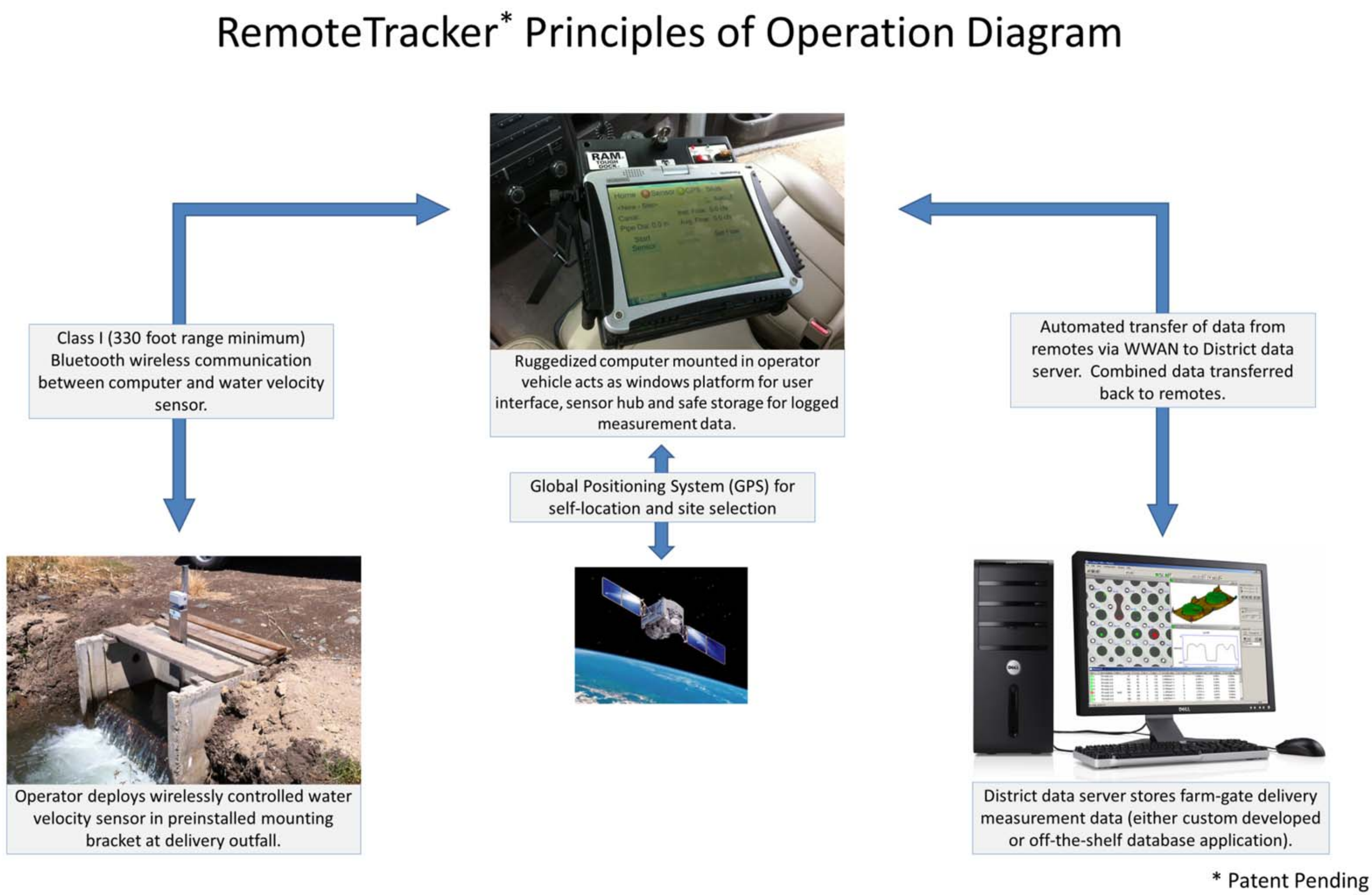


Figure 2. RemoteTracker Principles of Operation Overview

The key to pipe flow measurement using the RemoteTracker is the consistent relationship between a single velocity measurement at the center of the pipe and the average pipe flow velocity shown in Figure 3 derived from 146 measurements of center and mean pipe velocity. Based on this relationship, with the pipe diameter and cross sectional area known, the single point velocity can be accurately and reliably correlated with mean pipe velocity (flow rate).

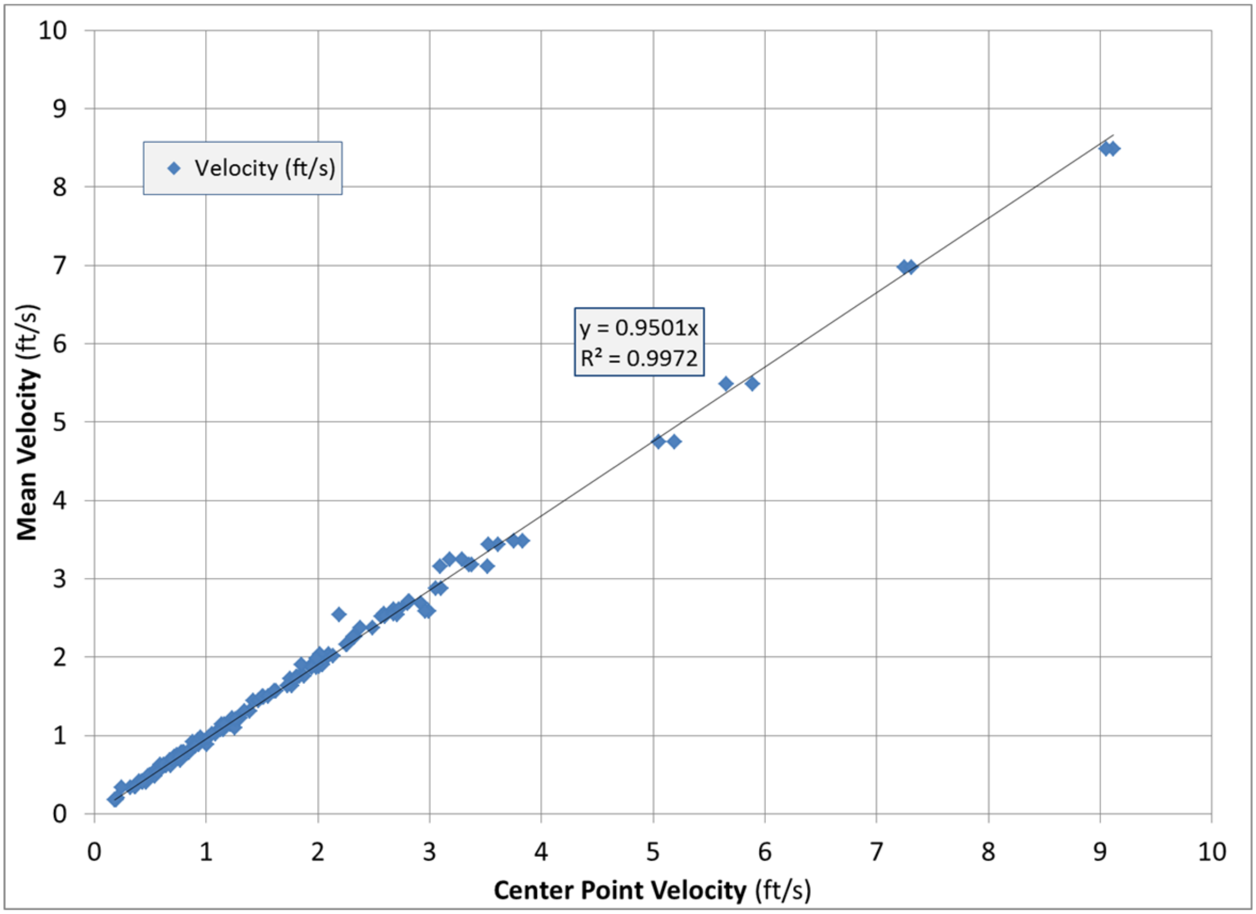


Figure 3. Relationship between Average and Center Point Pipe Flow Velocity

As with weir and orifice gate measurement, full pipe flow is required for the RemoteTracker to measure correctly. Therefore, a weir box is needed at each turnout to ensure full pipe flow as well as to accommodate the mounting bracket to hold the wireless water velocity sensor so that the sample volume is at the center of the pipe.

The RemoteTracker system can also be integrated with existing or new data management systems at the District office for report generation, accounting and billing. This capability can be added later to provide additional efficiencies in water billing and accounting procedures.

Initial Testing Results

Laboratory Testing

Additional testing was performed at the California State University Chico Agricultural Teaching and Research Center (CSUC ATRC) in July of 2012. Flow data obtained from the RemoteTracker was compared to measurements taken with a 10-inch diameter magnetic flow meter manufactured by Water Specialties. Figure 4 shows the Water Specialties Magnetic meter with an Endress & Hauser Transit-Time Meter installed just upstream as an additional check. The 3 foot wide by 3 foot deep concrete flume was modified to simulate a typical delivery configuration by forcing all the flow through a 20 foot length of 18 inch HDPE smooth interior wall pipe submerged in the concrete flume. The RemoteTracker wireless water velocity sensor was installed at the pipe outfall using a temporarily constructed headwall with a mounting bracket as shown in Figure 5.

Figure 4. Water Specialties Magnetic Flow Meter at CSUC ATRC

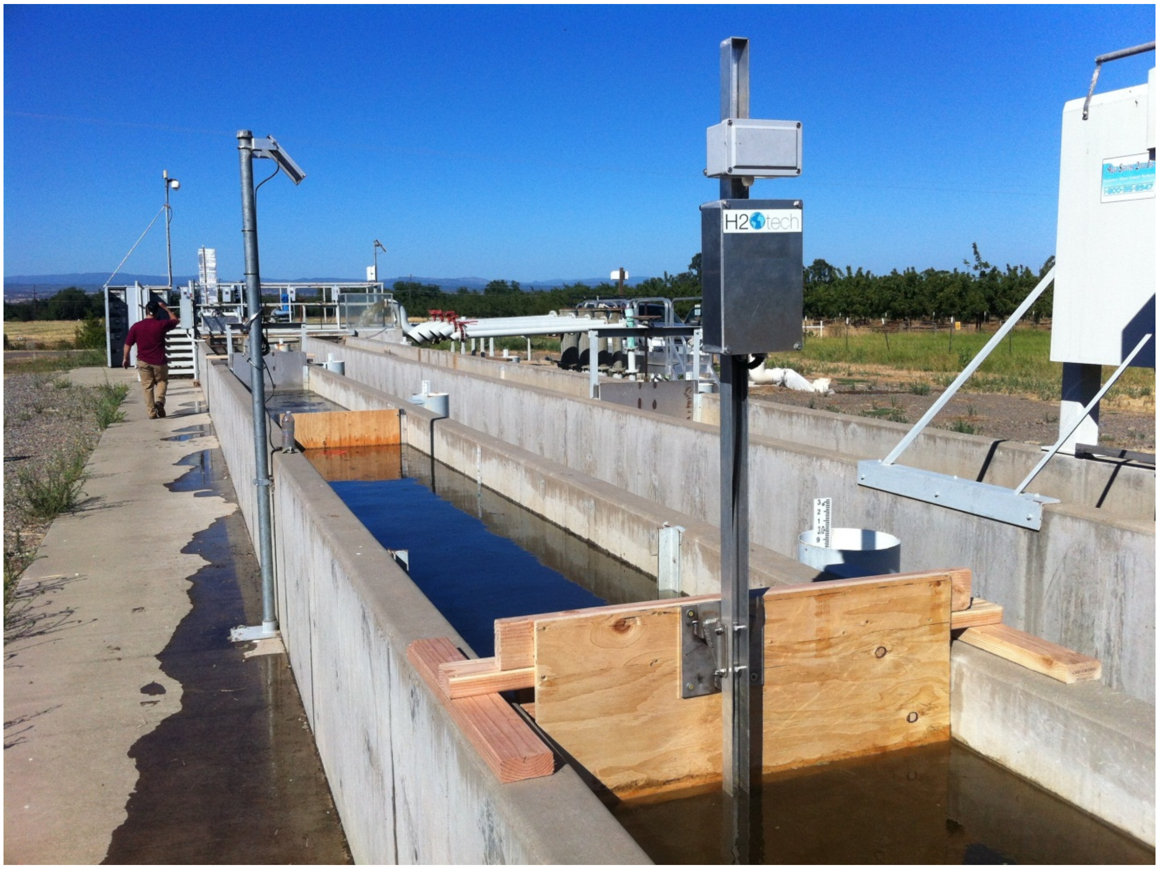


Figure 5. RemoteTracker Wireless Water Velocity Sensor Installed at CSUC ATRC

Seven comparison measurements were made between the RemoteTracker and magnetic meter ranging from 0.5 cfs to just over 3.0 cfs (the maximum pump capacity). The percent difference between the two measurements averaged roughly -2.6 percent with a range of -10.2 to 2.8 percent indicating that the RemoteTracker measurement methodology compares very well with the magnetic meter. Note that the -10.2 percent difference occurred at the lowest flow rate of approximately 0.5 cfs and represents an absolute flow rate difference of just 0.05 cfs between the two measurement methods. The results of the comparison measurements are presented in Figure 6 where the blue bars represent flow rates obtained with a magnetic meter, the red bars represent flow rates obtained with the RemoteTracker and the green triangles represent the percent difference between the two (secondary vertical axis).

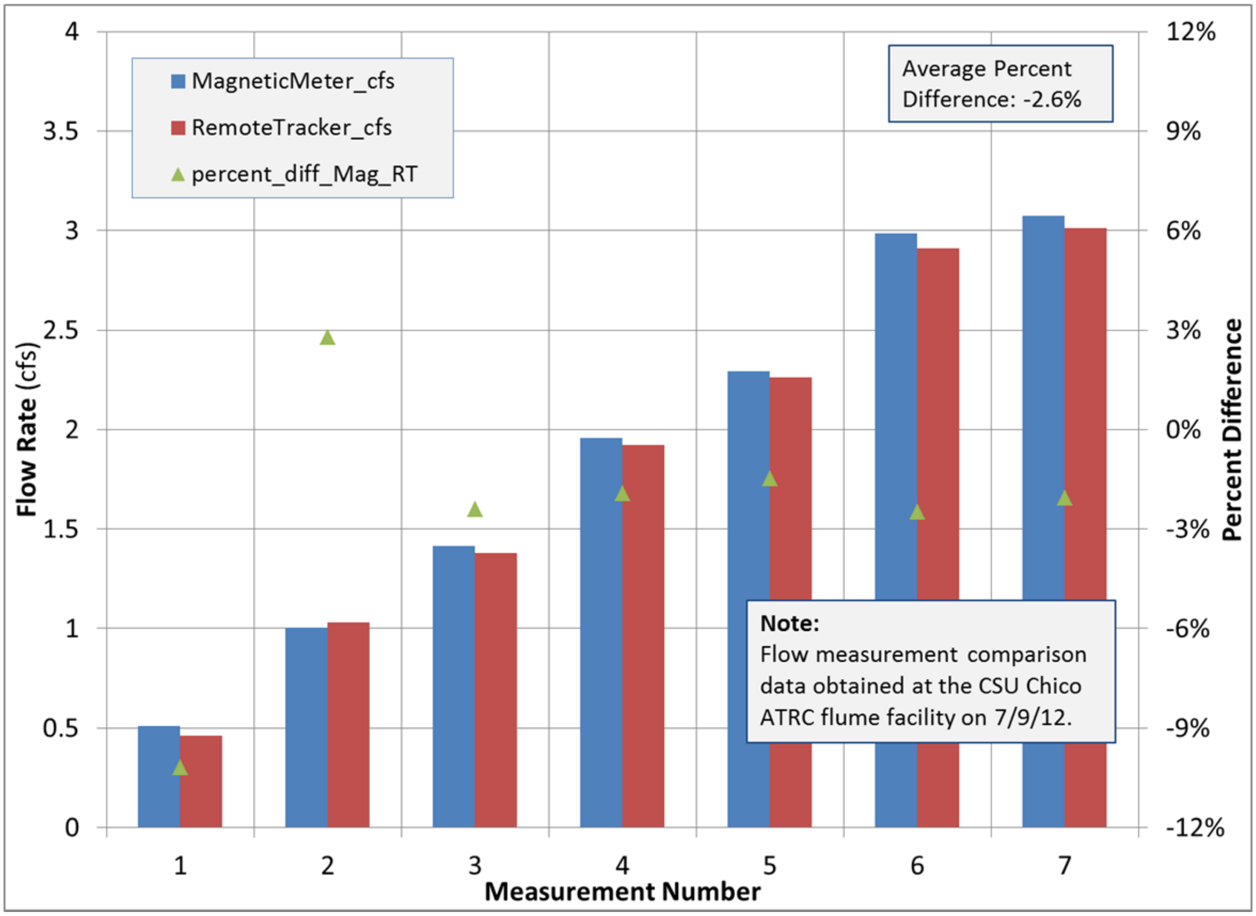


Figure 6. RemoteTracker and CSUC ATRC Magmeter Comparisons

Field Testing

Five comparison measurements between the RemoteTracker and USGS mid-section method measurements with a SonTek ADV were performed at two turnouts in two irrigation districts (one turnout in each District) in Northern California during the 2011 irrigation season. The turnouts were selected because the delivery spilled into a field ditch (or head ditch) rather than a field, so both a RemoteTracker and a USGS mid-section method measurement (Rantz 1982) could be taken and compared. Figure 7 shows the cross section report for one of the measurements in a typical earthen head ditch, in this case with a maximum depth of 2.5 feet, top width of 14 feet and bottom width of 5 feet. Typically, velocity measurements were performed at 0.5 foot intervals with velocities averaged over a 40 second period.

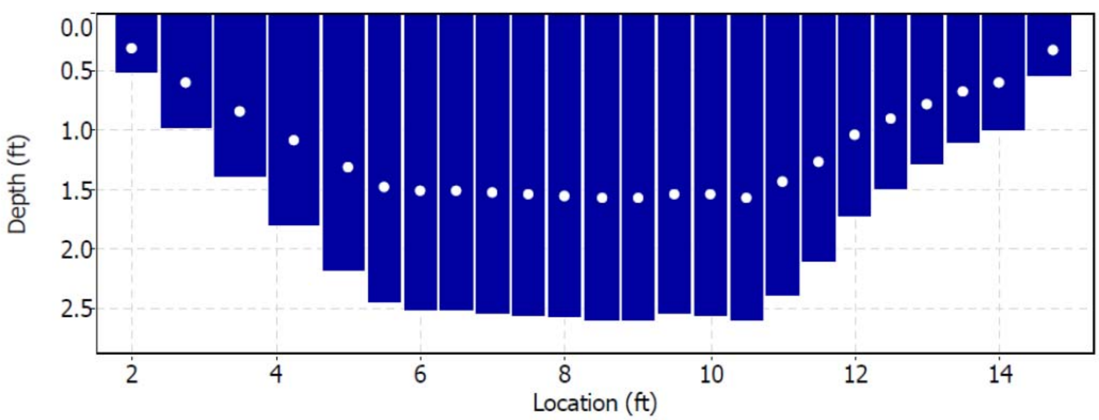


Figure 7. SonTek ADV Cross Section for Canal Verification Measurement

The percent difference between the RemoteTracker and the USGS mid-section method averaged roughly 0.9 percent with a range of -0.8 to 3.4 percent, indicating that the RemoteTracker measurement methodology compares very well with the standard mid-section open channel methodology. The results of the comparison measurements are presented below in Figure 8 where the blue bars represent flow rates obtained with a SonTek ADV in an open channel downstream of the turnout, the red bars represent flow rates obtained with the RemoteTracker and the green triangles represent the percent difference between the two (secondary vertical axis).

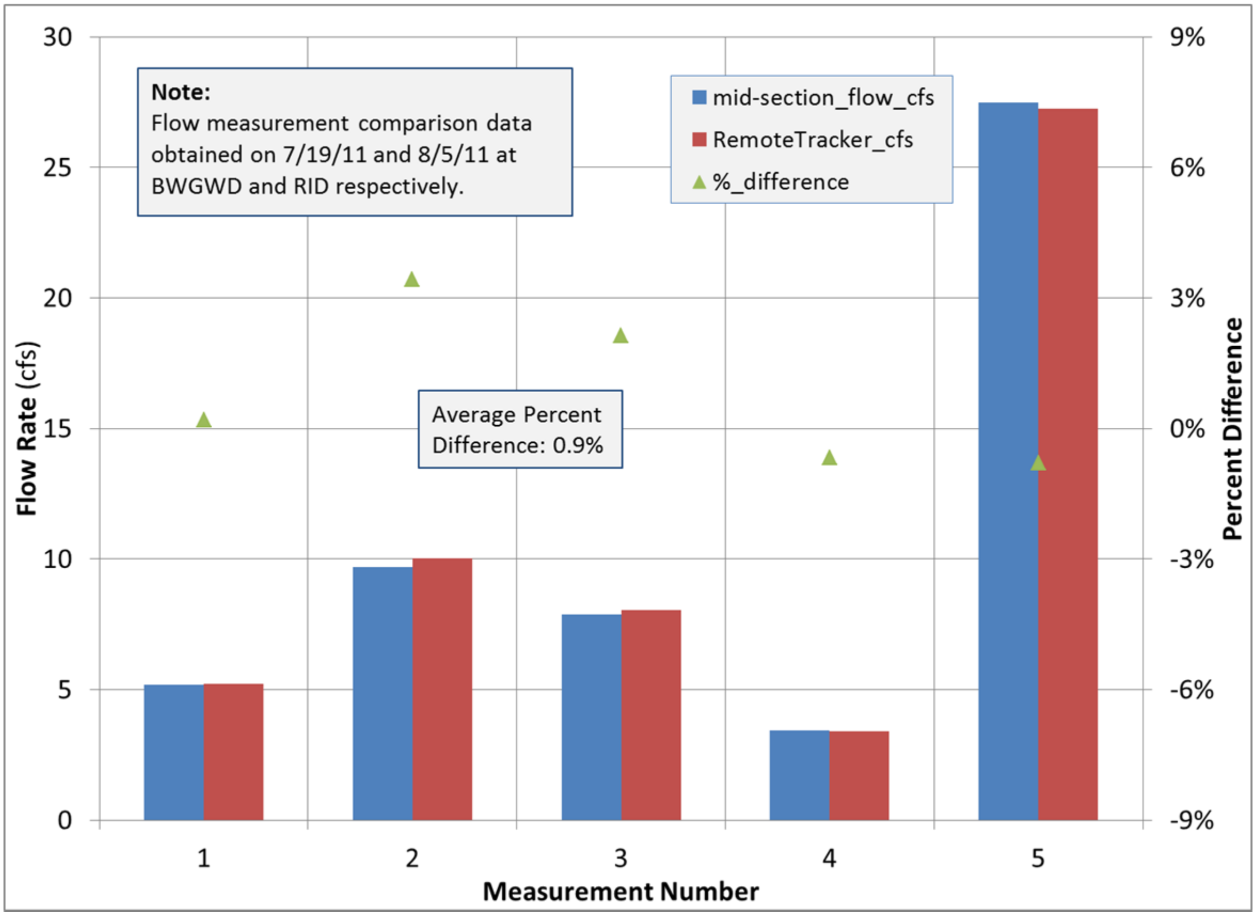


Figure 8. RemoteTracker and Mid-Section method Comparisons

Irrigation District Turnouts (ITRC December 2010)

moving water in new directions
IRRIGATION TRAINING AND RESEARCH CENTER
BioResource and Agricultural Engr. Dept.
California Polytechnic State University
San Luis Obispo, CA 93407-0730
Phone: (805) 756-2434
FAX: (805) 756-2433
www.itrc.org

Irrigation District Turnouts

Date: December 15, 2010

To: SBx7-7 ASC members

From: Charles M. Burt, Ph.D., P.E., D.WRE
Chairman, ITRC
Professor, BRAE Dept.
Office phone: 805-756-2379
Cell phone: 805-748-3863
cburt@calpoly.edu

Irrigation District Turnouts

This is meant to be a very quick, roughly written primer on irrigation district turnout selection. It by no means covers all of the details, but it might help out. ITRC offers flow measurement classes, with online registration at www.itrc.org. We have also done testing on quite a few designs over the years, but the work was almost all confidential in nature.

Definition

A "turnout" or "offtake" or "delivery gate" is the point at which the control of the water changes from the irrigation district to the customer(s).

Turnout Functions

At the turnout, several functions are typically found:

1. *On/off control of water flow*.
2. *Flow rate control*. That is, a turnout usually has a valve to adjust the flow rate somewhere between maximum and zero. However, in many cases the downstream conditions determine the flow rate, and the turnout on/off control valve remains completely open. An example would be a piped or gravity turnout with a pump immediately downstream.
3. *Flow rate measurement (instantaneous)*. A device may have a direct readout (digital or a needle or a height on a gauge). Or, a flow formula or table may be used with several measurements such as gate opening and difference in water level.
4. *Volumetric measurement*. A device may have an integral readout (totalizer wheels or digital), or there may be some way to integrate the flow rate over time (Volume = Flow rate × Time). "Integration" is done in several ways:
    a. The flow rate is measured periodically by an operator, and it is assumed that the average flow rate between readings is approximately correct.
    b. A datalogger automatically records key measurements frequently and sums up the volume of water per minute, or per 15 minute intervals, for example.

Maintenance of a Constant Flow Rate

In the "old days" of a few decades ago, it was thought that irrigation districts should deliver a constant flow rate. Therefore, a variety of control/measurement devices (such as the Neyrtec flow distributor baffle module) were developed to provide on/off, flow rate control, plus a constant flow rate (sort of). This is exactly the opposite of what is needed for more modern on-farm irrigation.

Figure 1. Baffle gates in Africa. Old, inappropriate technology for California.

What we need now is the ability for the district to not cause an unwanted flow change through a turnout. For example, over the course of a day the flow rate required by a drip system will constantly change. Every time the filters backflush, an additional 200 GPM or so might be needed for 10 or 20 minutes. As the water is moved between field blocks of varying sizes, the flow rate requirement changes. A center pivot sprinkler will turn end sprinklers on and off as it moves around a field. Therefore, farmers need the flexibility to change their flow rates easily, without constantly having to notify the district, and without needing to adjust their turnouts.

There are still various vendors of "modern" irrigation equipment that highlight the ability of their automated equipment to maintain a constant flow rate through the turnout. While this may be important for surface irrigation (such as in much of RD108 and Imperial Irrigation District), it is not what is needed for sprinklers and drip irrigation.

Figure 2. Example of an automated flow control turnout, with two adjacent manual turnouts

In the case of turnouts that need a constant flow rate versus time (such as with much of the surface, or flood, irrigation), irrigation districts attempt to maintain a constant pressure on the turnouts. This is done in canals with special canal dams called "check structures" that are designed to maintain very constant upstream water levels, regardless of the canal flow rate. These effective check structures can vary from very sophisticated PLC (programmable logic controller) controlled gates to very simple ITRC flap gates or long crested weirs.

Figure 3. Automated radial gates on Glenn Colusa ID main canal at IID. Radio tower and instrumental enclosure for a PLC are in the forefront.

Figure 4. Very long, but simple, long crested weir at San Luis Canal Company. California has many hundreds of these structures.

Figure 5. Three ITRC flap gates in parallel at San Luis Canal Company. These require no electricity, but must have a drop. There are hundreds of these throughout California.

Competing Demands

For irrigation district operation, it is convenient if farmers do not change their flow rates, and if they start and stop deliveries at prescribed, inflexible times. However, such inflexibility is contrary to the needs of modern on-farm irrigation. When districts provide more flexibility (to improve on-farm efficiency), they almost always suffer a loss in canal efficiency – that is, they have more spill at tail ends. There's a long explanation as to why this happens, but at this point just assume it's a challenging problem.

One of the ways we try to provide good on-farm irrigation flexibility while also minimizing spills is to use specially designed pipe systems to make up what is known as "downstream control" of canals, and regulating reservoirs. This is a whole topic in itself, and expensive.

Figure 6. Special entrance to a 200 AF regulating reservoir at Central California ID. The sluice gates in the center are automated to open if the water level gets too high. Pumps at the upper right hand side (not seen) empty the reservoir if the water level in the canal gets too low. The long walls are for emergency spill into the reservoir.

Flow Measurement at Turnouts

Every flow measurement device requires:

1. *Some type of "good" entrance condition*. In other words, most devices will ideally have a long, smooth entrance upstream of them so that the flow streamlines straighten out. Some pipeline measurement devices have special features that allow a short entrance section upstream of the device. But these are relatively new, and the exact sensitivity of a particular device depends in part on the manufacturer.

Figure 7. Example of poor entrance conditions into a field turnout. This is not in California.

2. *Some type of "good" discharge condition*. For a pipeline device, there is usually a short section of straight downstream pipe required. For flumes and weirs, it is typically desirable to not have too much "submergence" – that is, the downstream water level must be a certain depth lower than the upstream water level.
3. *Maintenance*. Gears wear out. Propellers collect trash. Algae grow on overshot gates and flumes. Dirt collects in pipes. Devices rust.

Figure 8. Several inches of algae and sediment on the crest of a flume. The water depth therefore gives an incorrect indication of flow rate.

4. *Proper installation*. Besides paying attention to proper upstream and downstream conditions, there may be other special considerations. Some devices are deployed in pipelines that must be completely full for accurate measurement. Other devices require measurement of water levels at very specific locations. Certainly, the access to water levels must therefore be properly sited.

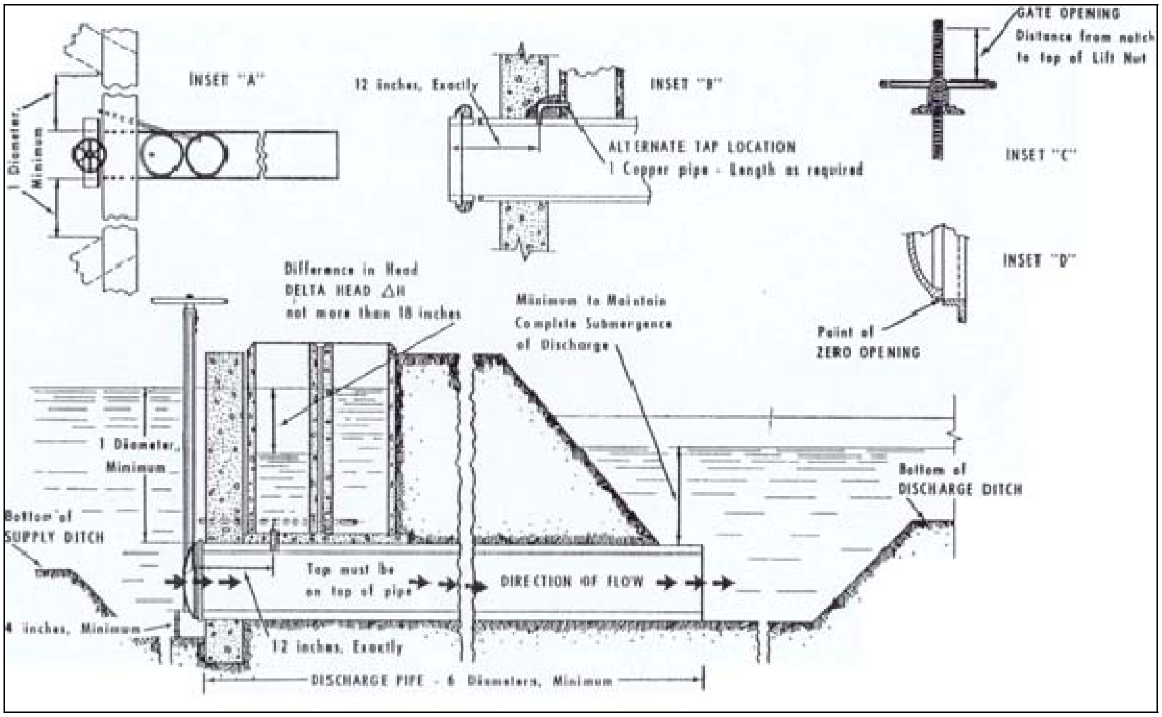


Figure 8. Photo courtesy of an old Armco flow measurement catalog. This depicts a common "metergate" with very specific dimensions that must be met if the rating tables are to be used.

5. *Proper size*. Flow meters can be too big or too small to be accurate for a flow rate. This is especially problematic for areas with rice fields, where at the beginning of the season there are high flows, and low flows are used in the summer.

Permanent Turnouts from Pressurized Pipelines

The best flow rate measurement is typically found on newer, pipelined irrigation districts. Those districts are often laid out with large, rectangular fields, and have pressurized pipe. Furthermore, the flow rates per turnout are often relatively small, and the water is filtered via centralized filtration screens at the head of the large lateral pipelines.

Propeller meters. Most of those districts were designed with propeller meters for measuring instantaneous flow rate, plus totalizing volume. Of course, maintenance is still needed on a systematic basis. But these are the easiest measurement situations – clean water, relatively small flow rates, pipelined, and easy access.

The old standby, depicted below, is the propeller meter. With correct installation and maintenance, it is generally understood to be within about 2-3% accurate over the rated range of flows and volume.

Figure 9. Typical propeller meter in a prefabricated, flanged section. Photo courtesy of McCrometer.

<u>Mag meters</u>. Many of the problems experienced with propeller meters (trash plugging, wearing of bearings, and the requirement of a long, straight inlet and outlet section) are eliminated with some of the newer magnetic meters (called "mag meters") of a spool design, as seen below. Some of these are battery operated. There is a large difference in quality among manufacturers. Also, there are limited models available in sizes greater than 6"or 8". ITRC testing has shown very accurate results from some mag meters, and less-to-horrible results from others.

Figure 10. Two different models of mag meters. Photo courtesy of Seametrics.

<u>Transit-time meters</u>. There is a class of meter that uses a different technology called "transit time" in which an acoustic signal travels from one side of a pipe to the other. The travel time varies, depending upon the velocity of the water. These tend to be expensive for turnout pipes, with variable results reported. They have not yet become well-accepted, permanent flow measurement devices for turnouts.

Venturis. Venturis are found in large pipe installations, such as for lateral turnouts from the Friant-Kern Canal or the Tehama-Colusa Canal. They have a restricted cross section, and two pressures are measured – one upstream of the restriction, and one at the restriction. Because of the large pressure loss across these devices, their high cost, inability to accurately measure at low flows, and sensitivity of instrumentation, they are almost never found on field turnouts.

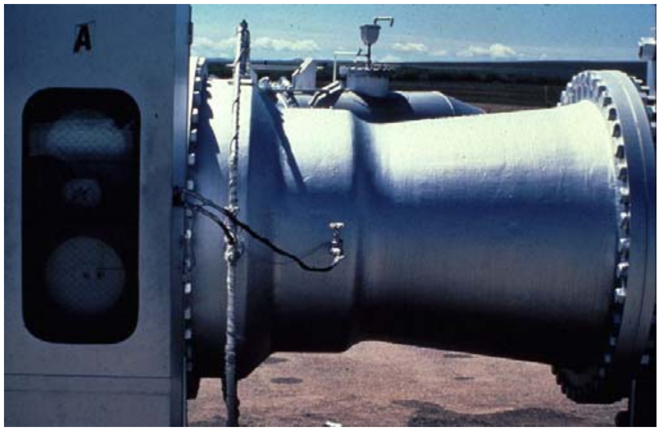


Figure 11. Large, old venturi and instrumentation at Berrenda Mesa WD pumping plant

Insert meters of any type. There are many types of "insert meters" – including small paddle wheels and mag meters. They are relatively inexpensive because they can be inserted into a tapped hole on a pipeline. But, because of their small sample area, they are extremely sensitive to poor entrance/exit conditions. Furthermore, they tend to accumulate trash (because they stick into the flow) or sometimes have cheap bearings that seize up and stop rotating. Many have been tried in irrigation districts; I am not aware of any large successful, sustained usage of them on turnouts.

Figure 12. Three models of paddle wheel flow meters. Courtesy Seametrics.

Flow Measurement – Canal to Open Ditch or to a Pipeline

This is where the biggest challenge lies in California. I won't try to cover every condition, as there are numerous special cases. Instead, I will focus on the main solutions that are available.

Physical configurations. There are several points to consider:

1. Many, but not all, canal turnouts have a pipeline under an access road between the canal and the field. If the pipeline can be kept full (and not fill up with trash and silt) during deliveries, a special type of propeller meter can be used.

Figure 13. Propeller meter in a typical installation, facing upstream into a full pipe

2. In general, constructing something on the field side of the pipeline is problematic. It gets in the way of tractors. The districts do not have authority to do any construction on farm property.
3. Anything constructed on the canal side must not interfere with canal maintenance operations (which can be somewhat brutal on equipment).
4. New equipment should not stick up too high, or it will be knocked off by vehicles traveling down the access road.

Calibrated slide gates. The simplest version is found in districts such as Imperial Irrigation District, which uses a rectangular gate for on/off, flow regulation, and measurement. It is open on both sides. The gate position and water level drop across the gate are measured, and then a formula or table is used to compute the flow rate. There are challenges with maintaining either continuous back pressure, or no back pressure, on the downstream side of the gate. A different formula must be used in those two hydraulic conditions, and it can be confusing for operators at some turnouts.

Figure 14. Imperial Irrigation District turnout. The gate opening and difference in head are measured for a known size of gate. The blue slip of paper in the hole near the top is left behind by the zanjero (operator) to let the farmer know the measurements and flow rate.

Metergate. The metergate was depicted earlier in a drawing from an old Armco gate measurement book. These are very popular in California, on perhaps 30% of the turnouts in one form or another. They function the same as the IID gate, except for three differences:

1. They must always have a submerged downstream condition.
2. They are placed directly against a pipeline on the downstream side, so the water level measurement must be taken at a specific distance downstream, using a stilling well that is tapped into the top of the pipe.
3. The gates themselves are circular.

Figure 15. A classic metergate installation. The two round holes are stilling wells to measure the water level in the canal, and downstream of the gate. The gate is in the closed position in this photo (the stem is down).

<u>Constant Head Orifice (CHO)</u>. This is another variation of the IID-style turnout. To avoid having the hydraulic condition change from submerged to free-flow on the downstream side of a fixed orifice, a second gate is installed. The second gate is used to turn on/off, and to adjust the flow while also keeping the downstream side of the first orifice flooded. The first orifice is usually adjusted once to make sure that everything works out as intended. Alta ID has a variation of this type of device.

Figure 16. CHO at Alta ID. The orifice (on the canal, upstream side) is a standardized rectangle with an adjustable, bolt-secured opening. The downstream gate with the round handle is used to adjust the flow rate to the target.

<u>Weirs and flumes</u>. Some districts have attempted to use weirs or flumes downstream of the on/off and flow adjusting gate. These can work very well if there is a large elevation drop between the field and the canal. But the remaining challenging installations are usually found in flat topography, and in general flumes and weirs are not recommended because they become flooded (they are highly dependent on downstream hydraulic conditions) in flat ground. These were very popular in the inter-mountain West on old USBR projects because there was often a lot of elevation gain.

Figure 17. On-farm flume with maintenance issues, installed in a slip-form canal

Weirs and flumes, of course, are not suitable for sprinklers and drip where the flow rates continually change and, by definition, the water must always back up to the source to provide flexibility. Installing weirs and flumes may meet temporary needs, but will be inadequate if the on-farm irrigation system is modernized. This pertains to fixed or adjustable weirs and flumes.

Vane meters. These were an interesting concept. The idea was that a pivoted shank, having a special triangular-type shape, was stuck into the water and the faster and deeper the flow, the more it would tilt. Therefore, by measuring the tilt one would know the flow. However, they only sampled a small section of the flow rate, were very sensitive to balance, and were susceptible to wind distortion. They are found in literature but not in the field. I saw one many years ago (abandoned) in Glenn Colusa ID. Several of us have looked at them over the years, but always discard the notion.

Bottom Line

Almost any standard device, whether a propeller meter, weir, flume, metergate, calibrated sluice gate, mag meter, etc. can provide volumetric measurement within 6% if it is:

- STANDARD,
- installed in conditions that match its calibration conditions,
- measured properly, and
- properly maintained

The specific device that is "best" for a situation will depend on numerous factors such as the size of the flow rate, the amounts and types of dirt in the water, the physical room available for installation, potential for theft (especially batteries and solar panels), susceptibility to being used as shooting targets, the ability to maintain a steady upstream pressure or canal water level, and obviously the initial and annual costs. Furthermore, some devices that are being promoted simply do not have a long track record of success, and are sometimes very complicated to understand and maintain. To complicate matters, spare parts may not be available. Therefore, districts are wise to be very deliberate about selecting the best option for their individual cases.

SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts (ITRC August 2012)

ITRC
moving water in new directions

IRRIGATION TRAINING & RESEARCH CENTER

SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts

SBx7 Compliance

Aug 26, 2012

IRRIGATION TRAINING & RESEARCH CENTER

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Irrigation Training & Research Center
Updated October 2012

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GROUPED DELIVERIES

Senate Bill x7-7 (SBx7-7) requires documented volumetric accounting to individual turnouts for water deliveries. Section 597.3 of the bill lists two very different requirements for devices (***bold, underlined, italics*** have been added for emphasis):

- Section 597.3(a) discusses measurement devices that must be used at points where there is a reasonable degree of flow rate control.
- Section 597.3(b) states that "An agricultural water supplier may measure water delivered at a location upstream of the delivery points or farm-gates of multiple customers using one of the measurement options described in §597.3(a) if the downstream individual customer's delivery points meet ***either*** of the following conditions:
    A. The agricultural water supplier does not have legal access to the delivery points of individual customers or group of customers to install, measure, maintain, operate, and monitor a measurement device.

        Or,

    B. An engineer determines that due to small differentials in water level ***or*** large fluctuations in flow rate or velocity that occur during the delivery ***season*** at a single farm-gate, accuracy standards of the measurement options in §597.3(a) cannot be met by installing a measurement device or devices (manufactured or on site built or in-house built devices) with or without additional components (such as gauging rod, water level control structure at the farm-gate, etc.).

This last section (B) in essence defines the most downstream point of measurement to be located at the "hand-off point".

The "hand-off point" can be defined as the location, moving downstream in the branching hydraulic network, below which the irrigation district no longer has good control over the flow rates that go to individual farm-gates.

For example, one might consider using a ditch or pipeline with a rotation delivery schedule, with one "head" or delivery at a time. That single "head" or flow rate is rotated among users, one at a time. There is no control over flow rates at individual turnouts (along that ditch or pipeline); the flow rate is controlled at the head of the ditch or pipeline.

This is also true of ditches or pipelines with a rotation delivery schedule, with two or three "heads" or deliveries. These systems typically have little or no precise flow control downstream of the heading. In some districts, the delivery points are not even to a field; the distribution pipelines have alfalfa valves for each border strip that is irrigated. When there is an internal splitting of two "heads", it is done without the benefit of the structures that provide good water level or pressure control.

While it may be possible in many cases to install flow measurement devices within these pipelines or canals, the measurement would be of uncontrolled flows unless the pipelines or canals were substantially modified. In other words, "additional components" besides the flow measurement devices would be required.

Rice systems are a special category, as good water management of rice irrigation is premised on maintaining a target water level in the fields, rather than on delivering a specific volume to a specific field.

That said, with traditional rice laterals, or with traditional rotation laterals, it is entirely reasonable to require farmers with new pressurized systems on such ditches/pipelines to install magnetic meters or propeller meters on their systems. Such flow measurement installations are rather typical and do not represent technical or fiscal challenges for implementation.

Conclusions

1. The wording of SBx7 appears to clearly indicate that the proper, most downstream flow measurement location would be at the head of any "community ditches". "Community ditches" (sometimes called "improvement districts") are defined as privately owned distribution systems that receive water from the irrigation district. The distribution, partitioning, and scheduling of water deliveries within the "community ditch" is not done by irrigation district personnel.
2. Irrigation district ditches and pipelines that are operated on a rotation schedule need an accurate flow measurement device at the head of the ditch or pipeline, but not at individual delivery points within/along the ditch or pipeline that receives water on a rotation schedule. This pertains to ditches and pipelines that are owned either by improvement districts or by irrigation districts.
3. Individual delivery points with pressurized irrigation systems that receive water from an irrigation district ditch or pipeline that is primarily a "rotation" system must be individually metered.

Note: The phrase "irrigation district" encompasses a wide range of district types including reclamation districts (e.g., RD108), water districts (e.g., Coachella WD), irrigation districts (e.g., Modesto ID), and Water Storage Districts (e.g., Buena Vista WSD).

FLOW RATE VS. VOLUMETRIC ACCURACY

SBx7 requires the verification of the accuracy of annual volumes provided at delivery points.

- For devices **with** totalizers, it can be assumed that:

  Flow rate accuracy = Volumetric accuracy

- For devices such as meter gates and orifice plates that do **not** have totalizers, the flow rate accuracy may only be part of the total desired 12% volumetric accuracy. The annual volumetric accuracy of any such single turnout depends upon errors due to:
  - IFR – Instantaneous flow rate error
  - CWLF – Canal water level fluctuations, or pipeline pressure fluctuations over time. The impact of these fluctuations are mostly self-canceling over the course of an irrigation season. This is discussed later in this report.
  - CBP – Changes in "backpressure". Backpressure is the pressure on the downstream side of the flow measurement device.
  - ARD – Accuracy of the recording of durations. For example, if an actual delivery lasts for a total of 25 hours but it is recorded and billed as a 24-hour delivery, this would be an error of one hour, or 4.2%

These inaccuracies must be mathematically combined to determine the total volumetric accuracy.

$$Volumetric\ accuracy = 100\ \times \left[1 - \sqrt{(IFR)^2 + (CWLF)^2 + (CBP)^2 + (ARD)^2} \right]$$

For example, assume the following errors expressed as decimals rather than as percentages. These are plus/minus errors ("within 5%" means "within +/- 5%"):

IFR is within 5% (IFR =.05) CBP = .03
CWLF = .02 ARD = .04

Then,

$$Volumetric\ accuracy\ (VA) = 100\ \times \left[1 - \sqrt{(.05)^2 + (.02)^2 + (.03)^2 + (.04)^2}\right]$$

VA = 92.7 = 93%

The errors are independent of each other. Therefore, the total error does ***not*** equal the sum of the errors (14%), which would incorrectly indicate an 86% accuracy.

The maximum acceptable flow rate measurement error (expressed as a decimal) equals:

Max. acceptable device flow rate error = $\sqrt{(1 - \frac{VA}{100})^2\ -\ ARD^2 - CBP^2 - CWLF^2}$

For example, if the required volumetric accuracy (VA) = 88% (88) (i.e., within 12%) and:
ARD = .04 CBP = .03 CWLF = .02

Then, the maximum acceptable device flow rate accuracy error = 0.107 = 10.7%

That is, this specific device, when tested at a specific representative flow rate, must be within 89.3% accuracy.

IMPACT OF CANAL WATER LEVEL CHANGES ON ANNUAL VOLUMETRIC ACCURACY

Background

The volume delivered through flow measurement devices without totalizers is computed as:

$$\text{Volume} = (\text{Flow Rate}) \times \text{Time}$$

The flow rate is typically checked once per day, and a new flow rate is either noted on the records, or the flow rate control device is re-adjusted to provide the target flow rate.

During any 24-hour period, the canal water levels will fluctuate, resulting in a delivery of more or less flow rate than was originally set.

The question addressed in this section is: Over the course of an irrigation season with ten, twenty, or thirty 24-hour irrigation events, do these minute-to-minute fluctuations cancel out? If they do, this will remove the "CWLF" (discussed in the previous section) from consideration.

To examine this, ITRC obtained water level data from multiple locations throughout San Luis Canal Company, over a time period from June 8 to July 11, 2012. Canal levels were recorded automatically on an hourly basis. The total change in water level across the turnout [(water surface in the canal) - (water surface in the downstream ditch)] was also recorded at the start of each datalogging session. The irrigation district has typical flashboard check structures to maintain water levels in the majority of its locations.

A series of 22 sites were analyzed for 48-72 hours. It is believed that these sites are representative of the range of conditions throughout the district. No special management of the check structures was involved; the canal operators were unaware that the levels were being recorded.

Error Analysis

Water Level Error Model

In order to assess the error of volumetric flow rate measurement in the canal system, first the fluctuations in water level must be computed. A model was constructed to measure the percent error of the water level over a 24-hour period from a given starting point in the sample set.

The raw data was normalized so that canal fluctuations would be represented as a percentage of the head difference. In this way, all the data points could be accumulated to create a contiguous set of hourly fluctuations for the model data set. The resulting model contains a total of 5500 hourly data points.

Sample Set

A sample set was generated from the model. The sample set contained three different blocks. Each block had 30 different seasons with varying numbers of irrigations events per season. Block 1 had 30 seasons of ten 24-hour irrigations, Block 2 had 30 seasons of twenty 24-hour irrigations, and block 3 had 30 seasons of thirty 24-hour irrigations.

The starting points for the irrigation events in each season were selected by a random number generator. The error was recorded for each hour from the starting point for a total 24 hours. Thus, each irrigation event consisted of 24 data points, resulting in a total of 21,600 data points sampled for all of the seasons in all 3 blocks.

Results

If the present water level for a moment during an irrigation event in the model is equal to the starting water level for that event, then the percent error at that moment is zero. The percent error at each recorded time during an irrigation is calculated by the following equation:

$$\%\ Error\ at\ a\ moment = \frac{Present\ Water\ Level - Initial\ Water\ Level}{Initial\ Change\ in\ Head} \times 100$$

Where "Initial Water Level" is the water level when the 24-hour irrigation began.

The characteristics of the population of "errors" in water level are shown in the figure below.

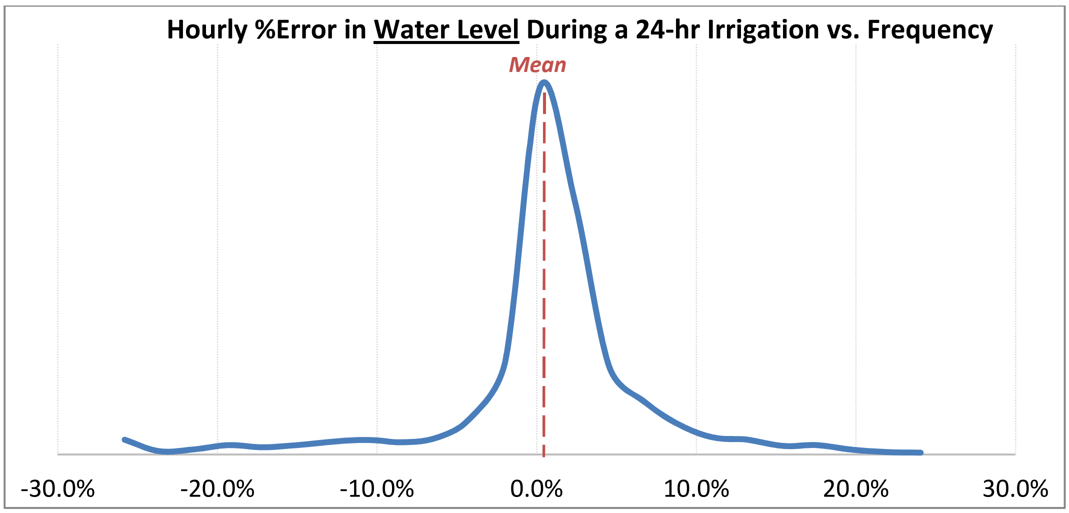


Figure 1. Sample distribution for hourly % error in water level vs. frequency

The variation in relative water levels over time is interesting, but of more interest is the impact on turnout flow rates. There are two possible situations, described below:

1. The flow measurement device is operated under "free flow". That is, the water jets out from it, and the flow rate through the orifice device is not affected by changing downstream water levels. The variation in flow rate over time can be computed, based solely on the upstream water level change. In this case, the sensitivity of the turnout flows to canal water levels is computed as:

$$Free\ Flow\ Error = (1 + Level\ Error)^{0.5} - 1$$

2. The flow measurement device operates under a "submerged" condition. In this case, what happens is that if the canal water level changes, the flow through the measurement device increases. But that also results in a rise in the downstream water level. This provides a "pressure compensating" effect. The total head change is less than the change in the canal water level. ITRC has examined a number of possible downstream channel conditions, and uses the following equation to estimate the effect of a change in canal water level:

$$Submerged\ Flow\ Error = (1 + Level\ Error)^{0.38} - 1$$

For each block (group of 30 randomly selected seasonal irrigation cycles), the mean and standard deviation of the error were computed. **Figure 2** shows the results of the analysis. The mean error is plotted for each block along with the standard deviations. The red bars are 1 standard deviation above the mean, and the green bars are 1 standard deviation below the mean.

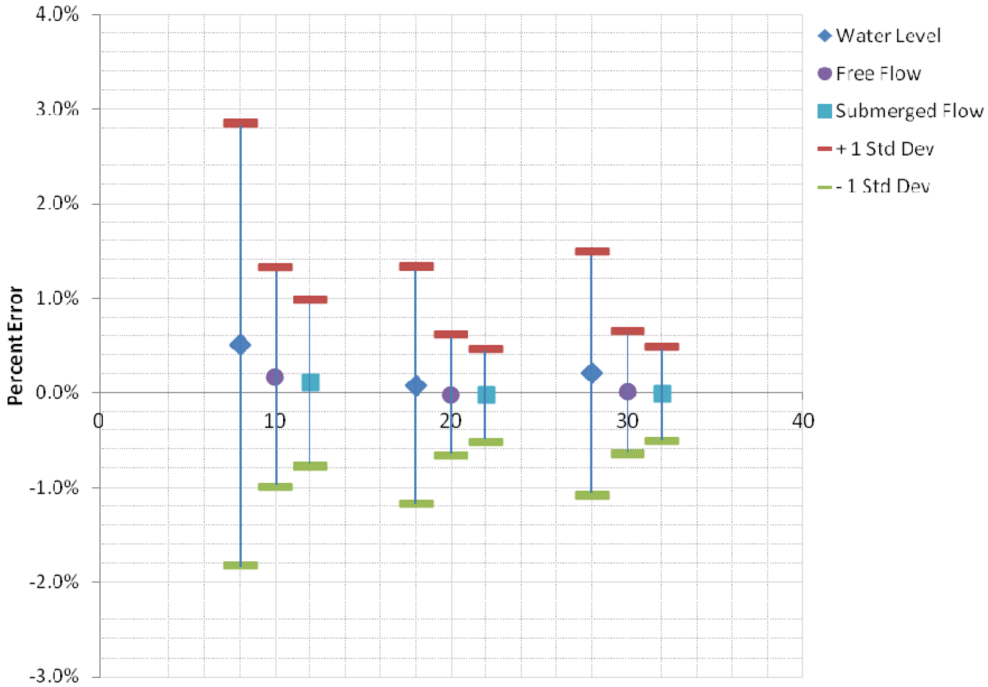


Figure 2. Means and standard deviations for each block

Conclusion

For the condition of 10 irrigations per season, the seasonal flow rate error due to fluctuating canal water levels averages less than 0.2%, regardless of whether the turnout is free flow or submerged flow. The average seasonal error for 20-30 irrigations per season is almost 0.0%.

Because most irrigation districts deliver more than 10 irrigations per season, it appears that a reasonable estimate of the annual volumetric error due to a fluctuating canal water level is about +/- 0.5%, when one considers one standard deviation from the mean.

While this data originated in a single district, ITRC believes that the conditions are representative of "typical" canal districts, based on experiences in about 150 irrigation districts in the western U.S. The exception would be the few irrigation districts that have a very extensive distribution of long-crested weirs or ITRC flap gates throughout the canals. An extreme example would be Modesto ID, in which case almost every check structure is a long-crested weir. In that case, the seasonal impact of fluctuating canal water levels is likely 0.0%, for all practical purposes.

SELECTION OF A REPRESENTATIVE SAMPLE FOR VERIFICATION OF ACCURACY

California Legislature SBx7 requires flow measurement devices to be within a required level of accuracy. For existing flow measurement devices, the acceptable error for volumetric flow measurement is ±12% as stated in §597.3(a)(1). Initial certification of existing devices requires a random and statistically representative sample set <u>or</u> an accepted statistical methodology as described in §597.4(a)(1) and §597.4(b)(1). This document defines a statistical methodology that can be used to provide good information that meets both the intent of SBx7 and the needs of the irrigation districts.

Background

<u>Representative Sample</u>

Irrigation districts have turnouts with flow measurement devices that supply water to areas with correspondingly varying annual delivered volumes. The selection process defined below is intended to define how to select a representative sample set of flow measurement devices for verification of volumetric measurement quality in the district as whole.

In an irrigation district with a wide range of acreages downstream of flow measurement devices, a simple random selection of measurement devices would statistically over-emphasize the importance of small delivery points. The sampling may only represent a very small percentage of all the water delivered in the district. The volume delivered through a turnout is related to the size of the area irrigated. Therefore, it is better to weigh the importance of each measurement device according to the area it services, rather than weighing all turnouts equally. Thus, the sample of flow measurement devices to be tested will be constructed using a ***probability-proportional-to-size (PPS)*** sampling method so that the likelihood of inspection for a given flow measurement device will be proportional to the acreage served by that device.

<u>Considerations for Availability</u>

Ideally, all the devices would be randomly selected by the PPS sampling process mentioned above, and then the selected devices would be evaluated for accuracy. However, only some percentage of the turnouts will be operating at a given time. Therefore, if a turnout is selected in a purely random manner, the customer served by that turnout may not be ready to irrigate, prohibiting evaluation of the flow measurement device at that turnout. It is also clear that even if farmers are scheduled to receive water from a turnout on a specific date/time, they do not always irrigate on that schedule; this makes advance and careful scheduling of field evaluations problematic.

A solution to this is to use ***opportunity sampling*** in combination with ***sampling quotas***. An opportunity sample is composed of samples taken as they are available or convenient. Since device availability will be an issue, devices should be inspected when they are available.

Point #1: To ensure that the data set is representative of the district's overall volumetric flow measurement, a minimum of 10% of the district's service area (or volume) should be represented by the combined service acreage for the turnouts in the sample set.

Point #2: To meet the SBx7 requirements, the minimum sample size of 5 and maximum of 100 for a particular device type should be evaluated.

Point #3: Two scenarios for sampling are described in this document:
- Advance Probability-Proportional-To-Size (PPS) Sampling
- Opportunity Sampling with a consideration of PPS

Scenario 1: Acreage-Based Sampling Using Probability-Proportional-to-Size (PPS)

Scenario 1 is the ideal situation, where at any given time all turnouts will be available for inspection.

Background

Representative Sample Selection

Flow measurement devices in a district will be assigned a number ***range*** based on the acreage (or known annual volume) that the devices serve (e.g., a turnout servicing 10 acres may be assigned 10 numbers such as 61-70). This numbering will have a logical sequencing that is appropriate for the given district. A random number generator will then be used to select a device from the developed sequence. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the random sample will be statistically representative of the overall accuracy of flow measurement within the district.

Random Selection Process

A random number generator will be used to select a device to be tested. If the number produced by the random number generator is within the range assigned to a device, then that device will be tested. Once a device has been tested, its range will no longer be considered in the selection process, and numbers randomly generated in its range will be ignored. This procedure will be improved from the example given in §597.4(b)(1), in that devices providing at least 10% of the district volume or acreage (rather 10% of the devices) will be tested, with a minimum of 5 devices, and not to exceed 100 individual devices of a certain type.

Device Types

It is important to take note of device types for this legislation. If 25% of existing devices (as estimated from the properly selected sample) of a particular type are not in compliance with ±12% accuracy requirements, the district must develop a plan to test another sample of measurement devices of this type as stated in §597.4(b)(2). This document interprets the intent of the legislation as applying to 25% of water delivered, rather than 25% of existing devices. For illustration, in the extreme case of a district with the following:

- 100 garden plots of 0.25 acres each, each with a measurement device (25 acres total)
- 50 larger fields of 80 acres each, each with a measurement device (4000 acres total)

Certainly, careful irrigation water management would not focus on the large number of very small plots that represent less than 1% of the total acreage. This document therefore assumes that the proper interpretation is to focus on reasonable measurement of at least 25% of sample water volume, rather than 25% of the sample devices.

Step 1: Assign Sequence Range Numbers to Each Turnout

Table 1 describes a sample scenario and shows a sequence range of number assignments for each turnout. The district in the sample scenario has one lateral with 10 turnouts serving a varying array of acreage.

Table 1. Example of assigning sequence range numbers

Turnout #	Acreage Served	Sequence Range From	Sequence Range To
1	10	**1**	**10**
2	10	**11**	**20**
3	15	**21**	**35**
4	15	**36**	**50**
5	2	**51**	**52**
6	2	**53**	**54**
7	5	**55**	**59**
8	5	**60**	**64**
9	50	**65**	**114**
10	50	**115**	**164**
Total	**164**		

Note that the final sequence number should be equal to the total acreage

Each turnout is assigned sequence range numbers based on their acreage. Turnout 1 is assigned the sequence range from 1 to 10 because it has 10 acres, and Turnout 2 is similarly assigned 11 to 20. Turnout 3 is assigned a longer sequence range, from 21 to 35, because it has 15 acres. Turnouts are continued to be assigned sequence range numbers in this fashion. As a result of this sequence range numbering, each turnout will represent a portion of the total 164 acres.

Step 2: Use a Random Number Generator to Select Turnouts

Use a random number generator to choose a number between 1 and the total acreage of the district. A random number generator can be a software program or simply pulling numbers out of a hat. In the example above the random number generator would pick a number between 1 and 164. If the number produced by the random number generator is between the sequence range numbers assigned to a device, then that device will be tested.

> Repeat this process until devices representing 10% of the acreage served (or volume delivered) have been selected with a minimum of 5 and a maximum of 100 per device type.

Continuing with the example data set above, assume that the first numbers selected by the random number generator were: 17, 24, 157, 156, 53, 42, 41, 36, 2, 12, and 52.

Eliminate duplicate turnouts, starting from the first random number.

With this random selection of numbers, the following turnouts are selected:

2 (selected by number 17; 12 is a duplicate)
3 (selected by number 24)
10 (selected by number 157; 156 is a duplicate)
6 (selected by number 53)
4 (selected by number 41; 41 and 36 are duplicates)

This provides the minimum number of 5 turnouts. Now, the acreage must be checked to verify that the selection represents more than 10% of the acreage (or volume).

Table 2. Example of randomly selected sample set

Green rows indicate the selected devices for the sample set

Turnout #	Acreage Served – Acres	Acreage Served – % of Total	Sequence Range – From	Sequence Range – To
1	10	6%	**1**	**10**
2	10	6%	**11**	**20**
3	15	9%	**21**	**35**
4	15	9%	**36**	**50**
5	2	1%	**51**	**52**
6	2	1%	**53**	**54**
7	5	3%	**55**	**59**
8	5	3%	**60**	**64**
9	50	30%	**65**	**114**
10	50	30%	**115**	**164**
Total	**164**	**100%**		

The five turnout samples represent 55% of the total acreage.

Therefore, this sample set meets the criteria of:
- greater than or equal to 10% of the acreage, and
- a minimum of 5 turnouts of a particular type - assuming all are the same device.

Note: If there is more than one device, this process would be repeated ***by device***. The final criteria to be met are:

- Including all device sample sets, at least 10% of the district acreage (or volume) must be accounted for.
- A minimum of 5 turnouts of a particular device, for each device.
- No more than 100 of any particular device.

Step 3: Evaluate Selected Turnouts and Record Data

Once the turnouts have been selected, evaluate each flow measurement device for accuracy. Record gate type, total acreage serviced by the device, and measured accuracy. This data will need to be retained for ten years or two Agricultural Water Management Plan Cycles as per 597.4(c).

To continue the example, **Table 3** shows how data should be recorded for the example district. For simplicity, it is assumed that all devices are meter gates.

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

Turnout #	Device Type	Acreage Served	Flow Accuracy Error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
	Total acreage sampled:	***92***	

Step 4: Determination of Compliance

SBx7 requires an annual volumetric accuracy of within 12% on existing devices. Table 3 addresses flow rate accuracy, not volumetric accuracy.

If 25% or more of the sampled area for a particular device type exceeds the 12% annual volumetric allowable error, then a second round of testing must be conducted. This second round of testing should be conducted in the same manner as the first, but only for the device type(s) that did not meet the required accuracy standard.

Compliance of this particular example. Table 3 is repeated below for illustration.

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

Turnout #	Device Type	Acreage Served	Flow Accuracy error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
	Total acreage sampled:	***92***	

Assuming that the minimum required flow rate accuracy is 10.7% (using the example), then only one turnout measurement device does not meet the requirement. No re-testing is needed, because:

1. Ninety-two acres were tested out of the total 164 acres. This is much greater than the 10% sample size required.
2. Five devices were sampled, which meets the minimum because all devices are of the same basic design.
3. The one device with greater than 10.7% error only represents 10 acres, which is 11% of the acreage sampled. This is below the allowable 25%.

Scenario 2: Limited Availability of Turnouts and Opportunity Sampling

Turnouts may not be available for inspection due to fluctuations in irrigation scheduling. Therefore, opportunity sample can be used to select devices to be evaluated. As opposed to the PPS random sample set, this sample will be based on availability and service size rather than a weighted random sampling.

Background

Representative Sample Selection

To ensure the sample is representative of the district as a whole, evaluators need to ensure that the area serviced by the devices evaluated is at least 10% of the district's entire area. Furthermore, when given a choice between devices of equal convenience, devices servicing a larger acreage should be given priority for inspection. Additionally, a minimum of 5 devices must be inspected. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the opportunity sample will be statistically representative of the overall accuracy of flow measurement within the district.

Selection Process

Devices will be selected as they are available to be tested. Priority for evaluation will be given to devices that service greater acreage. Once a device has been tested, it will no longer be considered in the selection process. A minimum of 5 devices will be tested, and all evaluated devices (summation of all types) will service a combined 10% of the district's total area (or delivered volume), not to exceed 100 individual devices of a certain type.

Step 1: Choose a Currently Available Turnout

Select a turnout that is available for testing based on the size of the turnout, giving priority to turnouts that serve greater acreage. Do not test the same device more than once. **Table 4** shows an example of the selection process for two days. On the first day Turnout 10 serves the largest acreage out of the available turnouts. On day two, Turnout 5 is chosen because it serves the largest area and has not yet been tested. The district in this example has one canal lateral with 10 turnouts, and the turnouts have limited availability for testing.

Table 4. Device selection on two separate days

Green rows indicate the selected turnout. Grey rows indicate a turnout that has been tested.

Day 1

Turnout #	Currently Available	Acreage Served
1	yes	10
2	yes	10
3	no	9
4	yes	7
5	no	30
6	no	1
7	yes	1
8	yes	2
9	no	50
10	yes	50

Day 2

Turnout #	Currently Available	Acreage Served
1	no	10
2	yes	10
3	no	9
4	yes	7
	yes	30
6	no	1
7	yes	1
8	yes	2
9	no	50
10	*yes*	*50*

Continue testing devices until the following criteria have been met:

- *At least 10% of the total district acreage is serviced by the devices tested*
- *At least 5 devices have been tested*
- *Test no more than 100 devices of a particular type*

Steps 2-4 : Follow the Previous Scenario Instructions

FLOW MEASUREMENT DEVICES

Background

This section is intended to provide useful information on several common flow measurement devices that might be considered for traditional, non-pressurized turnouts. Often, the problems with some of the devices (meter gates, orifice plates, and propeller meters) are largely associated with improper measurement, or improper installation or maintenance. If properly designed and maintained, all three of these measurement devices will generally fall well within required SBx7 requirements.

Meter Gates

Meter gates are one of the most common devices used in California irrigation districts to both measure and control flow rates. There is no doubt that many of these devices provide accurate results. However, as with all devices, certain rules must be followed. Typical physical inaccuracies associated with meter gates include:

1. *Incorrect "zero" measurement of gate opening*, as determined by the vertical movement of the threaded shaft.
   a. There are four primary reasons operators might measure the opening from an incorrect "zero" mark on the threaded shaft:
      i. The zero point is affected by "slop" in the connection between the shaft and the gate plate.
      ii. Wedges are used to force the plate against the gate frame during gate closure. These wedges are often adjusted in the field, so there is no standard stopping distance (vertically) for the plate.
      iii. When the plate begins to move, it may overlap the opening (by 0.5 - 2"). Although water may begin to leak as the plate moves out of the wedge constraint, the true zero is the opening at which the bottom of the plate is exactly at the bottom of the frame opening.
      iv. The "zero" point should always be determined while the gate is being raised.
   b. Once the zero point is known, a notch should be scribed into the shaft to note the location of the zero mark. Then the gate opening should always be measured as the gate is being opened, rather than being closed.

2. *Incorrect downstream water level measurement*.
   a. The stilling well must be placed over a full pipe, at a specific distance downstream of the meter gate.
   b. Many existing stilling wells were actually designed to be air vents, and have such a small diameter that there is constant surging. A large diameter stilling well, fed by a relatively small access hole at its bottom (about 1/6th the diameter of the stilling well), is needed to "still" the water surface so it can be measured downstream of the gate. The problem with a small access hole is that it can plug up easily. A good combination is a 2" access hole (connecting the stilling well to the top of the pipe) and a 12" stilling well.
   c. The pipe must be full at all flow rates. This may require the placement of a small obstruction downstream, in the pipe, similar to what is done with well pump discharges to keep propeller meters full. Various entities, including ITRC, have successfully designed side contractions in pipes to create "Replogle flumes" that have very little loss, and that pass bottom loads of silt. Something similar could be used downstream of the meter gates.

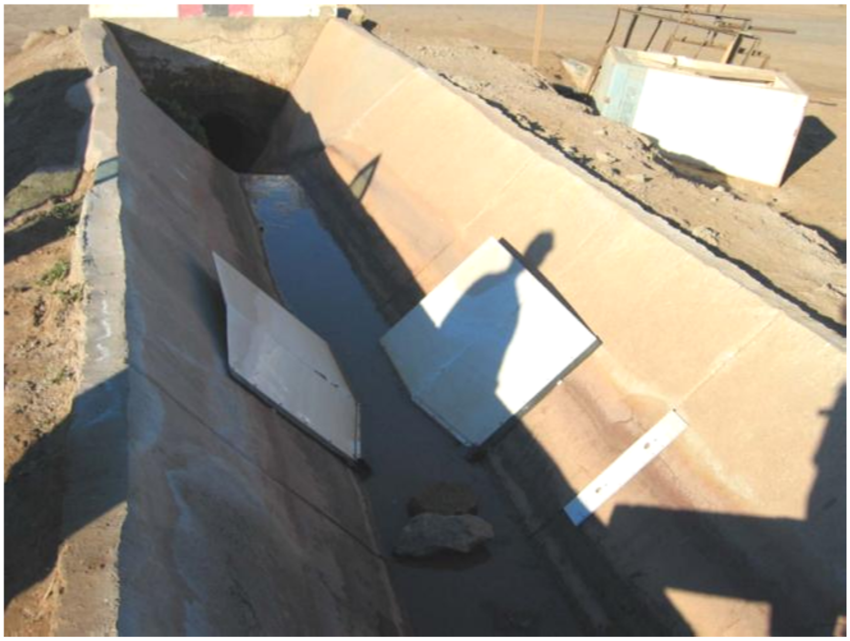


Figure 3. Side contractions rather than a traditional "Replogle Flume". Designed by USBR, Yuma. The rocks are not part of the design.

Another technique used in some districts to maintain a submerged condition on a gate is to install "bumps" in the bottom of a canal or ditch downstream of the turnout. These should be permanent "bumps" which, at low flows, will keep the water level high. The rule for building these "bumps" is:

> Build up the restriction from the bottom of the ditch/canal so that at high flow rates, the upstream water surface (relative to the bump) is only raised by about 0.1' or less. In other words, its presence will hardly be noticeable.

If farmers move downstream in their canal, setting siphons at a different place, this "bump" will keep the backpressure on the meter gate almost constant, and minimize the flow rate change that would normally occur.

3. *Incorrect gate opening geometry*. Since the plate has a larger outside diameter than the inside diameter of the pipe, the ratio of the open area between the two openings must be taken into account. Almost everyone uses tables that were developed decades ago. ITRC is not certain if the gate dimensions have changed since then, or if different manufacturers use different gate dimensions. ITRC is planning to verify this in the future.

4. *Non-standard entrance and exit conditions.* The flow rate is associated with a measured opening and head loss. The head loss will be different (at the same flow rate) with different entrance conditions. Various manuals, such as the USBR Flow Measurement Manual, provide recommended dimensions.

Orifice Plates

The following is an explanation of the characteristics of a submerged (on both sides) rectangular orifice plate.

According to the U.S. Bureau of Reclamation *Water Measurement Manual*, conditions for achieving accurate flow measurement of ± 2% for a fully contracted submerged rectangular orifice are:

- The upstream edges of the orifice should be straight, sharp, and smooth.
- The upstream face and the sides of the orifice opening need to be vertical.
- The top and bottom edges of the orifice opening need to be level.
- Any fasteners present on the upstream side of the orifice plate and the bulkhead must be countersunk.
- The face of the orifice plate must be clean of grease and oil.
- The thickness of the orifice plate perimeter should be between 0.03 and 0.08 inches. Thicker plates would need to have the downstream side edge chamfered at an angle of at least 45 degrees.
- Flow edges of the plate require machining or filing perpendicular to the upstream face to remove burrs or scratches and should not be smoothed off with abrasives.
- For submerged flow, the differential in head should be at least 0.2 feet.
- Using the dimensions depicted in **Figure 4** below, P > 2Y, Z > 2Y, and M > 2Y

The equation for determining the flow through a submerged orifice plate is:

$$Q = C_d A \sqrt{2g\Delta h}$$

Where:
Q = Flow Rate, CFS
C_d = Coefficient of Discharge, 0.61
A = Area of the orifice, ft^2
A = W x Y
W = Orifice opening width, ft
Y = Orifice opening height, ft
g = Acceleration due to gravity, 32.2 ft/s^2
Δh = Change in head, ft

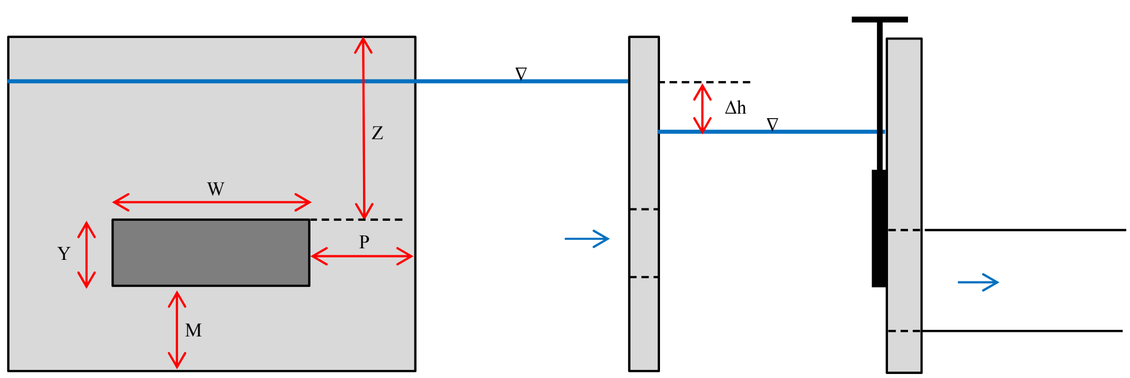


Figure 4. Flow through a submerged orifice plate

For a sharp-edged rectangular orifice where full contraction occurs from every side of the orifice, the coefficient of discharge is 0.61.

It is recommended that "Y" be smaller than "W", so that a good depth "Z" can be maintained. This helps keep the orifice entrance submerged all the time regardless of upstream water level fluctuations, and also provides for the proper entrance conditions.

It is assumed that the flow control gate will be located downstream of the orifice plate. The particular dimensions of that gate would rarely influence the performance of an orifice plate.

Typical problems include:

1. Inaccurate measurement of the difference in head.
   Solution:
   a. Careful relative calibration of pressure transducers, if used. They do not need to read a correct "elevation", but at zero flow rate must read the same "elevation".
   b. Install a horizontal reference steel plate on a bulkhead wall, so operators use the same reference elevation for both measurements if they manually measure the head difference.
2. The distances P, Z, or M are not greater than 2 times the smallest opening dimension (usually "Y"). In reality, it is rare that this "2 times" criteria is met in irrigation districts, except with very small flows.
   Solution:
   a. If only one side is suppressed (typically the bottom entrance, which might have no convergence), adjust the discharge coefficient, C_d as follows:

W/Y	1	2	4
Cd	0.63	0.64	0.65

   b. We do not know exactly how much to adjust the C_d if the distances P, Z, or M are less than two times the smallest opening dimension. Therefore, it is recommended that the orifice be installed in a plate that is wide enough and tall enough to approximately meet those required distances – even if the plate must be extended beyond the inlet to the turnout. See the figure below.

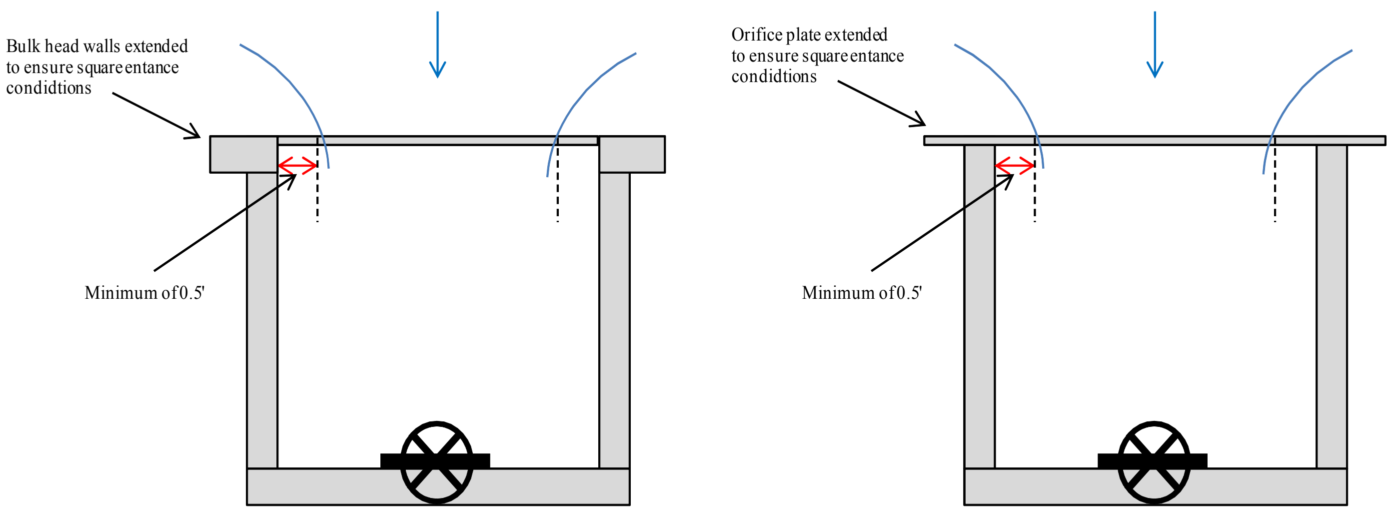


Figure 5. Installation of orifice

3. A single orifice size has a limited flow rate range. This is illustrated in the tables below. At too low a flow rate, the measured head difference is very small, often resulting in major errors in head difference. At too high a flow rate, the measured head difference is excessive, and may well exceed the available head. For this reason, *it is common to have a moveable plate that can be adjusted up and down,* varying the "Y" dimension.

   The addition of the moveable plate (often a rectangular sluice gate) creates the commonly known "CHO" or "constant head orifice". The device certainly does not create a "constant head", but it does provide an adjustable orifice. It provides the flexibility needed for a turnout to supply different flows at different times, with reasonably accurate head measurements. The opening should be adjusted so that the minimum head difference is greater than 0.2'. A 1' head loss across the orifice plate is more than what is attainable in many California irrigation district turnouts.

Table 5. Orifice size values

	Width of Orifice Opening, ft							
	1.0							
	Height of Orifice Opening, ft							
	0.3	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**
Flow Rate, CFS	**Change in Head, ft**							
5.0								**1.0**
4.5							**1.0**	**0.8**
4.0						**1.0**	**0.8**	**0.7**
3.5					**1.0**	**0.8**	**0.6**	**0.5**
3.0				**1.0**	**0.8**	**0.6**	**0.5**	**0.4**
2.5			**1.0**	**0.7**	**0.5**	**0.4**	**0.3**	**0.3**
2.0		**1.0**	**0.7**	**0.5**	**0.3**	**0.3**	**0.2**	**0.2**
1.5	**1.0**	**0.6**	**0.4**	**0.3**	**0.2**	**0.1**	**0.1**	
1.0	**0.5**	**0.3**	**0.2**	**0.1**				

	Width of Orifice Opening, ft						
	1.5						
	Height of Orifice Opening, ft						
	0.5	**0.6**	**0.8**	**1.0**	**1.2**	**1.4**	**1.5**
Flow Rate, CFS	**Change in Head, ft**						
11.0						**1.1**	**1.0**
10.0						**0.9**	**0.8**
9.0					**1.0**	**0.8**	**0.7**
8.0				**1.2**	**0.8**	**0.6**	**0.5**
7.0				**0.9**	**0.6**	**0.5**	**0.4**
6.0			**1.0**	**0.7**	**0.5**	**0.3**	**0.3**
5.0			**0.7**	**0.5**	**0.3**	**0.2**	**0.2**
4.5		**1.0**	**0.6**	**0.4**	**0.3**	**0.2**	**0.2**
4.0	**1.2**	**0.8**	**0.5**	**0.3**	**0.2**	**0.2**	**0.1**
3.5	**0.9**	**0.6**	**0.4**	**0.2**	**0.2**	**0.1**	**0.1**
3.0	**0.7**	**0.5**	**0.3**	**0.2**	**0.1**		
2.5	**0.5**	**0.3**	**0.2**	**0.1**			
2.0	**0.3**	**0.2**	**0.1**				
1.5	**0.2**	**0.1**					

Table 5 (continued). Orifice size values

	Width of Orifice Opening, ft								
	2.0								
	Height of Orifice Opening, ft								
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Flow Rate, CFS	Change in Head, ft								
20.0									1.0
19.0								1.2	0.9
16.0							1.0	0.8	0.7
13.0						0.9	0.7	0.5	0.4
10.0				1.0	0.7	0.5	0.4	0.3	0.3
9.0				0.8	0.6	0.4	0.3	0.3	0.2
8.0			1.0	0.7	0.5	0.3	0.3	0.2	0.2
7.0			0.8	0.5	0.4	0.3	0.2	0.2	0.1
6.0		1.0	0.6	0.4	0.3	0.2	0.1	0.1	
5.0	1.0	0.7	0.4	0.3	0.2	0.1	0.1		
4.5	0.8	0.6	0.3	0.2	0.1	0.1			
4.0	0.7	0.5	0.3	0.2	0.1				
3.5	0.5	0.4	0.2	0.1					
3.0	0.4	0.3	0.1						
2.5	0.3	0.2	0.1						
2.0	0.2	0.1							

	Width of Orifice Opening, ft											
	2.5											
	Height of Orifice Opening, ft											
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5
Flow Rate, CFS	Change in Head, ft											
30.0											1.0	1.0
25.0									1.0	0.9	0.7	0.7
20.0							1.0	0.8	0.7	0.6	0.5	0.4
15.0					1.0	0.8	0.6	0.5	0.4	0.3	0.3	0.2
10.0			1.0	0.7	0.5	0.3	0.3	0.2	0.2	0.1	0.1	0.1
9.0			0.8	0.5	0.4	0.3	0.2	0.2	0.1	0.1		
8.0		1.2	0.7	0.4	0.3	0.2	0.2	0.1	0.1			
7.0		0.9	0.5	0.3	0.2	0.2	0.1	0.1				
6.0	1.0	0.7	0.4	0.2	0.2	0.1						
5.0	0.7	0.5	0.3	0.2	0.1							
4.5	0.5	0.4	0.2	0.1								
4.0	0.4	0.3	0.2	0.1								
3.5	0.3	0.2	0.1									
3.0	0.2	0.2										

	Width of Orifice Opening, ft													
	3.0													
	Height of Orifice Opening, ft													
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
Flow Rate, CFS	Change in Head, ft													
45.0													1.2	1.0
40.0												1.1	0.9	0.8
35.0										1.2	1.0	0.8	0.7	0.6
30.0									1.0	0.9	0.7	0.6	0.5	0.5
25.0							1.1	0.9	0.7	0.6	0.5	0.4	0.4	0.3
20.0						0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2
15.0				1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
10.0			0.7	0.5	0.3	0.2	0.2	0.1	0.1					
5.0	0.5	0.3	0.2	0.1										

If steel theft is a concern, a marine plywood frame could be used to support a steel orifice opening frame. Fasteners used to connect the steel orifice to the plywood frame would need to be countersunk to minimize debris getting caught on them.

Trash Shedding Propeller Meters

For several decades there has been interest in "trash shedding propeller meters". ITRC examined the "cloggability" of an early design about 20 years ago. Boat propellers are sold with "weed shedding" features, which include specially designed propellers as well as fixed vanes upstream of the propeller that are intended to pass the weeds below or to the side of the boat propeller. McCrometer sells a saddle meter with the trash shedding options.

Mc® Propeller

MODEL M0300SW

CONFIGURATION SHEET
REVERSE BOLT-ON SADDLE
SURFACE WATER FLOWMETER

DESCRIPTION

The M0300SW is a bolt-on reverse-helix* propeller meter designed to shed debris often associated with surface water applications. The M0300SW is designed with the meter body turned 180 degrees from normal, a propeller installed nose-first on the bearing shaft, and a reverse flow style bearing assembly. This configuration allows the ell to curve with the flow, allowing grass or other debris to shed off with ease. The assembly design also reduces the ability of sand and silt to accumulate in the bearing.

The M0300SW features a fabricated stainless steel saddle with McCrometer's unique drive and register design. The stainless steel saddle eliminates the fatigue-related breakage common to cast iron and aluminum saddles and provides unsurpassed corrosion protection. Fabricated stainless steel construction offers the additional advantage of being flexible enough to conform to out-of-true pipe. The Model M0300SW is manufactured to comply with applicable provisions of American Water Works Association Standard No. C704-02 for propeller-type flowmeters. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

The impellers are manufactured of high-impact plastic, capable of retaining their shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of any standard McCrometer register, and since no change gears are used, the M0300SW can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The shielded bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

The instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective vinyl liner. The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

INSTALLATION

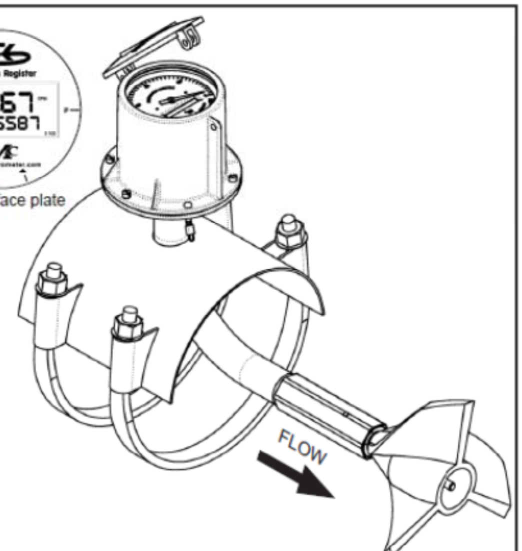
Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory. A straight run of full pipe the length of eight pipe diameters upstream and five diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least three pipe diameters upstream and two diameters downstream of the meter.

* 4" meters use a forward helix propeller with a reverse register.

Typical face plate

The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available.

Typical face plate



APPLICATIONS

- **Surface Water**
- **Water Containing Trash**
- **Sand Producing Wells**
- **Irrigation District Turnouts**

McCrometer will also mount a reverse-facing propeller on a standard open flow meter, which can be mounted on stands above low pressure pipelines.

MC® Propeller

CONFIGURATION SHEET

MODEL M1700 — OPEN FLOWMETER

DESCRIPTION

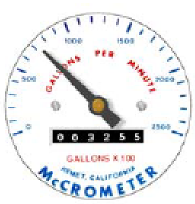
Model M1700 Open Flowmeters are designed to measure the flow in canal outlets, discharge and inlet pipes, irrigation turnouts and other similar installations. The M1700 series meets or exceeds the American Water Works Association Standard C704-02. Constructed of stainless steel, the meter incorporates bronze mounting brackets that permit simple installation and removal. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

Impellers are manufactured of high-impact plastic, designed to retain both shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of standard McCrometer registers, and since no change gears are necessary, the M1700 can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The sealed bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

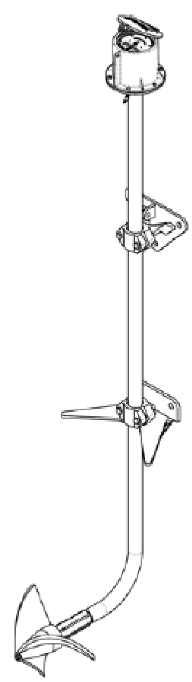
An instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective, self-lubricating vinyl liner. The die-cast aluminum register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

INSTALLATION

The M1700 must be mounted on a headwall, standpipe or other suitable structure so that the propeller is located in the center of the discharge or inlet pipe. A straight run of full pipe the length of ten pipe diameters upstream and two diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least five pipe diameters upstream of the meter. Please specify the inside diameter of the pipe when ordering.



The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available. *Typical face plates.*



APPLICATIONS

The McCrometer propeller meter is the most widely used flowmeter for municipal water and wastewater applications as well as agricultural and turf irrigation measurements. Typical applications include:

- Water and wastewater management
- Canal laterals
- Gravity turnouts from underground pipelines
- Sprinkler irrigation systems
- Golf course and park water management

A commercially available package that includes a reverse propeller meter and trash-shedding fixed vane, plus flow straighteners, is available from RSA.

Rubicon Transit Time Flow Meter

The Rubicon Sonaray flow meter is an interesting addition for larger turnouts with a canal supply, in that it also has a totalizer. The Rubicon literature cites a flow test in California, but it is unclear if the magmeter used for flow rate verification was recently calibrated. ITRC has found that new magmeters with guaranteed accuracies can be off by several percentage points. The device appears to be new, without substantial field testing in the USA.

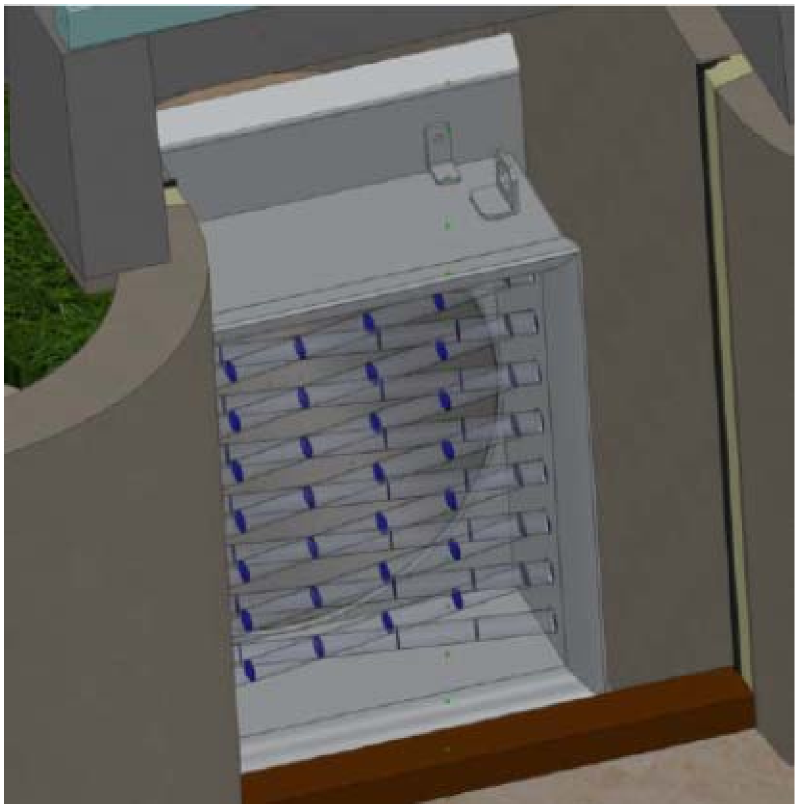


Figure 6. Rubicon Sonaray flow meter

Volumetric Flow Measurement for Irrigation District Turnouts ITRC January 2020

Volumetric Flow Measurement for Irrigation District Turnouts

updated January 2020

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Volumetric Flow Measurement for Irrigation District Turnouts

Introduction

Technical assistance related to irrigation district turnout flow/volumetric measurement is provided by ITRC on behalf of California Dept. of Water Resources, USBR, and BIA irrigation projects. Throughout that work, it was apparent there was a need to organize well-established information as well as to provide new insights into irrigation flow measurement. The target audiences are irrigation districts and others who want to improve measurement accuracy for irrigation flow rates and volumetric deliveries to meet regulations, improve the efficiency of ditchriders (system operators), and provide equity and transparency to farmers and managers. The focus of this publication is on turnouts (deliveries) to fields or to relatively small groups of fields, rather than flow measurement on large canals.

Dozens of excellent publications are available on the topic of flow measurement. This publication is not meant to replace those other references. Rather, it supplements those with two important types of information:
1. An overview of irrigation turnout flow measurement devices and situations for the western US.
2. Practical insights on the installation and operation of various devices.

Three important companion resources from the US Bureau of Reclamation are the following:
1. *Water Measurement Manual*. 1997. A Water Resources Technical Publication. Third Edition. Revised Reprint 2001. Available as a PDF download at: www.usbr.gov/tsc/techreferences/mands/wmm.html
2. WinFlume™ software. Updated 2016. The WinFlume™ home page contains downloadable design software and information on weirs and flumes: www.usbr.gov/tsc/techreferences/computer%20software/software/winflume/index.html
3. Water Management Planner Standard Criteria and Planner. 2017. Available as a PDF download at: http://www.usbr.gov/mp/watershare

Senate Bill X7-7 Requirements

Senate Bill X7-7 (SBX7-7) required that the California Department of Water Resources "adopt regulations that provide for a range of options that agricultural water suppliers may use or implement to comply" with various water measurement requirements. The details are found in Article 2 (Agricultural Water Measurement), Chapter 5.1 (Water Conservation Act of 2009), Division 2 (Dept. of Water Resources) and Title 23 (Waters) of the California Code of Regulations. Attachment 1 includes copy of this Article.

Briefly, the regulations specify that water deliveries must be measured volumetrically. The specific requirements depend upon the size of the agricultural water supplier and the history/type of measurement device.

Many conversations have been held as to what devices are suitable for water measurement. This publication provides insight into some common issues, although cost is not specifically addressed. For example, it is well-known that:
1. Not all devices are applicable for all situations. For example, there are installations with high-pressure pipes, low-pressure pipes, and no pipes at all.

2. Some devices are inherently more accurate than others, or may require less maintenance than others, for the same situation. Costs can also vary widely.
3. Proper installation and sizing can be as important for accuracy as the type of device.

Irrigation District Turnouts

In the most basic form, all irrigation turnouts, or delivery points, serve two purposes:

- Starting and stopping the flow of water
- Controlling delivered flow rates, which is typically done with a mechanism such as a valve or gate. In other cases, the turnout mechanism is adjusted wide open, and the turnout flow rate is determined by something such as the number of open alfalfa valves or sprinklers downstream.

SBx7-7 requires that turnouts in California also be capable of:

- Flow measurement – an instantaneous quantification provided by various methods.
    - For some turnouts, a supplementary device measures the flow rate (with various levels of accuracy) and displays the result digitally or with an analog gauge.
    - For canal or low-pressure pipeline deliveries, field measurements of the mechanism's opening, upstream and (sometimes) downstream water levels are sometimes applied to an equation or rating table. In these cases, the turnout structure itself is used as the flow measurement device, without auxiliary equipment.
- Volumetric totalizing – an accumulation of the flow measurement over time. The accumulation can be completed either:
    - Automatically, via mechanical or electronic methods, or
    - Manually, by "averaging" multiple, discrete flow measurements over an irrigation event.

Accurate flow measurement requires, among other things, satisfactory hydraulic conditions both upstream and downstream of the flow measurement location. For this reason, flumes are not recommended immediately downstream of a bend in the canal. Similarly, propeller meters are not recommended for installations immediately downstream of a partially closed butterfly valve. In these examples, it is unlikely that the instantaneous flow measurement would reflect the actual flow rate.

From an engineering perspective, achieving flow measurement and automatic volumetric totalizing within acceptable accuracy stipulations has become relatively straightforward for most pipeline turnouts because:

- The hydraulic conditions upstream and downstream of the flow measurement device can be easily "standardized" with a length of straight pipe. The exact length of straight pipe required by each product is specified by the manufacturer. "Straightening vanes" can be installed to correct swirling problems caused by elbows, and allow a shorter pipe length, but these do not correct problems with skewed velocity profiles.
- The round pipe cross section provides a clean and easily calculated flow area.
- There are numerous commercially available "flow meters" (utilizing various technologies) that provide flow measurement and *automatic* volumetric totalizing with more than acceptable accuracies. Many can also be delivered with factory calibration certificates traceable to the National Institute for Science and Technology (NIST).
- If the piping system is designed properly, the flow meter can be easily removed and recalibrated by the manufacturer or other entities.
- Flow meters can be easily installed with standard, commercially available fittings.

For the reasons listed, meeting flow measurement and volumetric totalizing regulations for new or existing pipeline turnouts has become more of an economic analysis than an engineering topic. A variety of irrigation districts simplify the challenge by requiring that farmers install accessible, properly installed magnetic or propeller meters downstream of their filter systems when the farmers install a drip/micro system.

Conversely, meeting flow measurement mandates for canal turnouts is more complex. Although there are good solutions for new canal turnouts, there are very few new canal turnouts being constructed and it can be prohibitively expensive to replace each non-conforming structure at the district level. As such, this publication will discuss options for utilizing existing structures for flow measurement as well as options for retrofitting existing canal turnout structures to meet flow measurement regulatory obligations.

A major constraint for canal turnout flow measurement is access. In general, most canal turnout structures and accompanying gate/valve mechanisms are installed on the canal side of an access road. The structure discharges into a buried pipe under the canal access road. The buried pipe may or may not daylight on the farm side of the access road. This physical configuration limits flow measurement options to one side of the buried pipe or the other, and many districts have limited (or no) jurisdiction to install devices on the farm side of the turnout.

The size and placement of a flow measurement device is also constrained by other factors. The device cannot obstruct normal canal maintenance operations, or be vulnerable to damage from access road traffic. Flow measurement devices are also susceptible to typical problems experienced in most open channel applications such as sedimentation, trash and biological debris, and vandalism.

Volumetric Flow Rate Measurement

Volume is an accumulation of water deliveries over time. In California agricultural irrigation districts, volumes are typically measured and billed as "acre-feet" (AF). Flow rate is an instantaneous measurement and may be measured as Gallons per Minute (GPM) or Cubic Feet per Second (CFS) – with GPM being used on smaller irrigation deliveries. The usage of the "miner's inch" is disappearing.

Volumetric Measurement with Totalizers

Some flow measurement devices have a totalizer (which reports cumulative volume) built into them. With pipeline flow measurement, this is common. The oldest and most common totalizer unit type is a propeller flow meter, with a display providing a rough estimate of instantaneous flow rate, and a more accurate totalized volume. Previously, the displays were mechanical (a dial for flow rate, and a series of small gears and wheels to provide total volume) that were usually mechanically moved via some type of speedometer cable mechanism driven by the rotating propeller. Now most companies also offer an electronic display option, which is still driven by the rotating propeller.

Other pipeline flow measurement devices such as magnetic meters or double beam ultrasonic meters have no moving/rotating parts and therefore only offer electronic (digital) displays. Within the electronics, instantaneous flow rates are accumulated over time to compute the volume of water delivered.

For water meters that have built-in totalizers, there are several factors that influence the accuracy of the volumetric estimate. These include:

- Inherently, the volumetric estimate cannot be more accurate than the instantaneous flow rate measurements. This will be discussed in more detail later.
- With electronic flow measurement devices such as magnetic meters, acoustic Doppler meters, transit time devices, and double beam ultrasonic meters, there can be a very large amount of signal noise. An accurate estimate of a flow rate may require that the instrumentation average hundreds of measurements. The accuracy of both the flow rate and volumetric estimates will depend upon the frequency of measurement, and how the instantaneous numbers are processed.

Some flow measurement devices require a single or multiple electronic readings that are input to a local datalogger or programmable logic controller. An example could be a water level measurement in a canal upstream of a weir or flume. The datalogger will take a water level reading every minute or so and translate each level into an instantaneous flow rate (Q). The flow rate, multiplied by the time interval between flow rate measurements, equals the volume for that time interval. The basic formula is:

Volume = (Flow rate) × (Time)

If the flow rates are measured every minute, for example, then:

Volume = Sum of all the 1 minute volumes

For example, if the flow rate is measured in CFS, once every minute (60 seconds), then:

$$\text{Total volume (cubic feet)} = \sum\left(\frac{Cubic\ feet}{sec} \times 60\ sec\right)$$

If an instantaneous flow rate was 10 CFS, then every minute, the volume would be:

Volume = 10 CFS × 60 sec = 600 cubic feet

Some conversion factors are:

1 acre-foot (AF) = 43,560 cubic feet
1 CFS × 1 hour = 0.993 Acre-inches = 0.08272 AF
1 CFS × 24 hours = 23.8 Acre-inches = 1.985 AF

Keep in mind that although we can report numbers to numerous decimal places, it would be extremely unusual to find a flow meter that could consistently be accurate within 1%.

Because the flow rate can change over time, the automatic summation of frequently measured (e.g., 1 minute) volumes can provide the same accuracy of volumetric measurement as that of the flow rate measurement.

Volumetric Measurement – Devices with Instantaneous Flow Rate Only

Many districts in California, especially those with turnout deliveries directly from canals, use devices that can be used for flow rate measurement but which have no automatic totalizing equipment. The volume delivered during a specific irrigation event is typically computed as:

Volume = (Flow rate) × (Duration of the Irrigation Event)

For example, an irrigation district operator may record:
10 CFS for 12.5 hours

The volume would be computed as:
10 CFS × 12.5 hours × 0.08272 AF/(CFS-hr) = 10.34 AF

The accuracy of this estimation depends upon three things:
1. Accuracy of flow meter
2. Accuracy of duration value
3. Accuracy of assumption that the flow rate remains constant

The accuracy of flow measurement will be discussed more in later sections on a device-by-device basis. Also, chapter 10 (Flow Measurement Calibration and Measurement) of the USBR Water Management Planner (2017) contains relevant information.

Duration Accuracy

In many irrigation districts, the policy is that only the district employees can open and close turnouts or adjust flow rates. In those cases, if district employees are very diligent and/or have portable electronic devices that automatically timestamp entries (such as observations of flow rate), the measurement of the total irrigation duration is quite accurate.

However, there are almost always occasions in which farmers or irrigators operate the turnouts. In those cases, the district employee must depend upon correct reporting by the farmer/irrigator.

Short of installing sensors and a telemetry (SCADA) system at every turnout, about the only practical option may be to install a simple wet/dry sensor connected to a datalogger. Similar equipment is used by some farmers on drip systems, to verify that hoses are pressurized for the proper duration. ITRC is unaware of any districts that have installed such sensors and dataloggers on irrigation district turnouts.

Unsteady (Varying) Turnout Flow Rates

Turnout flow rates may change with time, without the district operator knowing exactly when and by how much. Typical reasons are:

1. An irrigator may adjust the turnout flow control device without permission. There is very little that can be done about this except to lock the gate in a fixed position. This works in many cases.
2. The incoming pressure on the turnout changes. Canal water levels may fluctuate up or down. As the canal water level increases, the flow out of a turnout will increase. It is very similar in systems with pipeline deliveries; a change in pipeline pressure will give a change in turnout flow rate.
3. The water level on the farmer side of the turnout may change over time. If the flow control device is submerged (the water is backed up against the downstream side of the flow control gate), then this change in water level will change the flow rate. This often occurs in open ditch deliveries, as a farmer/irrigator moves dams and siphons further from the turnout on subsequent irrigation sets.

Solutions for these problems have been developed as follows:

Problem 1: Unauthorized turnout gate adjustment.
Solution: Lock the adjustment handle/wheel. The success depends upon the ability of the district to effectively punish the offender the first time the lock is cut off.

Problem 2: Varying canal water levels.
Solutions:

1. Most districts are modernizing with new canal control equipment to maintain fairly constant water levels. They understand that a fairly constant canal level not only gives more stable and known turnout flow rates – it also helps in moving flow changes safely and quickly along canals.
2. ITRC examined lateral canal water level fluctuations in one district over the course of an irrigation season. In that case, the fluctuations were random. The net result was that over the course of an irrigation season, they did not create a significant error in volumetric estimations. The high flows canceled out the low flows. However, on-farm irrigation management suffers if flows randomly vary over time.

Problem 3: Varying water level on the downstream side of a submerged flow control gate. The problem is often that when the district operator adjusts the turnout for the desired flow, the downstream water level (on the farmer's field) is at its highest level because a farmer will begin irrigating with siphons or spiles on the uphill side of the field. As the farmer/irrigator moves the irrigation down the field, the water level at the head of the ditch will drop. This will increase the flow rate through the turnout – with a net result of the farmer receiving a greater volume than assumed based on the initial flow rate.

Solution: The water level on the downstream side of the flow control gate should be maintained at a constant level over time. This is accomplished by installing a "bump" in the farmer ditch between the turnout gate and the first outlet from the farmer ditch. The action is illustrated in Figure 1 and Figure 2.

Figure 1. Field ditch with "bump" visible below the water surface near the head of the canal. This is the first irrigation set, with the area closest to the supply canal being irrigated first. The "bump" barely creates a ripple on the water surface.

Figure 2. Same ditch. The irrigated area, and check dam, have been moved downstream in the farm ditch. The "bump" has kept the water level in the first part of the ditch high – helping to ensure that the flow rate into the ditch remains fairly constant.

Farmer Meter or Irrigation District Meter?

With several million acres of drip/micro irrigation systems in California, some districts opt to use the farmer's flow meter rather than a standard district installation at the side of the canal. The reasons for doing this include:

1. This is often the most inexpensive option for accurate flow measurement.
2. Many farmers install meters on their own initiative, to keep good water management records.
3. Propeller meters and magnetic meters are most commonly used, and they have totalizers.
4. The meters are installed downstream of the filters (see Figure 3), which typically provides two benefits:
    a. There is usually a long, straight section upstream of the meter.
    b. The water is very clean because it has passed through the filters.

Figure 3. A propeller meter (white arrow) installed downstream of drip system filters, with a long, straight pipe section upstream of the meter (red arrow)

The potential disadvantages of using these farmer meters are:

1. The meter will not record any filter backflushing flows. These may or may not be significant; the importance will depend upon whether the dirty backflush water is returned to the canal or is discharged on the farmer's field, and how often the filter backflushing cycle is initiated.
2. The meter may be difficult to access.
3. The meter may not have been installed properly, or may be an inexpensive and inaccurate model.

It is strongly recommended that irrigation districts establish written policies for such installations that include topics such as installation, acceptable meters, and ease of access.

Pipeline Flow Meters

Turbulence and Accuracy

An excellent study was conducted in 1998 by Drs. Blaine Hanson and Larry Schwankl of the University of California Extension Service. It is provided as Attachment 2, because it provides great detail about turbulence and accuracy of pipeline flow meters. It is clear from the results that paddle-wheel meters (an example of small insert units) were much more impacted by turbulence than were full bore, velocity-integrating propeller meters.

Key points from the UC study include:

- Elbows and partially closed valves upstream of flow meters will create turbulence.
- Pipeline flow meters should be "full bore", rather than partial pipe "insert" meters. The least expensive pipe flow meters are insert meters, and will have some type of apparatus that is attached to one side of the pipe, and which extends a short distance into the pipeline. As such, they will only measure water velocities in a small area of the pipe. Typically, those are non-representative of the average pipe velocities.
- A single elbow does not create an unreasonable error for a full bore propeller meter, regardless of whether the meter is 2, 5, or 10 diameters downstream of the elbow.
- A partially closed butterfly valve creates a large error for a full bore propeller meter at distances of 2, 5, 10, and 15 diameters downstream of the valve – if the velocities are less than 4 feet/second. At 8 feet/second, the errors were acceptable (less than 4%).

Full Pipe

All pipeline meters require a full pipe. Typical techniques used to obtain a full pipe on low-pressure systems include:

1. The meter may be installed on a vertical pipe, as seen in Figure 4.

Figure 4. Propeller meter with a vertical orientation

2. An elbow is installed in the pipeline downstream of the meter.

Figure 5. A loop in a pipe is installed to keep the upstream pipe section full. A continuous acting air vent is needed at the top of the loop.

Figure 6. An elbow installed downstream of a propeller meter. In this case, the elbow is much higher than it needs to be. It only needs to be high enough to make the pipe completely full.

Figure 7. Weir boards are installed downstream of an open propeller meter. Obviously, these are not high enough to create a full pipe condition.

Figure 8. Open propeller meter installed at the discharge end of a large full turnout pipe. Water flows from right to left

3. Sufficient air vents are installed to remove any air that might accumulate in the pipe section that includes the flow meter.

Propeller Meters

Propeller meters are still the most common pipeline flow measurement device. There are a variety of manufacturers and a wide variety of configurations. They have been successfully used in irrigation districts for many decades.

Key points regarding propeller meters include:

1. Trash in the water can be a huge problem. A typical irrigation district bar grill assembly on a canal bank is usually inadequate because so much trash can pass through. Typical solutions include:
   a. At least one propeller meter manufacturer sells a "reverse propeller" meter that is designed to help shed trash.
   b. Static perforated steel plate screens with a very large open area are widely used in western Colorado by districts with propeller meters. They are very easy to clean with a floor squeegee, although the trash simply moves downstream in the canal.

Figure 9. Punch plate at the inlet to an irrigation district lateral pipeline. 1 inch holes, 50% open area, to maintain less than 0.5 ft/sec through the holes (0.25 ft/sec approach velocity).

   c. Some type of automatic trash rack that removes the trash from water before it enters the turnout is used.

Figure 10. Locally fabricated trash screen in Browns Valley ID

Figure 11. Automatic screen upstream of a turnout in Merced ID. Note the wall that helps prevent sand from entering the turnout.

2. Sand and silt in the water can quickly destroy bearings. Some manufacturers have special bearings that hold up very well with sand; other bearings are very intolerant. Sand barriers in a canal upstream of the turnout can help reduce the sand load in the water, as seen in Figure 11.
3. If a saddle configuration is used, it is absolutely essential to order it for the correct inside diameter of the pipeline, so that the meter will be properly calibrated when it arrives from the factory.
4. Propeller meters operate best (mechanically and accurately) within a certain range of velocities. Usually they are not very accurate at velocities under 1 ft/sec. At high velocities, manufacturers should be consulted because special bearing assemblies may be required.
5. Irrigation districts with long-term successful usage of propeller meters have programs (and sometimes special shops) for rebuilding the propeller meters every few years, and spin-testing them more frequently.

Magnetic Meters

Magnetic meters have become common in some districts over the past decade. Because water is a conductive liquid, it induces a voltage while it travels through the meter's magnetic field. The voltage produced is proportional to the velocity of the water. A microprocessor is able to compute the flow rate. One of the reasons for the increased interest is the availability of battery-operated magnetic meters, as opposed to the historical need for AC power. However, batteries may only last 1-2 years.

ITRC has had highly variable results with magnetic meters in irrigation district turnout applications. While a few brands/models have provided excellent results, others have had fatal errors with accuracy or dependability. The claims by some large manufacturers, of dependability and accuracy, have not always matched the actual performance. That said, the ITRC Water Resources Facility laboratory utilizes magnetic meters rather than propeller meters for most critical installations. Those magnetic meters are tested for accuracy every year, using a large weighing tank and are re-calibrated if necessary.

The major reasons that magnetic meters have been selected in some districts are:

1. Some brands/models only require 2-3 diameters of straight pipe upstream.
2. There are no moving parts or obstructions, so sand and trash are not problems, and there is no gradual wear over time.

Other Pipeline Meters – Closed Pipelines

Magnetic meters and propeller meters are by far the most common meters used in California for closed pipelines. A few other technologies are briefly mentioned here.

1. Venturi meters have typically only been used on large canal turnouts such as found on the Friant-Kern Canal and the Tehama-Colusa Canal. Venturis have large pressure losses, only operate effectively in a relatively narrow range of flows and are a bit complicated with instrumentation.
2. Transit time meters use ultrasonic waves to measure water velocity and operate under the theory that sound waves are accelerated or decelerated by the relative velocity of their medium. For example, if a wave is sent out in the same direction that the water is flowing, the wave will accelerate and travel faster in that direction. Likewise, a wave will decelerate and travel slower if it is directed against the flow. Transit time meters use pairs of transducers oriented diagonally across the diameter of the pipe. As the number of transducer pairs increases, the device will get a better representation of the actual cross section flow rate, and thus get better results.

   At this time, this technology is rarely used on irrigation district turnouts. It is more common on very large diameter (4' and greater) pipelines where there is a cost advantage. If this technology is used, it is highly recommended that the transducers be directly exposed to the water – rather than clamp-on configurations that attach the transducers to the outside of the pipeline.

   A relatively new approach to transit time meters is found in commercial valves that have the technology built in – rather than needing to install transducers separately in a pipe. An example of this technology is shown in Figure 12. The purported battery life expectancy is 10 years.

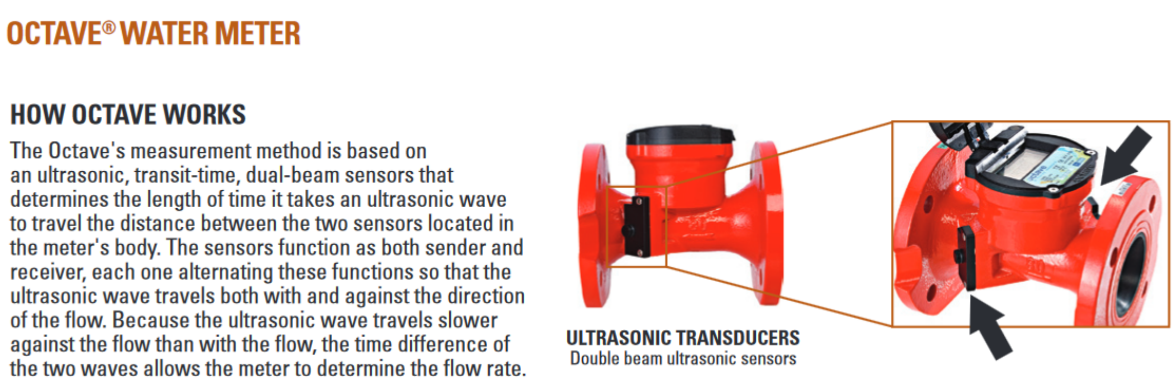

Figure 12. Example of transit time technology built into a water meter (from Netafim, 2016)

Other Flow Measurement Options at Canal Turnouts

There are two special characteristics for most other western USA canal turnout flow meter types (other than propeller or magnetic meters):

1. Most of the flow measurement/control devices used at canal turnouts consist of a variety of parts and pieces that are assembled locally. For example, flumes are locally constructed, and the staff gauges or electronic instrumentation are installed and calibrated locally. While this provides the necessary flexibility to have a flume/weir that matches the specific conditions, errors are often introduced if the device is improperly designed/located, or details are not taken care of.
2. Most of the devices (CHOs, metergates, weirs, etc.) have rating tables that were developed in a laboratory with a relatively small sample of devices, using a relatively small range of hydraulic conditions. These devices all have "empirical" equations, which means that the laboratory data were plotted to develop a "best-fit curve", or to create a table of flow rates versus measurements. The rating tables or curves were not developed using hydraulic theory. Therefore, if the device installations do not closely match the laboratory installations (velocity, side clearance, bottom clearance, etc.) that were used to develop the empirical calibrations, there will be an error and it is unclear how to correct the formulas/tables.

Even if a district purchases a complete gate assembly for an automated turnout, the accuracy of that device will still depend upon the installation, the flow rate equation calibration that was used for the device in some laboratory, the quality and positioning of the sensors, and their calibration. ITRC has found that some package gates, even when installed by the manufacturers, can experience large inexplicable errors in spite of being advertised as having very accurate results. It is truly "buyer beware", although in some irrigation districts the accuracy is never questioned.

General Types of Canal Turnout Flow Measurement

Canal turnout measurement devices can generally be grouped into the following types:

1. Submerged holes (orifices). The flow rate depends upon the pressure (head) difference across the orifice, and the orifice open area. Devices of this type that will be discussed in this publication are:
    a. Metergates (by far the most common device of this type in California other than propeller or magnetic meters, though quality of installation and usage varies widely)
    b. Orifice plates
    c. Sluice gates/CHOs
2. Weirs and flumes, over which water flows. The water level above the crest of the weir/flume is somehow measured and then translated into a flow rate. All of these devices require "free flow", or the creation of a hydraulic critical depth. If they are not designed with a large drop, they generally end up being abandoned because for one reason or another the downstream level will sometimes submerge them, preventing the development of free flow. Downstream channel maintenance is done by the farmer, not by the irrigation districts. These are not common in California, likely because of frequent downstream submergence problems.
3. Acoustic Doppler, transit time, or similar devices that are inserted into short pipeline sections, or in canals. These usually measure velocity of a relatively small sample of the current, which is then combined with canal/pipeline dimensions and water depth to estimate flow rate.

Field Calibration of Flow Meters

In 2016, while working for the USBR, Mid-Pacific Region, ITRC identified a need to provide the hardware and methodology for calibrating flow measurements at existing and new irrigation turnouts supplied by open canals. ITRC designed and built (and used) a portable turnout calibration unit (see Figure 13). The unit pumps water from the downstream side of a turnout and recirculates it (up to 10 CFS) to the source canal. The water passes through two calibrated magnetic meters. Three flow rates are tested: the highest flow for the turnout, the lowest, and an intermediate flow rate. The downstream water level is maintained at a typical depth. The results are then compared against the flow rate estimates that are made by district staff for that turnout. The ITRC magnetic meters used for calibration are within about 1% accuracy.

Figure 13. USBR/ITRC Irrigation Turnout Calibration Unit

Metergates

A metergate is a structure with an adjustable vertical round or rectangular gate controlling the flow into a pipeline. A specially designed stilling well is installed on the pipeline a specific distance downstream of the gate's frame, to measure the downstream head. Once the gate opening and the head loss between the canal and the stilling well are known, a table can be referenced that will give a specific flow rate.

Metergates have been used for over 70 years for turnout flow measurement in the USA. They are different from regular sluice gates and "canal gates" because they have a stilling well just downstream of the gate so that the downstream water level can be measured. Recent studies at ITRC, funded by California DWR, show that the 1950's rating tables for "Armco"-type gates provide good accuracy for flow measurement (Burt and Howes, 2015). The Waterman tables are less accurate and are not recommended. ITRC has produced improved tables and has established a variety of rules for proper installation and operation. Recommended rating tables for metergates are included in Attachment 3.

Accuracy of Metergates

1. A high level of accuracy (+/-5%) was found if all of the following conditions are met:
    a. Gate opening range: 20% < Gate opening < 75%
    b. Upstream submergence > 0.5D (where D is the gate diameter)
    c. The optimum stilling well access hole location is 12” downstream of the face of the gate
2. The distance downstream of the gate at which the stilling well is located (as long as it is within the 4” to 12” range) does not have a significant effect on the flow rate obtained using the tables **unless** the gate is **open** more than 70-75% (percent of fully open). In that case (which would occur if a small head difference is available across a turnout), it is important to install the stilling well access hole at the optimum location 12” downstream.
3. Tangential supply channel flow velocities of up to 1.9 feet/sec do not have a significant impact on the calibration flow through the metergates. Higher velocities could be expected to have an impact, but the magnitude is unknown.
4. Higher uncertainty (error) occurs at smaller gate openings.
5. Optimum range of operation for the highest accuracy was an opening between 20% and 75% under most conditions. Smaller gate openings seem to be more problematic than larger gate openings.
6. The water level in the supply canal above the turnout pipeline should be greater than (0.5 × gate diameter). The USBR standard is (1 × gate diameter).
7. The “zero” opening of the metergate must be closely defined.
8. The stilling well and access hole must be properly designed to stabilize the water level for proper reading.
9. The measurement of differential head is often awkward because many installations have no common, easily-accessed elevation datum for both the upstream and downstream measurements. This can contribute to inaccurate measurements.
10. Operators should be supplied with scales that read in 100ths of feet, rather than in inches. This eliminates fractions and conversions in computations.

Measured Field Accuracy of Metergates

In 2016, ITRC verified the accuracy of a total of 27 metergates from six different irrigation districts. The results are provided in Table 1. The Mechanical Associates gates do not have the same configuration as Waterman and Fresno Valves gates, and therefore it was not surprising that the tables a district received were inaccurate.

The pre-cast Briggs metergates come as a total assembled package. They were designed for Glenn-Colusa ID following ITRC guidelines. The accuracies of the measurements are quite good.

Table 1. Results of 2016 metergate accuracy testing

Flow Measurement Device	Gate Manufacturer/Type	Nominal Gate Size (in)	Typical Min Flow Rate (CFS)	Typical Max Flow Rate (CFS)	Flow Measurement Method	Average Absolute Error (%)
New, pre-cast Briggs **Metergates**	Waterman Round	15	3	6	ITRC Water Measurement Tables	**2**
		15	3	5		**4**
		18	3	8		**3**
		24	3	6		**6**
		18	3	6		**3**
New, field constructed Mech. Assoc. **Metergates**	Mechanical Associates Round and Square	18	1.5	3.5	Mechanical Associates Tables	**15**
		18	1.5	3.5		**18**
		24	2	4		**29**
		18	2.5	5		**28**
Existing, district constructed **Metergates**	Fresno Round	18	3	4	Armco Tables	**9**
		20	4	6		**9**
		18	2.5	4.5		**3**
		18	2.5	4.5		**11**
		24	3	5		**5**
		20	3	6		**8**
		20	3	6		**3**
		20	3	4		**2**
		24	1	3		**13**
		18	3	5		**3**
		18	3.5	5.5		**12**
		24	3.5	11		**8**
		18	5	10		**4**
		18	5	10		**10**
Canal Gate	Fresno Round	18	3	5	Armco Tables	**9**
		24	1	5		**4**

Details of Metergate Installation and Preparation

Figure 14 depicts the proper metergate dimensions as recommended by ITRC. Several practical details that are essential to accurate flow measurement with metergates are discussed. Additional details can be found in Burt and Howes (2015).

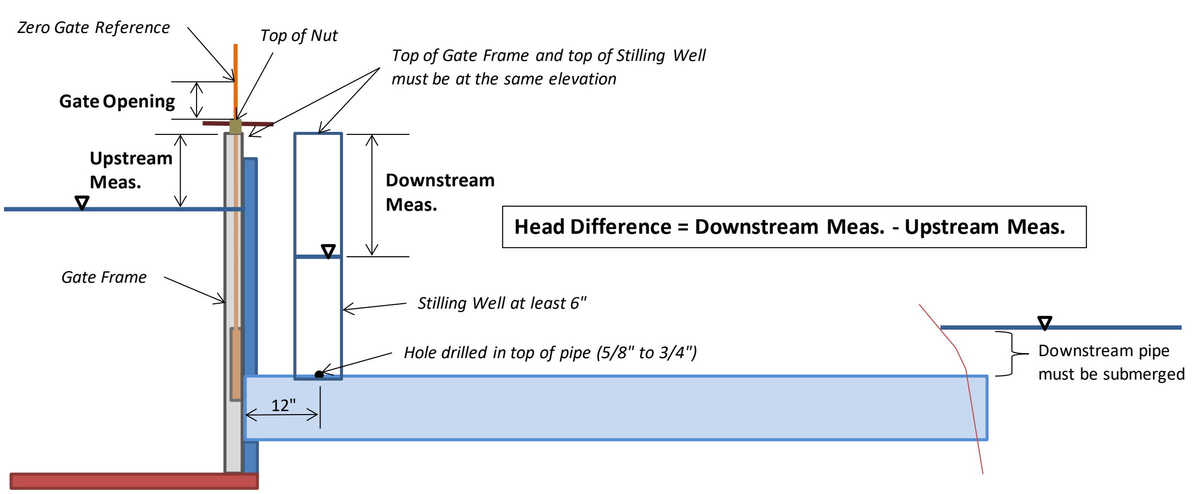

Figure 14. Proper metergate dimensions – but lacking precast design.

Practical Detail #1 – The pipe downstream of the metergate needs to be full. This means that the downstream pool must have a water level higher than the top of the pipe. Also, the water level needs to rise to some measurable level in the downstream stilling well.

Practical Detail #2 – Sufficient upstream submergence is needed (Figure 15). The required water level in the canal, above the top of the pipe at the inlet, must be at least ½ of the gate (or pipe) diameter. In other words, if there is a 12" pipe, the water level in the supply canal needs to be at least 6" above the top of the pipe.

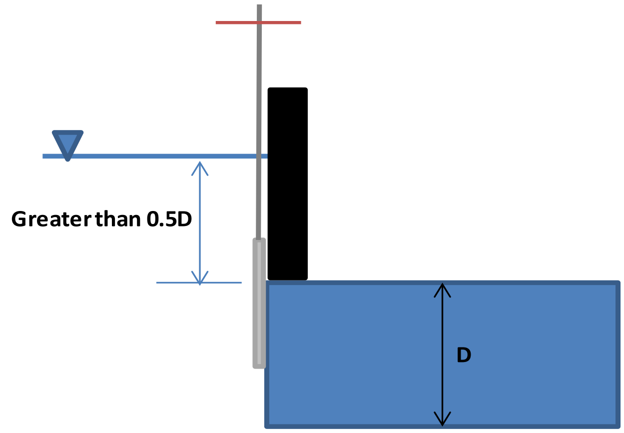

Figure 15. Minimum upstream submergence above the top of the gate

Practical Detail #3 – All of the calibration charts require knowledge of the **gate opening**, as measured by the shaft opening. The "zero" gate opening must be properly determined and marked on the gate shaft. This is not a trivial detail. Specific points are:

- All measurements of gate opening, as well as the initial marking, must be made after the gate stem has been lifted (opened). This is because there is some "slop" or movement between the shaft and the gate itself.
- The gate stem will move up some distance before the gate plate itself reaches the bottom of the pipe. The charts depend on knowing the gate opening, not the movement from the gate seating position. The gate must be closed beyond the bottom of the pipe to seal off completely. That sealed position is not the "zero" position.
- There must be some specific way to measure the shaft position when the bottom of the gate just barely clears the bottom of the pipe – in other words, when there is a "zero opening". This is fairly easy to set and measure if the canal is full. The gate is opened until a narrow strip of paper can be inserted into the crack. Figure 16 shows photos taken at San Luis Canal Company of a customized tool that is used to detect the actual gate opening, but a similar device can be used to detect the initial "cracking (zero) open" position.

Figure 16. Custom-made tool used to measure actual gate opening

- The shaft needs to be marked in a clear manner so that operators know where the “zero” opening is for the gate when they open the gate. Figure 17 shows a properly cut notch. It has a sharp bottom edge that was cut with a grinding wheel so that the bottom of the cut is at the same elevation as the top of the bushing. Notice from the color on the shaft that the shaft can be lowered from this position to properly seal the gate.

  The operator will measure from the bottom of cut to the top of the bushing, when the gate is open, to determine the gate opening. This is always measured after an “uplift” action.

Figure 17. The "zero" opening mark ground into the threaded rod

Practical Detail #4 – The stilling well needs to have sufficient diameter to dampen the turbulence, and so that operators can see into it. It is recommended to have a stilling well of 6”–8” diameter, with an access hole at the top of the pipe of about 5/8” or 3/4” diameter.

Figure 18. Example of a stilling well with too small of a diameter. The operators will not be able to see the water surface and severe surging (up and down movement) will occur.

Practical Detail #5 – The stilling well does not need to be centered over the access hole in the top of the discharge pipe. In general, it is good to have the stilling well close to the gate frame/bulkhead, so that it can be supported.

Practical Detail #6 – Make it easy to measure the difference in head (between the water level in the canal, and the water level in the stilling well). In other words, use the same datum (elevation) for both measurements. Figure 19 shows a stilling well with the top correctly placed at the same elevation as the gate frame, and with a proper diameter. **The top of the stilling well should be at the same elevation as the top of the gate frame (where the bottom of the nut rests), or have the same elevation as another reference point.** Then the upstream measurement should be taken from the top of the gate frame to the water level. The downstream measurement should be taken from the top of the stilling well to the water level. The head difference is the difference between the upstream and downstream water levels.

Figure 19. Stilling well installed on metergate with proper diameter, position, and height but not precast.

Practical Detail #7 – If possible, for new installations purchase a new integrated and properly designed precast unit from a company such as Briggs in Willows. Very importantly, the stilling well is built into the unit. This integration eliminates the very common problems with traditional stilling wells for metergates such as:

1. They are often located at an incorrect distance from the back of the gate.
2. The diameters are typically too small.
3. They are made of easily breakable material such as concrete or plastic pipe.
4. The top of the stilling well is not at the same elevation as the concrete box.
5. The diameter of the entrance hole at the bottom of the stilling well is too large or too small.
6. There is no cap on the top of the stilling well, and as a result they become filled with dirt from regular canal bank/road maintenance.

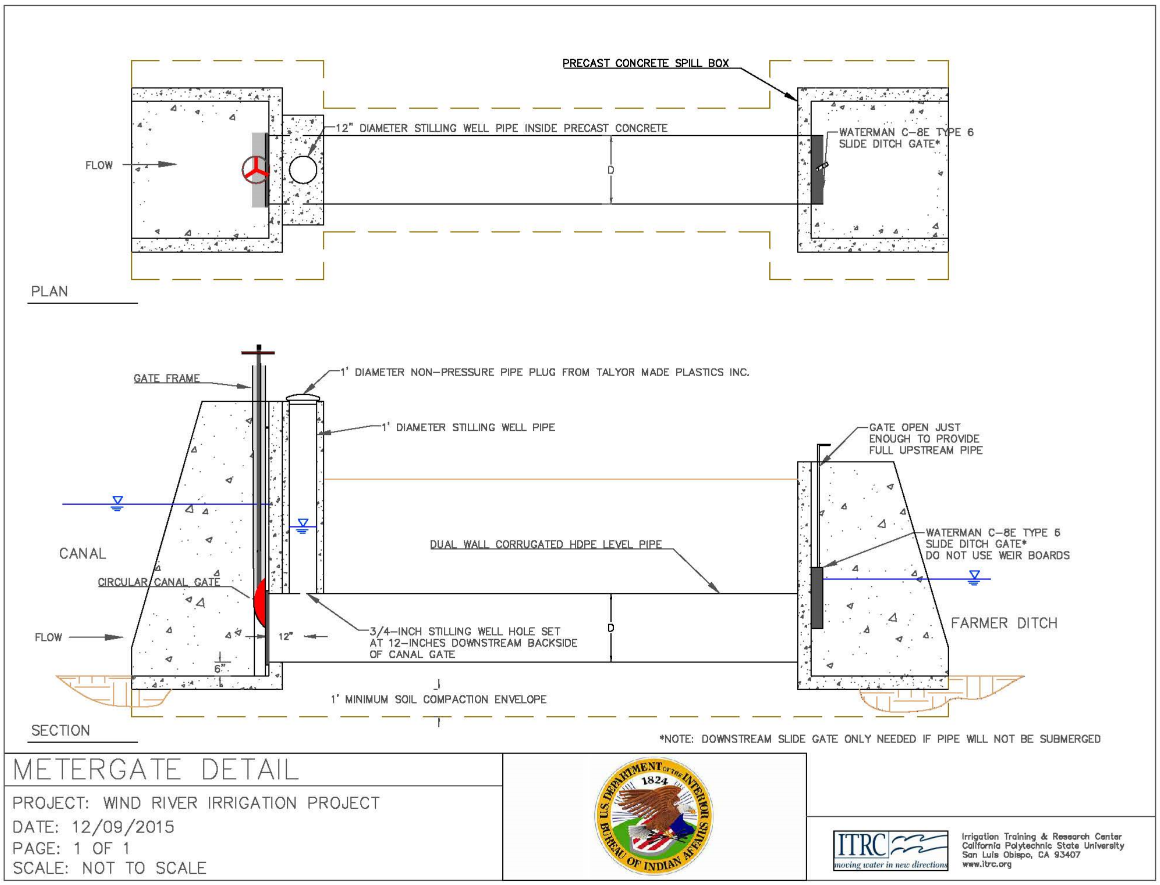

Figure 20. Example drawing for a metergate installation with pre-cast forms on both ends of the pipe that crosses a road

Figure 21. Field installation of a pre-cast canal metergate (Glenn Colusa ID)

Cost is always a challenge, especially with older existing gates. Fresno Irrigation District has recently (2019) experimented with a bolt-on unit that replaces an existing turnout canal gate. Figure 22 through Figure 24 show various views of the experimental unit.

Figure 22. Top view of prefabricated canal metergate (Fresno ID, 2019)

Figure 23. Side view of prefabricated canal metergate (Fresno ID, 2019)

Figure 24. Installed pre-fabricated canal metergate (Fresno ID, 2019)

Canal Metergates Gates in Free-Flow Conditions

It is strongly recommended that metergates be operated under submerged conditions to obtain the highest level of accuracy. However, in some cases this may not be possible until the district can modify the downstream condition. ITRC conducted testing of three sizes (12", 18", and 24") of round canal gates on round turnout pipelines in non-submerged conditions. In these cases, the downstream stilling well does not have a measurable water level because the downstream water level is at or below the top of the turnout pipe. The difficulty with this condition is that the downstream water level could still be high enough to submerge the gate opening or it could be fully free flow (downstream water level at or below the bottom of the gate). The testing examined both of these conditions and found that the flow rate could be measured within a reasonable level of accuracy (within +/-8% flow rate uncertainty) if operated within the recommended *Practical Details* outlined for metergates in this report.

Under free-flow conditions, the upstream head is measured from the top of the turnout gate pipe to the upstream water surface. This may be difficult to accurately measure depending on the gate configuration. During the off-season, a staff gauge or reference mark could be installed to more accurately measure the head above the top of the turnout pipe. There is no need to measure the downstream water level as long as the downstream water surface is at or below the top of the turnout pipe at the exit. Special tables for the free-flow condition are included for the 12”, 18”, and 24” round gates in Attachment 3. For this situation, the normal metergate tables also shown in this attachment should not be used, since those are for submerged conditions only.

Fixed Submerged Rectangular Fully Contracted Orifice Plate

This design option is sometimes used for surface irrigation deliveries at turnouts that always receive the same flow rate. For a target flow rate, the orifice can be sized to have about 0.2’-0.25’ of head loss. A minimum of 0.2’ of head loss (i.e., “difference in head”) is recommended because the accuracy of the head measurement can be unacceptably poor with less head loss. A maximum head loss of 0.25’ is recommended to minimize turbulence in the box that has the orifice plate at its entrance.

Figure 25 illustrates such an installation. The downstream gate is used for on/off and flow rate adjustment. Operators adjust that gate until a target head loss is measured across the orifice plate.

Figure 25. A fixed contracted submerged rectangular orifice at Fresno ID

The equation for determining the flow through a submerged orifice plate is:

$$Q = C_d A\sqrt{2g\Delta h}$$

Where:
Q = Flow rate, CFS
C_d = Coefficient of discharge, 0.63
A = Area of the orifice, ft^2
A = W × Y
W = Orifice opening width, ft
Y = Orifice opening height, ft
g = Acceleration due to gravity, 32.2 ft/s^2
Δh = Difference in head (head loss), ft

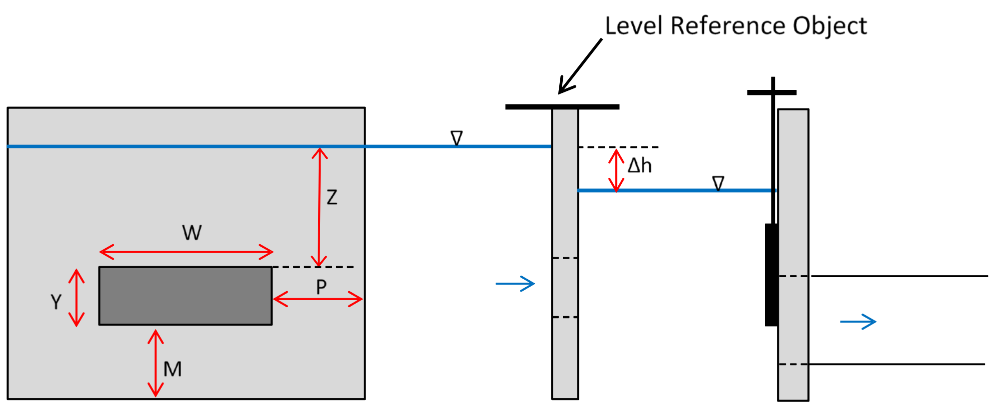

Figure 26. Dimensions for fully contracted submerged rectangular orifice

For a sharp-edged rectangular orifice where full contraction occurs from every side of the orifice, the coefficient of discharge is typically reported to be 0.61. ITRC has found that 0.63 is more accurate for the sizes and configurations found with irrigation district turnouts.

It is recommended that "Y" be considerable smaller than "W", so that a good depth "Z" can be maintained. This helps keep the orifice entrance submerged all the time regardless of upstream water level fluctuations, and also provides for the proper entrance conditions.

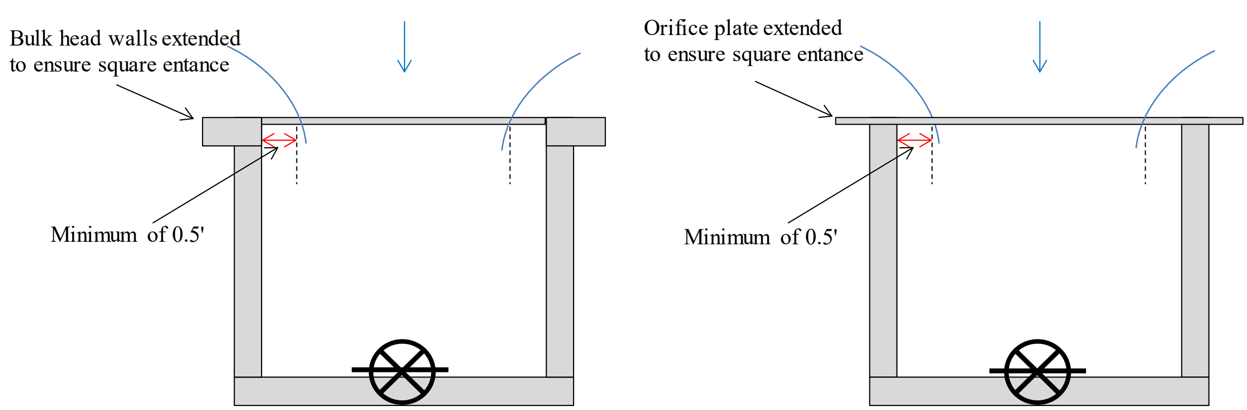

Figure 27. Guidelines for orifice entrance extensions

According to the USBR *Water Measurement Manual*, conditions for achieving accurate flow measurement for a fully contracted submerged rectangular orifice are:

- The upstream edges of the orifice should be straight, sharp, and smooth.
- The upstream face and the sides of the orifice opening need to be vertical.
- The top and bottom edges of the orifice opening need to be level.
- Any fasteners present on the upstream side of the orifice plate and the bulkhead must be countersunk.
- The face of the orifice plate must be clean of grease and oil.
- The thickness of the orifice plate perimeter should be between 0.03 and 0.08 inches. Thicker plates would need to have the downstream side edge chamfered at an angle of at least 45 degrees.
- Flow edges of the plate require machining or filing perpendicular to the upstream face to remove burrs or scratches and should not be smoothed off with abrasives.
- Using the dimensions depicted in Figure 26, P, Z, and M must all be greater than 2Y.

Table 2 provides some guidance for orifice dimensions and target flow rates. The box dimensions are based on a target ratio of about 20 (cubic feet)/CFS, with a depth dimension (B) that provides one 1.5 feet of freeboard in the box at zero flow. Dimensions also account for the requirement that P, Z, and M must all be greater than 2Y.

Table 2. Design dimensions and flows for fixed fully contracted submerged rectangular orifice plates

		Orifice dimensions, ft		Head loss, ft		Min. dimensions for the box, ft		
				0.20	0.25			
Y, in	W, in	Y, height	W, width	CFS		B, depth	E, width	L, length
9	24	0.75	2.00	3.4	3.8	7.5	4.0	3.5
12	24	1.00	2.00	4.5	5.1	7.5	5.0	3.5
15	30	1.25	2.50	7.1	7.9	8.0	6.5	4.0
15	36	1.25	3.00	8.5	9.5	8.0	6.5	4.5
15	48	1.25	4.00	11.3	12.6	8.0	6.5	6.0
18	48	1.50	4.00	13.6	15.2	8.5	7.0	6.0
18	60	1.50	5.00	17.0	19.0	9.0	7.5	6.0

The measurement of the Δh (difference in head, or "head loss") needs special attention. Almost all published drawings show staff gauges installed both upstream and downstream of the orifice plate. ITRC's experiences show that (a) the staff gauges are often placed without having the zeroes on the two gauges at the same elevation, and (b) staff gauges often have short lives because of corrosion. Furthermore, staff gauges often have a poor resolution.

The following recommendations are offered by ITRC to remedy the staff gauge problems:

1. Do not use staff gauges.
2. Equip ditchriders (i.e., "zanjeros" or "DSOs" or "operators") with a rigid ruler that reads either in hundredths of feet (not inches) or in mm. Mm is preferable simply because there is better resolution than with hundredths of feet. Discharge tables will need to be converted for Δh in mm.
3. Install a thick horizontal steel strip on the top of the concrete box wall, at an accessible location, to serve as a reference point to measure down to both the upstream and downstream water levels.
4. If stilling wells are used, they should have access tubes (1.5" diameter) located no deeper than 1' below the lowest water surface. The stilling wells should be at least 12" diameter. The stilling wells should be placed adjacent to each other, be capped, and the tops should have exactly the same elevation.

Sloping Fully Contracted Rectangular Submerged Orifice Plate

USBR recommendations for orifice plates are very clear in requiring vertical orifice plates. However, almost all canal linings have side slopes. It would be very convenient to simply lay a steel plate over the turnout entrance, on an angle, and measure the head difference across it. ITRC has found that there is no difference in the Cd between vertical and sloping orifice plates. The average Cd found with ITRC testing was 0.63.

Adjustable Contracted Rectangular Submerged Orifice Plate

The previously described “fixed” orifice plate has the following limitations:

1. If a turnout needs a high flow sometimes, and a low flow at other times, a fixed orifice is unsatisfactory because each flow will require a very different head loss. High head losses cause turbulence in the box and make accurate head loss readings difficult.
2. The flow rate requirement may vary from turnout to turnout. Therefore, there may not be a constant target flow rate that matches all installations.

The solution is to provide an adjustable orifice plate opening. A sliding plate can be used to vary the “Y” dimension seen in Figure 26. Figure 28 shows a very inexpensive retrofit Alta ID design that provides an adjustable orifice opening. The opening size is normally adjusted once and then fixed in place with a bolt between two vertical strips of metal. It can be noted that all the dimensions do not conform to the dimensions recommended in Table 2. Design dimensions and flows for fixed fully contracted submerged rectangular orifice plates Nevertheless, farmers in the district have accepted the measurements and this is a tremendous improvement over just having a canal gate (seen in the background) to adjust an unknown flow rate.

Figure 28. Alta ID rectangular orifice gate (front) provides flow measurement, while sluice gate (rear) provides flow control

Constant Head Orifice (CHO)

First, there may be some confusion about the name. There is nothing about the CHO structure that will automatically maintain a constant head difference or a constant flow rate. If the supply canal water level goes up, the turnout flow rate will increase because the available head difference increases.

At first glance, a constant head orifice (CHO) may appear to be the same as the adjustable contracted orifice plate described in the previous section. The operation is the same:

1. The most upstream opening is set at a position that will provide the target flow rate with a head loss of 0.20-0.25 feet. Sometimes this upstream gate is a rectangular gate, and sometimes it is just a steel plate with a rectangular orifice. The "head loss" is the difference in water level across this orifice.
2. The downstream gate is used for on/off and flow rate adjustment. It also ensures that the upstream orifice remains submerged – that the water level on the downstream side of the orifice is above the top of the orifice.

The most important differences are:

1. The orifice of a CHO is not a fully contracted rectangular submerged orifice. Rather, it should have a suppressed (smooth, no obstructions jutting into the flow) floor both upstream and downstream, and suppressed sides. The only contraction is at the top of the orifice (hole). The fundamental discharge equation is the same: $Q = C_d A\sqrt{2g\Delta h}$

   However, the C_d value varies significantly depending upon the relations between the elevations of upstream water and the top of the orifice, and with the relative orifice perimeter length that is suppressed versus contracted.
2. The "box chamber" between the flow measurement sluice gate and the flow control gate is typically much smaller than found in a pre-fabricated fully contracted rectangular submerged orifice design. This can result in significant turbulence, which reduces the accuracy of head measurements.

A standard, old USBR design for a CHO is shown in Figure 29. It has been noted by ITRC and much earlier by Kruse (1965) that field installations of CHOs have historically had significant variations in contractions, entrance conditions, and so on. It appears that engineers and districts often install two gates in series and use the same discharge table for all conditions. This is similar to what is seen with canal metergates and is definitely incorrect.

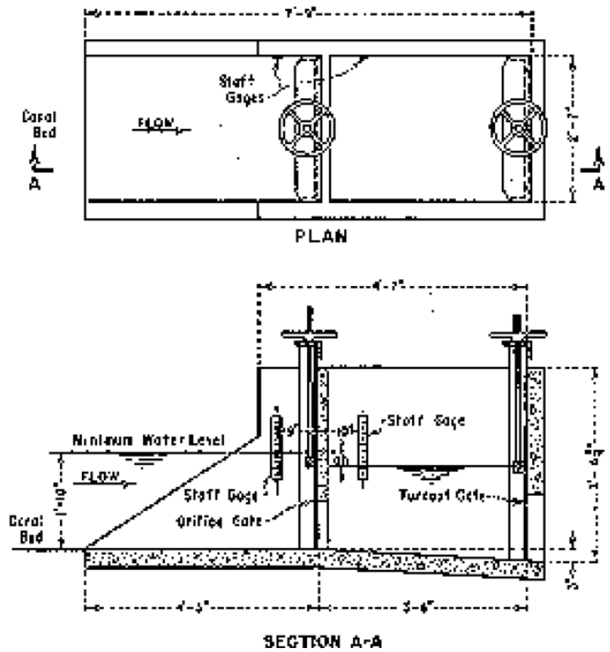

Figure 29. Schematic of a USBR CHO *(from USBR, 2001)*

Recommended designs differ in several ways:

1. Figure 29 shows a gate frame that extends into the flow path on the sides. Those obstructions do not provide suppressed walls. The concrete walls should have a groove into which the gate frame can be placed, so that the flow path never touches the gate frame on the sides or floor. Designs should have straight suppressed walls and floors.
2. The figure shows staff gauges. A previous section stated that (a) the staff gauges are often placed without having the zeroes on the two gauges at the same elevation, and (b) staff gauges often have short lives because of corrosion. Furthermore, staff gauges often have a poor resolution. See the earlier discussion on using rulers to measure depths to water surfaces.
3. The figure shows dimensions for illustrative purposes, but actual dimensions will depend upon the design maximum flow rate.
4. Such figures also often show access holes for stilling wells (sometimes called “piezometers” in CHO literature). Usually those access holes are shown to be below the bottom of the open gate. Because of the dynamic pressure distributions around the gate, that location will give incorrect readings. If stilling wells are used, the access holes should be no more than 1’ below the water surface.

Kruse (1965) noted that if the entrance floor sloped downward (to provide sufficient submergence on the gate opening), there was excessive turbulence downstream of the first gate and it was difficult to measure water depths within 0.1’. He was experimenting with relatively shallow water depths.

The following provides a more detailed discussion of the recommended configuration. To repeat, a distinguishing feature of this is that the sluice gate opening is suppressed on three sides: the two vertical sides, and on the bottom both upstream and downstream. This means that no part of the gate frame extends into the opening, and that the floor is absolutely flat before, across, and after the sluice gate. This is important because we have fairly accurate coefficients for the flow rate computation of suppressed sluice gates. If there are side or bottom obstructions, the amount of flow contraction is different and we are unsure of how to adjust the formulas.

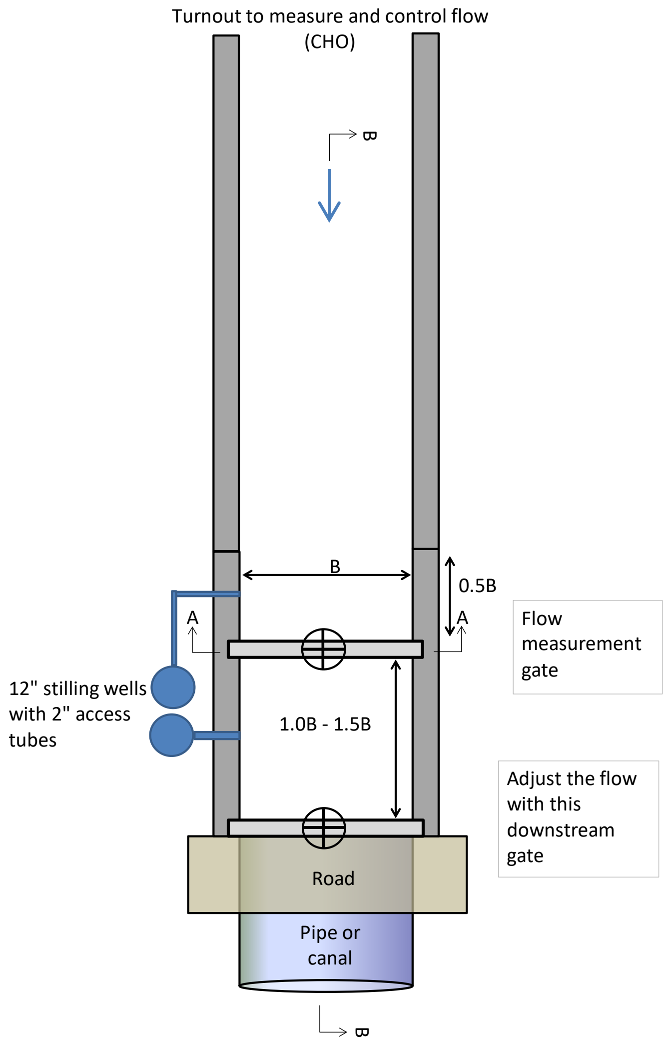

Figure 30. Sluice gate (CHO) configuration for flow measurement on side sloping canals. Plan view. Not to scale.

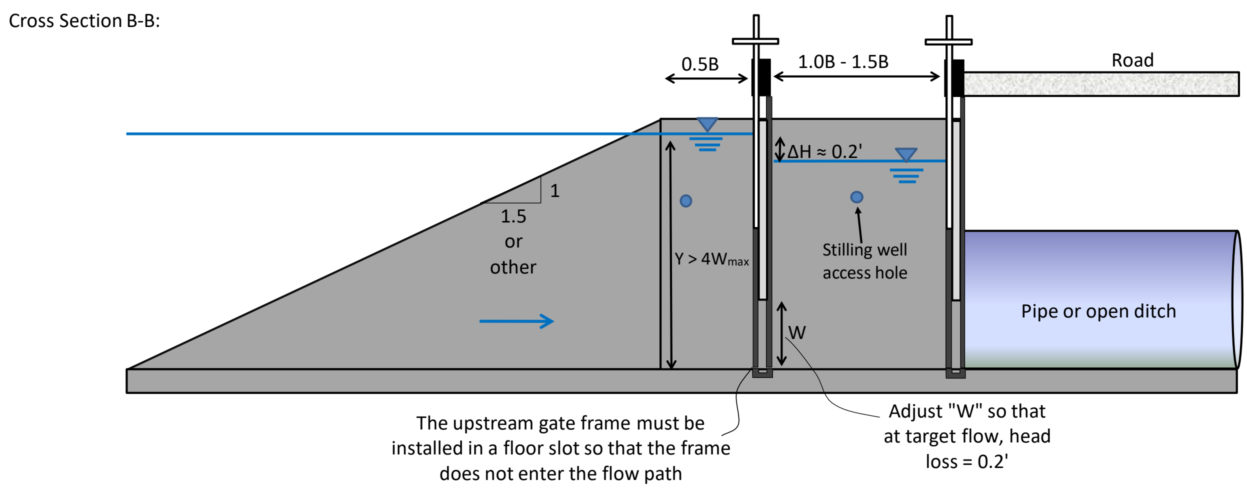

Figure 31. Side view of CHO on lined canal bank. Not to scale.

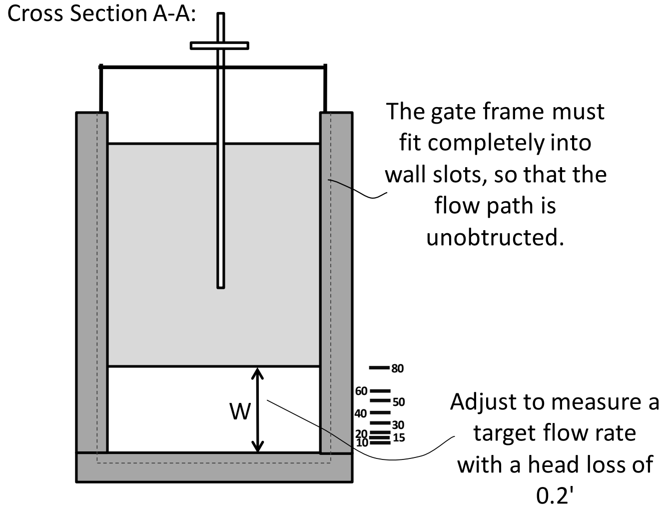

Figure 32. End view of upstream gate of CHO

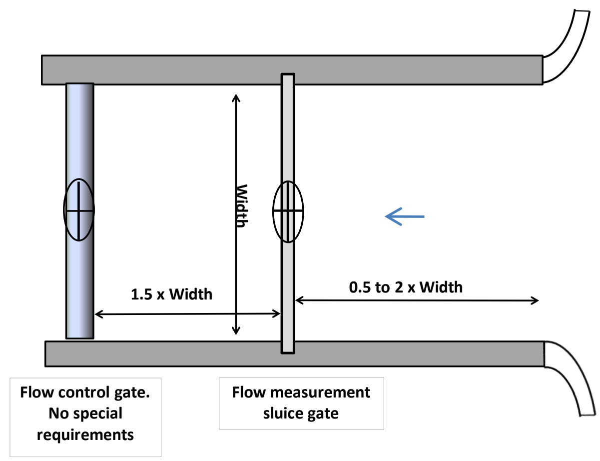

Figure 33. Plan view of CHO constructed in earthen canal. Not to scale. Rounded entrances are recommended.

A major advantage of CHOs over orifice plates is that because there is no side or bottom contraction, the structure can be smaller. A second advantage is that because the floor is flat, there is little/no accumulation of sediment with CHOs. There are also many irrigation district turnouts that have the entrance depicted in Figure 31; they just lack the upstream gate and stilling wells.

Because the structures are relatively small (per unit flow rate) downstream of the flow measurement gate (the upstream gate), the velocity is higher than with contracted submerged orifice plate boxes. Therefore, there is more turbulence in the section between the two gates. For this reason, it is highly recommended to install stilling wells to measure the head difference. As recommended earlier for orifice plates, they should have access tubes (2" diameter) located no deeper than 1' below the lowest water surface. The stilling wells should be at least 12" in diameter. The stilling wells should be placed adjacent to each other, and the tops should have exactly the same elevation. The tops should be covered when not used (for a lid source see: http://www.thepipeplug.com/NonPressurePlugs.htm), and the stilling well pipes should be constructed from steel pipe so that they do not chip or break easily.

The flow rate is calculated using the following equation with dimensions from the upstream sluice gate (Burt et al, 2019):

$$Q_{Gate} = C_{dcomb} \times W \times B \times \sqrt{64.4 \times \Delta Head}$$

Where: Q = flow rate, CFS
C_{dcomb} = Gate flow coefficient, described below
B = Gate width, ft
W = Gate vertical opening, ft
ΔHead, ft = (Upstream Water Depth – Downstream Water Depth)

C_{dcomb} = (0.7206a^2 - .0867a + .3988) (1+.9B/(B+W))

$$a = \frac{\text{Gate Vertical Opening}}{\text{Upstream Water Depth above floor}}$$

Table 3. CHO rating table for ΔH = 0.2'

	Gate Openings (W) for Various Bottom Widths (B)							
	1 ft.		2 ft.		3 ft.		4 ft.	
CFS	W, ft	Min Y, ft	W, ft	Min Y, ft	W, ft	Min Y, ft	W, ft	Min Y, ft
1	0.41	1.6	0.19	0.8	0.12	0.5	0.09	0.4
1.5	0.63	2.6	0.28	1.1	0.18	0.7	0.13	0.5
2	0.88	3.5	0.38	1.5	0.24	1.0	0.18	0.7
2.5	1.11	4.5	0.48	2.0	0.3	1.2	0.22	0.9
3	1.37	5.5	0.59	2.4	0.37	1.5	0.27	1.1
3.5			0.7	2.8	0.43	1.8	0.31	1.3
4			0.81	3.2	0.5	2.0	0.36	1.5
4.5			0.92	3.7	0.57	2.3	0.42	1.7
5			1.03	4.1	0.64	2.6	0.46	1.8
5.5			1.14	4.6	0.7	2.8	0.51	2.0
6			1.27	5.1	0.78	3.1	0.56	2.2
6.5			1.38	5.6	0.84	3.4	0.61	2.4
7			1.51	6.0	0.92	3.7	0.66	2.6
7.5			1.62	6.5	0.99	4.0	0.71	2.8
8					1.07	4.3	0.75	3.0
8.5					1.13	4.6	0.81	3.2
9					1.21	4.9	0.86	3.4
9.5					1.29	5.2	0.91	3.6
10					1.37	5.5	0.97	3.9
10.5					1.43	5.8	1.02	4.1
11					1.52	6.1	1.07	4.3
11.5					1.59	6.4	1.13	4.5
12					1.68	6.7	1.18	4.7
12.5					1.74	7.0	1.23	4.9
13					1.82	7.3	1.29	5.2
13.5					1.9	7.6	1.33	5.4
14					1.99	8.0	1.39	5.6
14.5							1.44	5.8
15							1.5	6.0
15.5							1.56	6.3
16							1.62	6.5
16.5							1.67	6.7
17							1.73	7.0
17.5							1.78	7.2
18							1.84	7.4
18.5							1.89	7.6
19							1.95	7.8
19.5							2.01	8.1
20							2.07	8.3

Acoustic Doppler Velocity Meters

Acoustic Doppler velocity meters (ADVMs) are non-mechanical devices that can be used in both open channel and pressurized pipe systems. They usually contain two or more ultrasonic transducers that can emit and receive sound waves. The ADVM works by sending out an ultrasonic wave at discrete points along the channel/pipe cross-section; as the wave hits air bubbles or suspended solid particles, a wave is reflected with a Doppler shift (Figure 34). This shift in the wave is proportional to the velocity of the water in the channel or pipe. Using the depth measurement in the canal, or the pipe inside diameter to find the cross-sectional area, the meter can calculate the flow rate, similar to manual current metering devices.

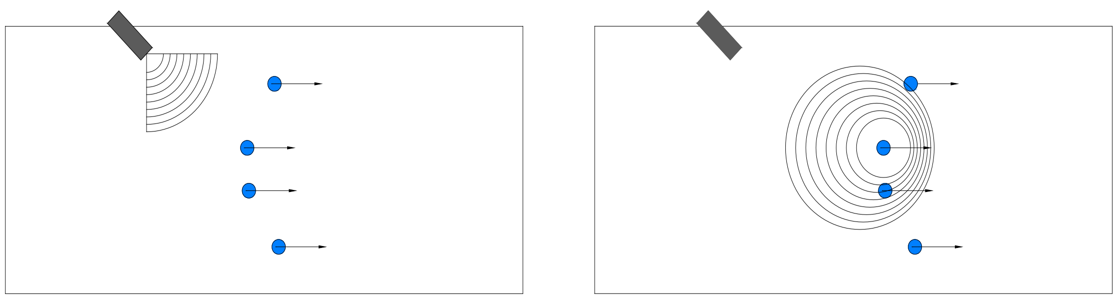

Figure 34. Doppler shift caused by moving particles in the water

There are two different wave transmitting/receiving methods for ADVMs: **continuous** signaling (incoherent) and **pulsed** (coherent) signaling (USBR, 2001). As the name implies, a continuous ADVM sends a continuous sound wave through the water and continuously reads the reflected waves without any pause between readings. The ADVM only averages the velocities along a single beam path, without taking into account the water depth.

On the other hand, a pulsed ADVM sends out short bursts of sound waves and waits a certain length of time before beginning to receive reflected waves. The pulsed ADVM is able to send its pulse to discrete points along the cross-section. The ability to read velocities at certain points gives pulsed ADVMs better velocity resolution, but generally makes them more expensive than their counterpart.

When looking at ADVMs, another important factor to take into consideration is the device's transducer wave output frequency. In general irrigation applications, ADVMs are usually set to frequencies between 1.2 MHz and 5 MHz, although the devices have the capability to go above or below those values. The lower end of the spectrum is usually used in situations where the water is very deep or the channel is very wide, but results in lower resolution. Higher frequencies are better for shorter distances and shallower waters, and have much better resolution.

Acoustic Doppler Velocity Meters on Open Channels

In open channel applications, ADVMs can be mounted on either the canal floor or on the side wall of the canal. Floor mounted units are "upward looking." They contain one transducer that "looks up" and determines the height of the water, and another two transducers that determine the velocity upstream and downstream of the unit, usually at beam angles of 25 or 45 degrees. For open channel systems, the beam angle is measured relative to the vertical beam center line, as seen in Figure 35. Figure 36 shows a 3D rendition of an upward-looking ADVM installation.

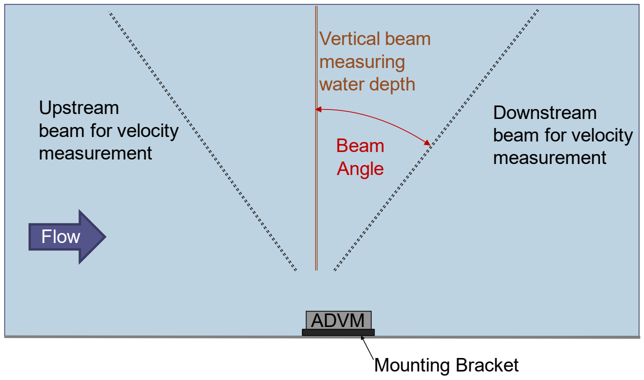

Figure 35. Beam angle relative to flow path

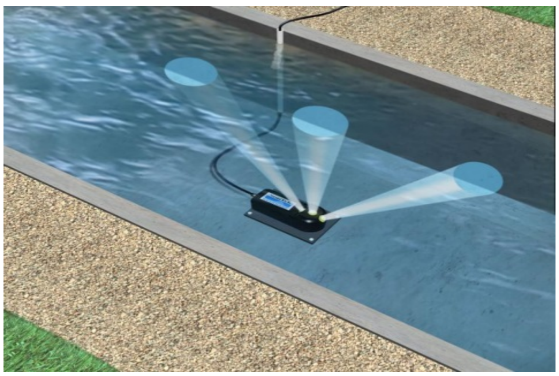

Figure 36. Water depth beam (center) and velocity beams (left and right) on an upward-looking ADVM *(from SonTek, 2005)*

Another configuration option for an ADVM in open channels is a "side looking" installation. The concept is very similar to an upward-looking ADVM, except that the device is mounted on a side wall of the canal instead.

It is very important to understand that all ADVMs only take a sample reading of the velocities in a channel. Those are not the same as the average velocities. Therefore, there must be some type of mathematical adjustment within the electronics to change the sample readings into average readings. The result may be close or quite distant from reality. In large installations, it is typical to spend a fair amount of time using current meters to measure actual flow rates, and then to develop some type of calibration curve. This is impractical for field turnouts.

Choosing an Installation Location

When installing an ADVM in an open channel, it is important to choose a location where there is little to no turbulence and where there is a uniform velocity profile so that the device can get the best readings possible. The USBR *Water Measurement Manual* (2001) recommends having at least 5 to 10 channel widths upstream and 1 to 2 widths downstream of the device in order to reduce turbulence.

ITRC developed a velocity conditioning device for open channels that is meant to create a uniform velocity profile over a variety of different flow rates and depths. The device is known as a subcritical contraction and is meant to cause a sudden change in channel cross section and equalize all the velocities in the profile, as seen in Figure 37. In other words, with a contraction installed, the velocity taken directly at the cross-section centerline should be equal to the actual mean channel velocity. Designs of subcritical contractions vary depending on the actual site characteristics, such as inlet channel width and channel material (i.e., earth or concrete), but will equalize velocities just the same.

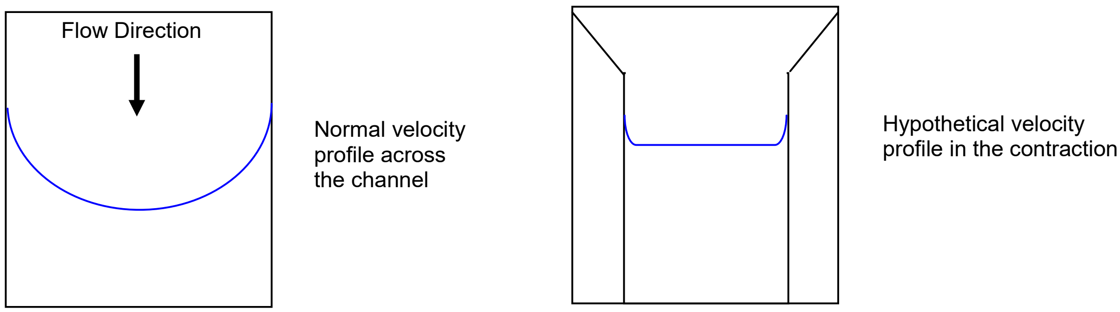

Figure 37. Parabolic velocity distribution without a contraction (left) and theoretical velocity distribution with contraction installed (right)

Additional notes include:

- It is recommended to install a subcritical contraction at every site where an ADVM is to be placed in order to get the most accurate results for volumetric flow rate.
- ADVMs need to be positioned in the proper angle. They also need to be cleaned off occasionally. They should be installed with brackets that make it easy to remove the ADVM and inspect it, and then return it to the exact location and orientation (angle) as before. This is especially important if calibration was done to develop the signal/flow relationship, as any change in location or orientation will change the calibration curve.
- ADVMs have had a varied history of complexity, life expectancy, and accuracy. Some of the more accurate devices do not have good user interfaces (there is no simple display of volume and flow rate).
- ADVMs are typically used when there is not enough head available in a canal to use any other device such as a flume.

Acoustic Doppler Meters in Pipes

ADVMs can also be used on systems where water passes through a pipe section, such as in an intermediate delivery between district canals and farmer-owned ditches. A variety of techniques have been developed that allow the ADVM to be attached to the inside of pipe walls, yet also be easily removable for servicing. Again, there can be challenges with quality control. ITRC worked with 30 units from one large manufacturer and had to discard all of them. There were problems even detecting flow, and obtaining an accurate answer was even less likely.

If the pipe is full, it is generally advised to install the ADVM on the side of the pipe to prevent it being covered with sediment or being hit by floating trash.

Flumes and Weirs

Flumes and weirs are sometimes used downstream of flow control gates (turnout canal gates). Major challenges include:

1. These devices must be far enough downstream of turbulence to have relatively straight approach sections. This usually means they are on the farmer's property.
2. Because the devices are on the farmer's property, the hydraulic conditions (damming up of water, weeds, etc.) downstream of the device may deteriorate and the weir or flume may become submerged, rendering them useless.
3. Flumes and weirs require a fair amount of head loss across them. In theory, flumes can be operated with a very small head loss, but experienced designers know that it is unwise to assume too much about downstream conditions. Therefore, they will typically design them for at least 6"-12" head loss, which is often not available if one also considers the head loss needed for water to flow into the turnout and through the gate and structure, plus ideally leaving about 1' of extra head loss for good flow control.

Weirs are less expensive to construct than flumes, but they are very sensitive to the approach velocity. The equations used by most people assume that where the head is measured upstream of the weir, the velocity is zero. That is rarely the case, so the typical weir equations often underestimate the flow rate. Additionally, turnout weirs are rarely constructed with the appropriate dimensions, clearances, and approach conditions.

In the western US there has been a fair amount of standardization of flume design. The most common is called a "Replogle flume" or a "ramp flume" or a "broad-crested weir" – all names for the same design.

Figure 38. A "Replogle flume" installed on a ditch with high flows in Truckee-Carson ID in Nevada. This is constructed in a trapezoidal section of canal.

The accuracy of both flumes and weirs is very sensitive to silt and sand in the water. Figure 39 illustrates such a problem.

Figure 39. Flume with expensive monitoring and a slight maintenance problem

Flumes also tend to have a large algae growth on the top and entrance concrete, in which case the flow rate is overestimated. This can be minimized by carefully painting the flume with a special paint. Figure 40 shows a flume that has received an ePaint™ non-toxic anti-fouling coating.

Figure 40. A flume with an ePaint™ coating to minimize algae growth

If a weir or flume is used for turnout flow measurement, it is highly recommended that staff gauges be purchased that read out directly in flow rate. This eliminates errors in conversion from feet to CFS. A variety of companies (e.g., Stevens, Oregon Rule, All Star Trophy) provide such staff gauges in a variety of widths and materials. The discharge equation needs to be provided, and if the staff is on a slope that angle also needs to be provided. Interestingly, one of the biggest errors with flume and weir measurement is that the staff gauges are not put in the proper location, and/or the "zero" is not placed at the correct height.

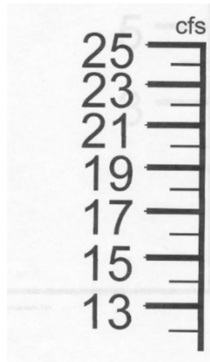

Figure 41. Example of a staff gauge from Modesto ID, reading directly in CFS

Weirs

Key characteristics of weirs were mentioned previously. All weir equations are derived empirically using limited laboratory test results. Therefore, the importance of following the installation rules cannot be over-emphasized. The USBR *Water Measurement Manual* (2001) provides excellent information regarding weir types and weir dimensions.

Besides problems with not considering the entrance velocity and using improper clearances for weirs, the most common problems appear to be:

1. Many weirs are not properly sized for the flow rates that will be encountered. Specifically, many are oversized and therefore only have a shallow depth over the crest.
2. Many weirs are submerged on the downstream side.
3. Staff gauges are not zeroed properly.

ITRC Weir Stick

The ITRC weir stick is used by many districts to measure flow rates in canals. It was intended to provide a relatively quick and reasonably accurate estimate of flow rates over flashboards used in irrigation district canal check structures. Some districts use it at the turnout level.

Figure 42. Use of an ITRC weir stick on flashboards

Ideally, the weir would be suppressed and well-aerated. The nappe (downstream side) of the weir seen in Figure 43 is aerated; air can move under the nappe and prevent a suction from forming.

Figure 43. Example of a suppressed weir. The upstream channel has the same width as the weir crest. In this particular case, the walls diverge immediately downstream of the weir, so the nappe is aerated.

The weir in Figure 44 is not suppressed but is "contracted". In other words, the water flows in from the sides of the weir. As can be seen in Figure 43, a foot of weir length at the sides does not convey as much flow rate as a foot of weir length in the middle.

Figure 44. Example of a rectangular contracted weir

The ITRC weir stick reads directly in CFS/ft of *effective* weir length. The actual weir length usually needs to be reduced to provide the value of "effective weir length" that is used in an equation. In other words, if the boards were 6' wide, perhaps the effective length is 5.5'.

The general equation (assuming zero velocity head where the staff gauge is located) for a sharp-crested *suppressed* weir is:

$$CFS = 3.33 \times L \times H^{1.5}$$

Where: L = length of the weir, feet
H = Head above the weir crest, feet (measured before the water begins to converge downward over the crest.

For a perfectly designed/installed contracted (not suppressed) weir, for which water converges from the sides, bottom, and top to pass over the crest, the equation is:

$$CFS = 3.33 \times (L - 0.2H) \times H^{1.5}$$

Where: L and H are the same values as earlier

The value of (L-0.2H) represents the "effective length" of the weir. As more flow passes over the weir, the head (H) increases, and so does the side convergence – reducing the effective weir length.

Operators that use the ITRC weir stick may not understand the need to use an effective length, rather than an actual length. This is not necessary, of course, if the weir is suppressed on its sides.

The ITRC weir stick does automatically take the velocity head into consideration, because it measures the total head at the crest (the water "runs up" the stick above the actual water surface elevation, by an amount equal to the velocity head).

While the accuracy of the ITRC weir stick is reasonable for flashboards, it has not been verified on weirs that may be used for farm turnouts.

Flumes

For the past 30 years, most irrigation districts in the US have standardized the Replogle flume. The main advantages of this flume are:

1. It can be designed with trapezoidal or vertical side walls.
2. The WinFlume™ program is free from USBR and provides good designers with excellent design and analysis capabilities.
3. The post-construction flume dimensions can be inserted into the WinFlume™ program to obtain flow rate equations that match what is actually in the field.
4. These flumes have minimal head loss.
5. These flumes are very accurate if designed and installed properly.
6. There is no adjustment for the velocity of approach.

The two major errors that are made in design are likely:

1. The entrance velocity is too high (in hydraulic terms, the Froude number is too high). This occurs on steep canals.
2. The downstream conditions are not well defined, and therefore the flume becomes too submerged for accurate readings.

A "standard" Replogle flume configuration is illustrated in Figure 45.

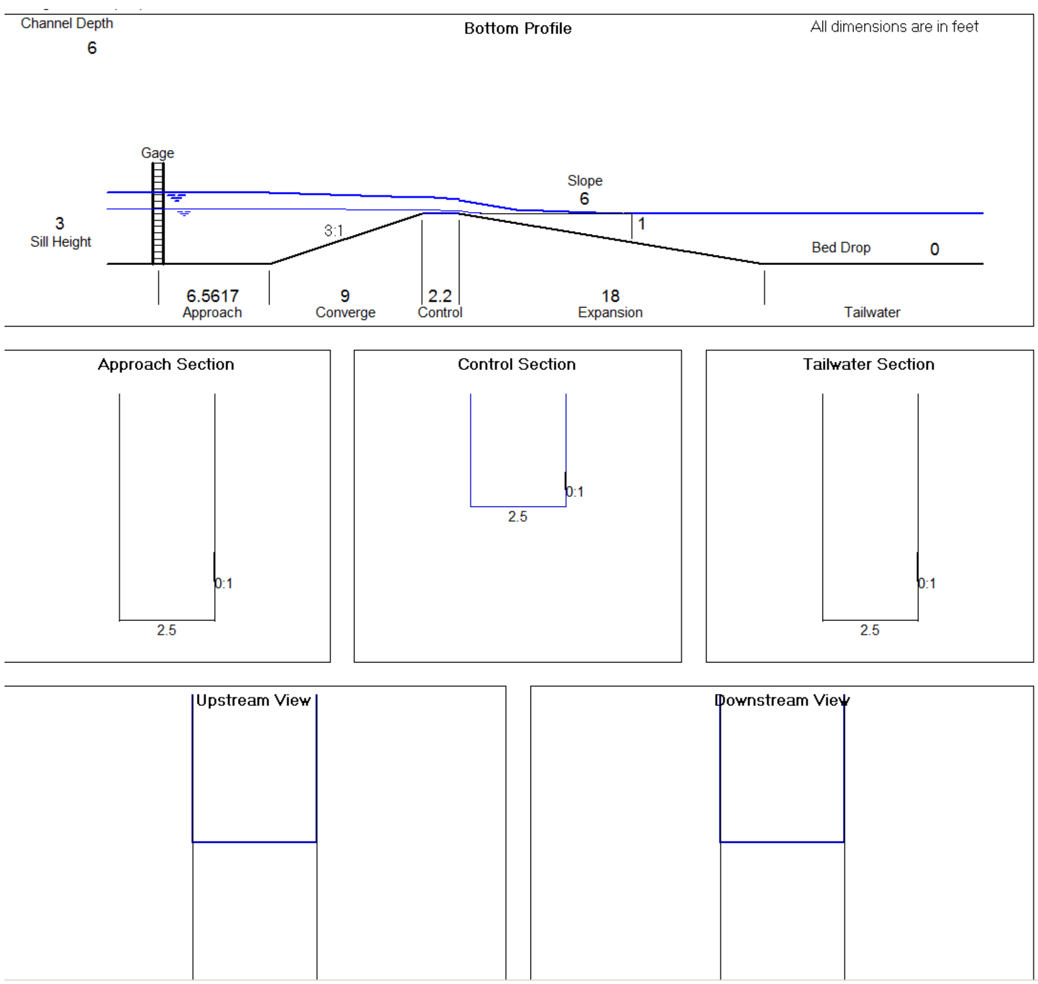

Figure 45. Example output from WinFlume™ for a typical Replogle flume. This has rectangular side walls.

For situations in where there is a heavy silt/sand load, the trend is to use WinFlume™ to design a flat-bottomed flume, with contractions on the sides but not on the bottom. Figure 46 shows an example of such a flume.

Figure 46. Flat-bottomed (actually, a "Vee" in this case) flume immediately after construction. The sediment will flush out once water flows in the ditch.

Pump Kilowatt-Hours

Some districts have pumped turnouts from canals. It is generally not recommended to use the power billing records to estimate the volume that is pumped, because:

1. Pump inlet conditions often change. For example, the pumping depths in wells can change substantially from month to month, which impacts the volume/kwh.
2. Pump parts wear with time, changing the volume/kwh.
3. Pump discharge conditions can change. In Figure 47, the height of water in the concrete stand will be different, depending on where in the field the water is going. This creates different pressure requirements for the pump. For low lift pumps, the flow rate can change substantially with only a foot or two of discharge pressure difference.
4. Pump discharge pressures (and therefore flow rates) also change over time if the pump discharges directly into a pressurized pipe.

Figure 47. The discharge pressure of the pump will change over time with this type of direct connection to a standpipe

Instead, it is recommended to just put a flow meter on the pump discharge with appropriate clearances.

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Attachment 1

California Code of Regulations
Title 23. Waters
Division 2. Department of Water Resources
Chapter 5.1. Water Conservation Act of 2009
Article 2. Agricultural Water Measurement

§597. Agricultural Water Measurement

Under the authority included under California Water Code §10608.48(i)(1), the Department of Water Resources (Department) is required to adopt regulations that provide for a range of options that agricultural water suppliers may use or implement to comply with the measurement requirements in paragraph (1) of subdivision (b) of §10608.48.

For reference, §10608.48(b) of the California Water Code states that:

> *Agricultural water suppliers shall implement all of the following critical efficient management practices:*
>
> *(1) Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2).*
>
> *(2) Adopt a pricing structure for water customers based at least in part on quantity delivered.*

For further reference, §531.10(a) of the California Water Code requires that:

> *(a) An agricultural water supplier shall submit an annual report to the department that summarizes aggregated farm-gate delivery data, on a monthly or bi-monthly basis, using best professional practices.*

Notes:

(1) Paragraphs (1) and (2) of §10608.48(b) specify agricultural water suppliers' reporting of aggregated farm-gate water delivery and adopting a volumetric water pricing structure as the purposes of water measurement. However, this article only addresses developing a range of options for water measurement.

(2) Agricultural water suppliers reporting agricultural water deliveries measured under this article shall use the "Agricultural Aggregated Farm – Gate Delivery Reporting Format for Article 2" (Rev. 6-20-12), developed for this article and hereby incorporated by reference.

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(3) The Department shall report on the availability of new commercially available water measurement technologies and impediments to implementation of this article when reporting to the Legislature the status of adopted Agricultural Water Management Plans in plan submittal years 2012, 2015 and every five years thereafter as required by California Water Code §10845. The Department shall also report the findings to the California Water Commission.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 531.10, 10608.48 (b), 10608.48 (i), 10608.52 (b) and 10845 Water Code.

§597.1. Applicability

(a) An agricultural water supplier providing water to 25,000 irrigated acres or more, excluding acres that receive only recycled water, is subject to this article.

(b) A wholesale agricultural water supplier providing water to another agricultural water supplier (the receiving water supplier) for ultimate resale to customers is subject to this article at the location at which control of the water is transferred to the receiving water supplier. However, the wholesale agricultural water supplier is not required to measure the receiving agricultural water supplier's deliveries to its customers.

(c) A water supplier providing water to wildlife refuges or habitat lands where (1) the refuges or habitat lands are under a contractual relationship with the water supplier, and (2) the water supplier meets the irrigated acreage criteria of Water Code §10608.12(a), is subject to this article.

(d) An agricultural water supplier providing water to less than 10,000 irrigated acres, excluding acres that receive only recycled water, is not subject to this article.

(e) An agricultural water supplier providing water to 10,000 or more irrigated acres but less than 25,000 irrigated acres, excluding acres that receive only recycled water, is not subject to this article unless sufficient funding is provided specifically for that purpose, as stated under Water Code §10853.

(f) A canal authority or other entity that conveys or delivers water through facilities owned by a federal agency is not subject to this article.

(g) Pursuant to Water Code §10608.8(d), an agricultural water supplier "that is a party to the Quantification Settlement Agreement, as defined in subdivision (a) of Section 1 of Chapter 617 of the Statutes of 2002, during the period within which the Quantification Settlement Agreement remains in effect," is not subject to this article.

(h) Pursuant to Water Code §10608.12(a), the Department is not subject to this article.

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Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 10608.12 (a), 10608.48 (d), 10608.48 (f), 10828, and 10853 Water Code.

§597.2. Definitions

(a) For purposes of this article, the terms used are defined in this section.

(1) "Accuracy" means the measured volume relative to the actual volume, expressed as a percent. The percent shall be calculated as 100 x (measured value – actual value) / actual value, where "measured value" is the value indicated by the device or determined through calculations using a measured value by the device, such as flow rate, combined with a duration of flow, and "actual value" is the value as determined through laboratory, design or field testing protocols using best professional practices.

(2) "Agricultural water supplier," as defined in Water Code §10608.12(a), means a water supplier, either publicly or privately owned, providing water to 10,000 or more irrigated acres, excluding acres that receive only recycled water. "Agricultural water supplier" includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells water for ultimate resale to customers. "Agricultural water supplier" does not include the Department.

(3) "Approved by an engineer" means a California-registered Professional Engineer has reviewed, signed and stamped the plans, design, testing, inspection, and/or documentation report for a measurement device as described in this article.

(4) "Best professional practices" means practices attaining to and maintaining accuracy of measurement and reporting devices and methods described in this article, such as operation and maintenance procedures and practices recommended by measurement device manufacturers, designers, and industry professionals.

(5) "Customer" means the purchaser of water from an agricultural water supplier who has a contractual arrangement with the agricultural water supplier for the service of conveying water to the customer delivery point.

(6) "Delivery point" means the location at which the agricultural water supplier transfers control of delivered water to a customer or group of customers. In most instances, the transfer of control occurs at the farm-gate, which is therefore, a delivery point.

(7) "Existing measurement device," means a measurement device that was installed in the field prior to the effective date of this article.

(8) "Farm-gate," as defined in Water Code §531(f), means the point at which water is delivered from the agricultural water supplier's distribution system to each of its customers.

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(9) "Irrigated acres," for purposes of applicability of this article, is calculated as the average of the previous five-year acreage within the agricultural water supplier's service area that has received irrigation water from the agricultural water supplier.

(10) "Manufactured device" means a device that is manufactured by a commercial enterprise, often under exclusive legal rights of the manufacturer, for direct off-the-shelf purchase and installation. Such devices are capable of directly measuring flow rate, velocity, or accumulating the volume of water delivered, without the need for additional components that are built on-site or in-house.

(11) "Measurement device" means a device by which an agricultural water supplier determines the numeric value of flow rate, velocity or volume of the water passing a designated delivery point. A measurement device may be a manufactured device, on-site built device or in-house built device.

(12) "New or replacement measurement device" means a measurement device installed after the effective date of this article.

(13) "Recycled water" is defined in subdivision (n) of §13050 of the Water Code as water that, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur, and is therefore considered a valuable resource.

(14) "Type of device" means a measurement device that is manufactured or built to perform similar functions. For example, rectangular, v-notch, and broad crested weirs are one type of device. Similarly, all submerged orifice gates are considered one type of device.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 10608.12 (a), 10608.12 (m), 10608.48, and 10813 Water Code.

§597.3 Range of Options for Agricultural Water Measurement

An agricultural water supplier subject to this article shall measure surface water and groundwater that it delivers to its customers pursuant to the accuracy standards in this section. The supplier may choose any applicable single measurement option or combination of options listed in paragraphs (a) or (b) of this section. Measurement device accuracy and operation shall be certified, tested, inspected and/or analyzed as described in §597.4 of this article.

(a) Measurement Options at the Delivery Point or Farm-gate of a Single Customer

An agricultural water supplier shall measure water delivered at the delivery point or farm-gate of a single customer using one of the following measurement options. The stated numerical accuracy for each measurement option is for the volume delivered. If a device measures a value other than volume, for example, flow rate,

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velocity or water elevation, the accuracy certification must incorporate the measurements or calculations required to convert the measured value to volume as described in §597.4(e).

(1) An existing measurement device shall be certified to be accurate to within ±12% by volume.

and,

(2) A new or replacement measurement device shall be certified to be accurate to within:

(A) ±5% by volume in the laboratory if using a laboratory certification;

(B) ±10% by volume in the field if using a non-laboratory certification.

(b) Measurement Options at a Location Upstream of the Delivery Points or Farm-gates of Multiple Customers

(1) An agricultural water supplier may measure water delivered at a location upstream of the delivery points or farm-gates of multiple customers using one of the measurement options described in §597.3(a) if the downstream individual customer's delivery points meet either of the following conditions:

(A) The agricultural water supplier does not have legal access to the delivery points of individual customers or group of customers needed to install, measure, maintain, operate, and monitor a measurement device.

Or,

(B) An engineer determines that, due to small differentials in water level or large fluctuations in flow rate or velocity that occur during the delivery season at a single farm-gate, accuracy standards of measurement options in §597.3(a) cannot be met by installing a measurement device or devices (manufactured or on-site built or in-house built devices with or without additional components such as gauging rod, water level control structure at the farm-gate, etc.). If conditions change such that the accuracy standards of measurement options in §597.3(a) at the farm-gate can be met, an agricultural water supplier shall include in its Agricultural Water Management Plan, a schedule, budget and finance plan to demonstrate progress to measure water at the farm-gate in compliance with §597.3(a) of this article.

(2) An agricultural water supplier choosing an option under paragraph (b)(1) of this section shall provide the following current documentation in its Agricultural Water Management Plan(s) submitted pursuant to Water Code §10826:

(A) When applicable, to demonstrate lack of legal access at delivery points of individual customers or group of customers downstream of the point of measurement, the agricultural water supplier's legal counsel shall certify to the Department that it does not have legal access to measure water at customers delivery points and that it has sought and been denied access from its customers to measure water at those points.

(B) When applicable, the agricultural water supplier shall document the water measurement device unavailability and that the water level or flow conditions described in §597.3(b)(1)(B) exist at individual customer's delivery points downstream of the point of measurement as approved by an engineer.

(C) The agricultural water supplier shall document all of the following criteria about the methodology it uses to apportion the volume of water delivered to the individual downstream customers:

(i) How it accounts for differences in water use among the individual customers based on but not limited to the duration of water delivery to the individual customers, annual customer water use patterns, irrigated acreage, crops planted, and on-farm irrigation system,

and;

(ii) That it is sufficient for establishing a pricing structure based at least in part on the volume delivered,

and;

(iii) That it was approved by the agricultural water supplier's governing board or body.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 531.10, 10608.48 *(i)* (1), and 10826 Water Code.

§597.4 Accuracy Certification, Records Retention, Device Performance, and Reporting

(a) Initial Certification of Device Accuracy
The accuracy of an existing, new or replacement measurement device or type of device, as required in §597.3, shall be initially certified and documented as follows:

(1) For existing measurement devices, the device accuracy required in section 597.3(a) shall be initially certified and documented by either:

(A) Field-testing that is completed on a random and statistically representative sample of the existing measurement devices as described in §597.4(b)(1) and §597.4(b)(2). Field-testing shall be performed by individuals trained in the use of field-testing equipment, and documented in a report approved by an engineer.

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Or,

(B) Field-inspections and analysis completed for every existing measurement device as described in §597.4(b)(3). Field-inspections and analysis shall be performed by trained individuals in the use of field inspection and analysis, and documented in a report approved by an engineer.

(2) For new or replacement measurement devices, the device accuracy required in sections 597.3 (a)(2) shall be initially certified and documented by either:

(A) Laboratory Certification prior to installation of a measurement device as documented by the manufacturer or an entity, institution or individual that tested the device following industry-established protocols such as the National Institute for Standards and Testing (NIST) traceability standards. Documentation shall include the manufacturer's literature or the results of laboratory testing of an individual device or type of device.

Or,

(B) Non-Laboratory Certification after the installation of a measurement device in the field, as documented by either:

(i) An affidavit approved by an engineer submitted to the agricultural water supplier of either (1) the design and installation of an individual device at a specified location, or (2) the standardized design and installation for a group of measurement devices for each type of device installed at specified locations.

Or,

(ii) A report submitted to the agricultural water supplier and approved by an engineer documenting the field-testing performed on the installed measurement device or type of device, by individuals trained in the use of field testing equipment.

(b) Protocols for Field-Testing and Field-Inspection and Analysis of Existing Devices

(1) Field-testing shall be performed for a sample of existing measurement devices according to manufacturer's recommendations or design specifications and following best professional practices. It is recommended that the sample size be no less than 10% of existing devices, with a minimum of 5, and not to exceed 100 individual devices for any particular device type. Alternatively, the supplier may develop its own sampling plan using an accepted statistical methodology.

(2) If during the field-testing of existing measurement devices, more than one quarter of the samples for any particular device type do not meet the criteria pursuant to §597.3(a), the agricultural water supplier shall provide in its Agricultural Water

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Management Plan, a plan to test an additional 10% of its existing devices, with a minimum of 5, but not to exceed an additional 100 individual devices for the particular device type. This second round of field-testing and corrective actions shall be completed within three years of the initial field-testing.

(3) Field-inspections and analysis protocols shall be performed and the results shall be approved by an engineer for every existing measurement device to demonstrate that the design and installation standards used for the installation of existing measurement devices meet the accuracy standards of §597.3(a) and operation and maintenance protocols meet best professional practices.

(c) Records Retention

Records documenting compliance with the requirements in §597.3 and §597.4 shall be maintained by the agricultural water supplier for ten years or two Agricultural Water Management Plan cycles.

(d) Performance Requirements

(1) All measurement devices shall be correctly installed, maintained, operated, inspected, and monitored as described by the manufacturer, the laboratory or the registered Professional Engineer that has signed and stamped certification of the device, and pursuant to best professional practices.

(2) If an installed measurement device no longer meets the accuracy requirements of §597.3(a) based on either field-testing or field-inspections and analysis as defined in sections 597.4 (a) and (b) for either the initial accuracy certification or during operations and maintenance, then the agricultural water supplier shall take appropriate corrective action, including but not limited to, repair or replacement to achieve the requirements of this article.

(e) Reporting in Agricultural Water Management Plans

Agricultural water suppliers shall report the following information in their Agricultural Water Management Plan(s):

(1) Documentation as required to demonstrate compliance with §597.3 (b), as outlined in section §597.3(b)(2), and §597.4(b)(2).

(2) A description of best professional practices about, but not limited to, the (1) collection of water measurement data, (2) frequency of measurements, (3) method for determining irrigated acres, and (4) quality control and quality assurance procedures.

(3) If a water measurement device measures flow rate, velocity or water elevation, and does not report the total volume of water delivered, the agricultural water supplier must document in its Agricultural Water Management Plan how it converted the

measured value to volume. The protocols must follow best professional practices and include the following methods for determining volumetric deliveries:

(A) For devices that measure flow-rate, documentation shall describe protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.

(B) For devices that measure velocity only, the documentation shall describe protocols associated with the measurement of the cross-sectional area of flow and duration of water delivery, where volume is derived by the following formula: Volume = velocity x cross-section flow area x duration of delivery.

(C) For devices that measure water elevation at the device (e.g. flow over a weir or differential elevation on either side of a device), the documentation shall describe protocols associated with the measurement of elevation that was used to derive flow rate at the device. The documentation will also describe the method or formula used to derive volume from the measured elevation value(s).

(4) If an existing water measurement device is determined to be out of compliance with §597.3, and the agricultural water supplier is unable to bring it into compliance before submitting its Agricultural Water Management Plan in December 2012, the agricultural water supplier shall provide in its 2012 plan, a schedule, budget and finance plan for taking corrective action in three years or less.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 531.10, 10608.48 *(i)* (1), and 10826 Water Code.

State of California The Natural Resources Agency Department of Water Resources

Agricultural Aggregated Farm-Gate[1] Delivery Reporting Format for Article 2

Due annually beginning no later than July 31, 2013 from agricultural water suppliers subject to Title 23, Division 2, Chapter 5.1, Article 2 of the CCR - Agricultural Water Measurement

1. Water Supplier Information

Name:

Address:

Phone Number:

Fax:

Total Number of Farm-Gates:

Number of Measured Farm-Gates:

Service Area Acreage:

2. Contact information

Name:

Title:

Address:

Phone Number:

Fax:

E-mail:

Submittal date:

3. Aggregated Farm-Gate Delivery Data[2]: *(provide monthly or bimonthly data, acre-feet)*

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Monthly Deliveries													

	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun	Total
Bimonthly Deliveries							

4. Explanations, Comments and Best Professional Practices[3]:

Note: An agricultural water supplier's total water use may be different from Aggregated Farm-Gate deliveries because measurement at these points may not account for other practices (such as groundwater recharge/conjunctive use, water transfers, wheeling to other agencies, urban use, etc).

1. "Farm-gate" means the point at which water is delivered from the agricultural water supplier's distribution system to each of its individual customers as specified in the Agricultural Water Measurement Regulation (Title 23, Division 2, Chapter 5.1, Article 2 of the CCR).
2. "Aggregated farm-gate delivery data" means information reflecting the total volume of water an agricultural water supplier provides to its customers and is calculated by totaling its deliveries to customers.
3. "Best Professional Practices" is defined in Title 23, Division 2, Chapter 5.1, Article 2 of the CCR, Section 597.2.

Article 2 Form - Rev. 6-20-2012

Attachment 2

Growers depend on flow meters to measure the amount of irrigation water being applied to crop. If meter readings are inaccurate, some of the precious resource may be wasted.

Water turbulence disrupts accuracy of some flow meters

Blaine R. Hanson ❑ Larry J. Schwankl

Flow meters were tested under a variety of conditions to determine potential errors in flow rate measurements due to excessive turbulence in the water. Results showed that propeller meters, the Hall meter and the Collins meter were not particularly sensitive to turbulence caused by elbows, while paddle-wheel meters and velocity gauges were sensitive to turbulence. Relatively large errors occurred for all meters under turbulence caused by a partially closed butterfly valve. Inserting six straightening vanes greatly reduced the error caused by partially closed valves.

As water resources become more scarce and competition for them increases, using flow meters to measure the amount of irrigation water applied to a crop field is becoming more common. The flow of irrigation water in pipelines is measured with a variety of devices and is often done under less-than-ideal flow conditions, particularly where a flow measurement device is retrofitted into an existing agricultural pumping plant.

Flow meter manufacturers generally suggest installing an 8-to-10-pipe-diameter section of straight pipe (length is always relative to the diameter of the pipe) upstream of the flow meter and a 2-pipe-diameter length of straight pipe downstream. Over time, this rule of thumb has been generally accepted without a clear understanding of its origin or the impact on flow measurement devices of upstream flow conditions. The origin of this rule of thumb is difficult to determine, but the 1935 standards of the Joint American Gas Association–American Society of Mechanical Engineers Committee on Orifice Coefficients and subsequent work seem to form the basis for it.

Pumps used for irrigation systems are rarely installed with sufficient straight pipe upstream of the flow meter. Little information appears to exist on the possible error resulting from a nonideal flow condition. This project was conducted to assess the error in flow rate measurements of flow meters used in agricultural applications under a variety of nonoptimal upstream flow conditions.

Flow rate measurement

Flow rates were measured with eight different flow meters at distances of 2-, 5-, 10- and 15-pipe diameters downstream from a source of excessive turbulence in the water. Measurements were made in an 8-inch Schedule 40 PVC pipe. The flow meter measurement was compared to flow rate measurements obtained with a volumetric tank, where water flowing though the pipe containing the flow meter discharged into the volumetric tank. Each test consisted of making two tank measurements by filling the tank, draining it and then refilling it. The flow meter reading was compared with the average of the two tank measurements. The percent error was calculated as

RE = 100(Meter – Tank)/Tank

where RE = error, Meter = flow meter reading, and Tank = volumetric tank measurement. Flow rates ranged between about 400 gallons per minute (gpm) and nearly 1,300 gpm.

Water velocity profiles across the horizontal pipe diameter were measured with a pitot tube to characterize the turbulence patterns for each condition. Measurements were made every half inch across the diameter.

We used eight flow meters for this experiment. However, in this article, we discuss the results of only four of the meters — a propeller flow meter, a paddlewheel meter, a Collins pitot meter and a Hall pitot meter. The propeller meter was a strap-on saddle meter installed by cutting a hole in the pipe, inserting the propeller into the hole and strapping the meter onto the pipe. The paddle-wheel meter consisted of a paddle wheel mounted at the end of a metal stem and inserted 1.5 inches into the top of the pipe. The Hall and Collins meters measured the flow rate across the horizontal diameter of the pipe.

The propeller meter, Hall meter and Collins meter were classified as velocity-integrating meters because they responded to some type of integration of the water velocity across the pipe cross-sectional area. The paddle-wheel meter was classified as a point-velocity meter because its flow rate readings were based on the water velocity at a point within the pipe cross-sectional area.

There were nine flow conditions studied in this project:

1. Control. Flow rate measurements were made at 9- and 22-pipe-diameter distances downstream from a 90-degree elbow.

2. Check valve. This disk type valve was installed in such a way that the disk was at the top of the pipe during water flow.

3. Partially closed butterfly valve. The stem of the valve deviated about 10 degrees from the vertical. This was necessary because the valve stem extended beyond the bottom of the valve and therefore the test pipe. The test section could not be raised to accommodate this extension.

4. 90-degree elbow. The elbow was installed with the bend in the horizontal plane.

5. Butterfly valve and elbow. The 90-degree elbow was installed immediately upstream from the partially closed valve.

6. Single vane and butterfly valve. A straightening vane was installed immediately downstream from a partially closed butterfly valve.

7. Six vanes and butterfly valve. The straightening vanes were inserted 1-pipe diameter downstream from a partially closed butterfly valve.

8. Six vanes and elbows. The straightening vanes were inserted 1-pipe diameter downstream from a 90-degree elbow.

9. Six vanes, butterfly valve and elbow. The straightening vanes were inserted 1-pipe diameter downstream from a 90-degree elbow and a partially closed butterfly valve.

Tank measurements

The difference between the individual flow rate measurements and the average flow rate (average of the two volumetric tank measurements) was less than 1% for 81% of the volumetric tank measurements and less than 1.25% for 91% of the individual measurements. The maximum difference was 3.6%. The percent difference decreased as the average flow rate increased. The standard error of the mean of the two measurements was 4.7 gallons per minute.

Control condition

Figure 1 shows the water velocity profiles across the pipe diameter at 9-pipe diameters to be uniform until the pipe wall was approached. As would be expected, smaller velocities occurred adjacent to the pipe wall. Similar behavior occurred at 22-pipe diameters.

Average errors under the control condition were 1.6% for the propeller meter, 1.2% for the paddle-wheel

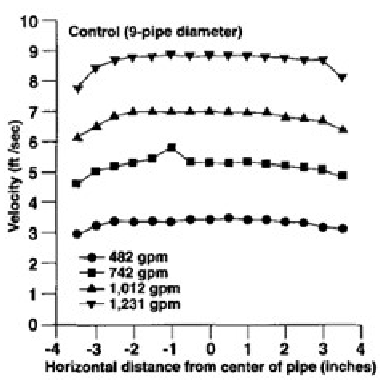


Fig. 1. Water velocity profiles under control conditions.

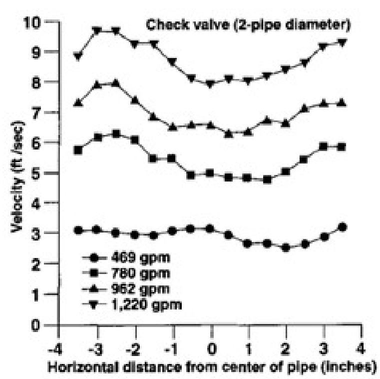


Fig. 2. Water velocity profiles under a check valve.

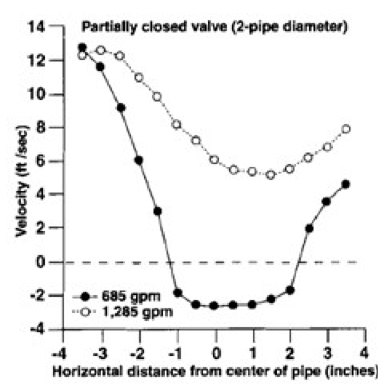


Fig. 3. Water velocity profiles under a partially closed butterfly valve.

meter, -0.9% for the Hall meter and 0.5% for the Collins meter. The average control error for the propeller meter was statistically different from zero at a level of significance of 0.05 because of the small standard deviation. The average control errors of the Hall and Collins meters and the paddle-wheel meter were not statistically different from zero.

We used the control errors to help interpret the results of the tests made under the various conditions. Turbulence was assumed to have little effect on the flow meter reading when the actual error was about equal to the average control error. Where a sufficient number of tests existed for a particular condition, the errors were statistically compared with the control errors.

Check valve

At 2-pipe diameters, larger water velocities occurred near the edges of the pipe for all flow rates except for the smallest (fig. 2). At 5- and 10-pipe diameters (not shown), velocity profiles were similar to the control profiles.

Errors similar to the average control error generally occurred for the propeller and Hall meters (table 1). Little or no trend in error occurred with increasing downstream distance for the propeller meter. For the Collins meter, larger errors occurred at 2-pipe diameters for each flow rate compared with the other downstream distances.

Errors were generally large relative to the control errors for the paddle-wheel meter, with a trend of decreasing error with increasing downstream distance.

Average errors were calculated for each flow meter at each downstream distance since no trend with flow rate appeared to exist in the error data. Differences between these average errors and the control errors were statistically significant at all downstream distances for the paddle-wheel meter. Differences were not statistically significant for the propeller meter, the Hall meter and the Collins meter.

These results indicate that the velocity-integrating meters were not adversely affected by the turbulence caused by the check valve. The point-velocity meter, however, would be affected by the turbulence, depending on the location of the meter's sensor with respect to the water velocity profile.

TABLE 1. Check valve errors

Pipe diameters	Propeller		Paddle-wheel		Collins		Hall	
	Flow rate	Error	Flow rate	Error	Flow rate	Error	Flow rate	Error
	gal/min	%	gal/min	%	gal/min	%	gal/min	%
2	470	−1.1	464	3.7	470	−12.6	478	0.8
5	—	—	485	−13.4	467	−2.6	468	2.9
10	—	—	470	−4.3	486	−4.5	479	1.5
2	734	3.8	762	−28.4	738	5.8	766	1.2
5	—	—	757	−7.6	771	−3.4	779	−2.9
10	—	—	738	−2.6	761	−3.3	776	2.6
2	969	0.9	980	−25.6	969	4.7	997	−2.9
5	—	—	976	−6.9	981	−1.3	961	3.2
10	—	—	969	−3.1	956	0.6	984	−3.2
2	1,224	2	1,244	−28.5	1,155	8.2	1,197	1
5	—	—	1,183	−4.6	1,165	3.4	1,219	2.8
10	—	—	1,155	1	1,179	1.3	1,185	3.6

TABLE 2. Butterfly valve errors

Pipe diameters	Propeller		Paddle-wheel		Collins		Hall	
	Flow rate	Error	Flow rate	Error	Flow rate	Error	Flow rate	Error
	gal/min	%	gal/min	%	gal/min	%	gal/min	%
2	393	14.2	—	—	—	—	—	—
5	395	8.6	—	—	—	—	—	—
10	392	7.9	—	—	—	—	—	—
15	391	7.9	—	—	—	—	—	—
2	677	15.1	541	29.4	558	4.2	554	0.5
5	682	8.1	549	−3.5	540	1.1	542	−1.3
10	684	7.4	539	2.8	545	0.7	553	−1.6
15	647	10.5	558	−8.6	562	−2.1	540	0
2	1,289	2.4	987	33.6	976	8	987	−11.2
5	1,273	2.8	969	3.1	976	−0.6	969	−3.1
10	1,284	2.8	985	−4.7	1,000	0.1	985	−3.8
15	1,281	3.6	971	−1.2	971	0.1	971	3.68

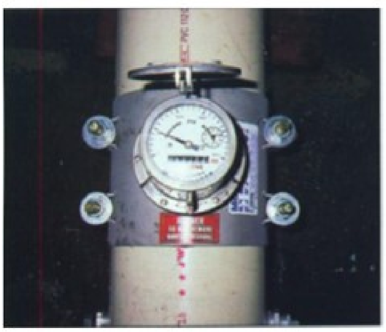
Partially closed butterfly valve

The velocity profiles at 2-pipe diameters (fig. 3) show relatively large velocities near the pipe wall for the smallest flow rate caused by jetting around the valve disk and negative velocities along the middle of the pipe cross section, indicating an eddy. At the larger flow rate, however, there was much less turbulence and no eddy existed. The differences in the velocity profiles at 2-pipe diameters indicate that the flow geometry differed between the two flow rates.

At downstream distances of 5- and 10-pipe diameters (not shown), velocities were relatively uniform and similar across the horizontal pipe diameter. However, the possibility exists that the normalized profile in the vertical cross section may not be uniform.

For the propeller meter, relatively large errors occurred compared with the average control error for all downstream distances except for the largest flow rate (table 2). The largest errors occurred at 2-pipe diameters. Smaller errors relatively constant with distance occurred for the other downstream distances.

At the largest flow rates, small errors occurred for the propeller meter regardless of downstream distance. This behavior is an experimental artifact caused by increasing the valve opening to obtain the larger flow rate, which greatly changed the flow geometry. Thus, at these flow rates, during which the valve was 70% open, the



Above, **propeller flow meter, the most common flow meter used for irrigation pumping plants. *Below*, flow meter installed in test section used for this study.**

turbulence caused by the valve had little effect on the flow-meter readings.

Large errors also occurred at 2-pipe diameters for the paddle-wheel meter for the middle and largest flow rates. For the other downstream distances, much smaller errors were found, fluctuating between positive and negative values. However, caution should be used in assuming that these small errors indicate that this meter is particularly accurate under this flow condition. These results reflect the point-velocity characteristic of the meter, which depends on the location of the paddle wheel relative to the velocities across the pipe cross-sectional area.

Interestingly, relatively small errors occurred for the Collins and Hall meters, with no apparent trend with downstream distance or flow rate. One would not expect these small errors, given the amount of turbulence for this flow condition. Errors fluctuated between positive and negative values with downstream distance.

The average error of each group of flow rates was determined for each flow meter and then compared with the average control error. For the propeller meter, differences between these errors were statistically significant for the smaller flow rates but not for the largest flow rate. For the Collins and Hall meters, differences were not statistically significant for all flow rates. Mixed results occurred for the paddle-wheel meter.

These results suggest that turbulence from a partially closed valve can substantially affect the flow meter reading, particularly at small downstream distances from the valve such as 2-pipe diameters.

90-degree elbow

Higher water velocities occurred along the right side of the pipe at 2-pipe diameters, reflecting larger water velocities along the outer edge of the elbow (not shown). At 5- and 10-pipe diameters, however, uniform profiles were found across the pipe diameter (not shown).

The results showed that small errors were caused by the turbulence from the elbow. Little or no trend in error with either downstream distance or flow rate occurred for each flow meter.

The average error for each group of flow rates was compared with the average control error. Differences in the average errors were not statistically significant for the propeller meter. Differences in the errors were statistically significant at all flow rates for the paddle-wheel meter, where negative but small errors occurred in contrast with a positive average control error. For the other flow meters, mixed results occurred for the statistical tests, with differences not significant at 2-pipe diameters but significant at 15-pipe diameters.

The results of these data suggest that the elbow did not adversely affect the flow meters' performance. This is particularly true for the velocity-integrating meters. However, a point-velocity meter at 2-pipe diameters positioned on the right-hand side of pipe would read differently from one positioned on the left-hand side because of differences in water velocity.

Butterfly valve and elbow

At 2-pipe diameters, an eddy existed along the right side of the pipe for the smallest flow rate (fig. 4), similar to that of the valve only, while at 5- and 10-pipe diameters (not shown), a trend of increasing velocity occurred from left to right across the pipe. The magnitude of the trend decreased as the downstream distance increased, although the trend was reversed for the middle flow rate at 10-pipe diameters. For the largest flow rates, profiles were very different compared to the smallest flow rate.

Very large errors generally occurred at 2-pipe diameters for all flow meters except at the largest flow rates, for which only the propeller meter was used (table 3). The error relative to length of straight pipe downstream from the flow meter differed among the meters. For the propeller meters, errors of the smallest flow rates were relatively constant regardless of downstream distance. Errors tended to decrease with distance for the middle group of flow rates. The average error of each group of flow rates was statistically different from the average control error for the meter, except for the largest flow rate. As with the valve-

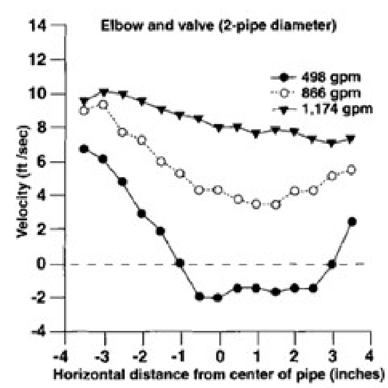


Fig. 4. Water velocity profiles under an elbow and a partially closed butterfly valve.

only condition, the small errors of the largest flow rates reflect opening the valve to obtain the largest flow rates.

The paddle-wheel meter, Collins meter and Hall meter showed a trend of decreasing error with increasing downstream distance for both groups of flow rates. Very large errors occurred at 2-pipe diameters. Some fluctuation between positive and negative errors occurred for the smallest flow rates. The fluctuation of the errors of these meters prevented grouping tests together to obtain a sample size needed to conduct statistical tests on the differences of average values compared with the average control errors.

TABLE 3. Elbow and butterfly valve errors

Pipe diameters	Propeller Flow rate	Propeller Error	Paddle-wheel Flow rate	Paddle-wheel Error	Collins Flow rate	Collins Error	Hall Flow rate	Hall Error
	gal/min	%	gal/min	%	gal/min	%	gal/min	%
2	368	28	434	84.3	393	17.5	412	-37.9
5	383	28.9	432	-20.2	366	12.3	396	14.6
10	419	21.9	366	14.8	432	-0.9	440	-18.4
15	372	20.2	393	6.4	434	-0.9	410	1
2	875	11.6	929	30.1	832	13.6	877	-11.8
5	840	16.3	902	1.9	895	-1.7	937	-7.5
10	899	6.7	895	-4	902	-0.1	931	-1.5
15	869	9.8	932	-4.6	929	-5.1	922	-3.5
2	1,156	0.2	—	—	—	—	—	—
5	1,189	-1.7	—	—	—	—	—	—
10	1,190	-0.4	—	—	—	—	—	—
15	1,159		—	—	—	—	—	—

Straightening vanes

Straightening vanes installed upstream of the flow meter are used to reduce excessive turbulence. We investigated the effects of two commercially available straightening-vane arrangements on the readings of some of the flow meters. One arrangement was a single steel plate, 6 inches wide by 7 inches long, mounted vertically inside the pipe. The other was an arrangement of six vanes installed radially across the pipe cross section. Each of the six vanes was 3 inches long and 3.5 inches wide.

Single vane and butterfly valve. The velocity profile for the smallest flow rate at 2-pipe diameters is considerably different for the single vane and the butterfly valve than that for the butterfly valve only (fig. 5). Velocities were largest in the middle of the pipe where previously an eddy existed. As the flow rate increased, the turbulence lessened, with a relatively uniform profile at the largest flow rate. At 5-pipe diameters (not shown), relatively uniform profiles occurred at all flow rates across the horizontal pipe diameter.

Large errors were found for all flow meters at 2-pipe diameters (table 4). Errors of the propeller meter were larger than the errors for the butterfly valve only, except at the largest flow rate. Thus the single vane increased the error in the flow meter measurements at 2-pipe diameters. Errors were less at 5-pipe diameters, but were still excessive for the propeller flow meter except at the highest flow rates.

TABLE 4. Errors with straightening vanes

Pipe diameters	Propeller Flow rate	Propeller Error	Paddle-wheel Flow rate	Paddle-wheel Error	Collins Flow rate	Collins Error	Hall Flow rate	Hall Error
	gal/min	%	gal/min	%	gal/min	%	gal/min	%
			Butterfly valve and single vane					
2	391	26	368	19.6	360	-19.1	390	8.7
5	384	17.2	360	19.4	368	-4.1	365	-2.5
2	664	8	643	56.6	636	-11	661	7.7
5	640	17.6	636	2.2	643	0	647	6.5
2	1,147	-3.5	1,156	21.6	1,149	5.2	1,140	-9.9
5	1,104	0.9	1,149	-1.7	1,156	-2.6	1,119	2
			Butterfly valve and 6 vanes					
2	436	10.1	362	10.5	355	16.3	446	18.8
5	362	-0.6	417	-11.3	446	-5.6	355	4.8
2	866	4.7	831	37	860	4.8	864	-12.6
5	881	3.2	866	7.3	864	0.8	860	-5.5
2	1,242	2.1	1,216	23.2	1,253	1.6	1,199	-12.7
5	1,232	3	1,270	-5.2	1,199	0	1,253	-12.1
			Butterfly valve, elbow and 6 vanes					
2	490	17.6	423	-7.8	382	13.1	404	29
5	42	8.8	409	-2.2	404	6.9	382	3.4
10	361	10.3		—		—		—
2	915	3.9	924	21.2	880	2.9	949	-12.8
5	840	4.6	902	-60	949	-5.9	880	-2.5
10	843	4.7	—	—	—	—		—
2	1,196	-7.4	1203	-3.8	1,204	-0.8	1,204	-6.4
5	1,078	3.1	1226	-18.5	1,204	5.9	1,204	-7.7
10	1,084	3.1	—	—		—	—	—

For the paddle-wheel meter, large errors occurred at 2-pipe diameters for all flow rates. No trend in decreasing error with increasing flow rate was found at 2-pipe diameters. Errors were smaller at 5-pipe diameters. Errors for the Collins and Hall meters were also larger than those for the valve-only condition.

Six vanes and butterfly valve. Turbulence was much less for the valve and the six-vane arrangement at 2-pipe diameters for all flow rates compared with the single-vane ar-

Attachment 3
Metergate Tables

ITRC Water Measurement Tables for
ROUND (Armco-Type) Gates on Round Pipes
Discharge Values in CFS

Normal submerged metergate operation

ITRC Water Measurement Tables – **12" Armco-Type Gate**, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																	
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00
0.08	0.07	0.16	0.25	0.34	0.42	0.48	0.55	0.61	0.67	0.73	0.79	0.85	0.97	1.10	1.20	1.27	1.32	1.34
0.10	0.08	0.18	0.28	0.38	0.47	0.54	0.61	0.68	0.75	0.81	0.89	0.96	1.09	1.23	1.34	1.42	1.47	1.50
0.13	0.09	0.20	0.31	0.42	0.51	0.59	0.67	0.74	0.82	0.89	0.97	1.05	1.19	1.35	1.46	1.56	1.61	1.64
0.15	0.09	0.21	0.33	0.45	0.55	0.64	0.72	0.80	0.88	0.96	1.05	1.13	1.28	1.46	1.58	1.68	1.74	1.77
0.17	0.10	0.23	0.36	0.49	0.59	0.68	0.77	0.86	0.94	1.03	1.12	1.21	1.37	1.56	1.69	1.80	1.86	1.89
0.19	0.10	0.24	0.38	0.52	0.63	0.72	0.82	0.91	1.00	1.09	1.19	1.28	1.46	1.66	1.79	1.91	1.98	2.01
0.21	0.11	0.25	0.40	0.54	0.66	0.76	0.87	0.96	1.06	1.15	1.25	1.35	1.53	1.74	1.89	2.01	2.08	2.12
0.23	0.12	0.26	0.42	0.57	0.69	0.80	0.91	1.00	1.11	1.20	1.31	1.42	1.61	1.83	1.98	2.11	2.19	2.22
0.25	0.12	0.28	0.44	0.60	0.72	0.84	0.95	1.05	1.16	1.26	1.37	1.48	1.68	1.91	2.07	2.21	2.28	2.32
0.27	0.13	0.29	0.45	0.62	0.75	0.87	0.99	1.09	1.20	1.31	1.43	1.54	1.75	1.99	2.16	2.30	2.38	2.41
0.29	0.13	0.30	0.47	0.64	0.78	0.90	1.02	1.13	1.25	1.36	1.48	1.60	1.82	2.06	2.24	2.38	2.47	2.50
0.31	0.14	0.31	0.49	0.67	0.81	0.94	1.06	1.17	1.29	1.41	1.53	1.66	1.88	2.14	2.32	2.47	2.55	2.59
0.33	0.14	0.32	0.50	0.69	0.84	0.97	1.09	1.21	1.34	1.45	1.58	1.71	1.94	2.21	2.39	2.55	2.64	2.68
0.35	0.14	0.33	0.52	0.71	0.86	1.00	1.13	1.25	1.38	1.50	1.63	1.76	2.00	2.27	2.46	2.63	2.72	2.76
0.38	0.15	0.34	0.53	0.73	0.89	1.03	1.16	1.28	1.42	1.54	1.68	1.81	2.06	2.34	2.54	2.70	2.80	2.84
0.40	0.15	0.35	0.55	0.75	0.91	1.05	1.19	1.32	1.46	1.58	1.73	1.86	2.12	2.40	2.61	2.78	2.87	2.92
0.42	0.16	0.36	0.56	0.77	0.93	1.08	1.22	1.35	1.49	1.62	1.77	1.91	2.17	2.47	2.67	2.85	2.95	2.99
0.46	0.16	0.37	0.59	0.81	0.98	1.13	1.28	1.42	1.57	1.70	1.86	2.00	2.28	2.59	2.80	2.99	3.09	3.14
0.50	0.17	0.39	0.62	0.84	1.02	1.18	1.34	1.48	1.64	1.78	1.94	2.09	2.38	2.70	2.93	3.12	3.23	3.28
0.54	0.18	0.41	0.64	0.88	1.06	1.23	1.40	1.54	1.70	1.85	2.02	2.18	2.47	2.81	3.05	3.25	3.36	3.41
0.58	0.19	0.42	0.66	0.91	1.10	1.28	1.45	1.60	1.77	1.92	2.10	2.26	2.57	2.92	3.16	3.37	3.49	3.54
0.63	0.19	0.44	0.69	0.94	1.14	1.32	1.50	1.66	1.83	1.99	2.17	2.34	2.66	3.02	3.27	3.49	3.61	3.67
0.67	0.20	0.45	0.71	0.97	1.18	1.37	1.55	1.71	1.89	2.06	2.24	2.42	2.75	3.12	3.38	3.60	3.73	3.79
0.71	0.20	0.46	0.73	1.00	1.22	1.41	1.60	1.76	1.95	2.12	2.31	2.49	2.83	3.22	3.49	3.71	3.84	3.90
0.75	0.21	0.48	0.75	1.03	1.25	1.45	1.64	1.82	2.00	2.18	2.38	2.56	2.91	3.31	3.59	3.82	3.96	4.02
0.79	0.22	0.49	0.77	1.06	1.29	1.49	1.69	1.87	2.06	2.24	2.44	2.63	2.99	3.40	3.68	3.93	4.06	4.13
0.83	0.22	0.50	0.79	1.09	1.32	1.53	1.73	1.91	2.11	2.30	2.50	2.70	3.07	3.49	3.78	4.03	4.17	4.23
0.92	0.23	0.53	0.83	1.14	1.39	1.60	1.82	2.01	2.22	2.41	2.63	2.83	3.22	3.66	3.97	4.22	4.37	4.44
1.00	0.24	0.55	0.87	1.19	1.45	1.67	1.90	2.10	2.31	2.52	2.74	2.96	3.36	3.82	4.14	4.41	4.57	4.64
1.08	0.25	0.57	0.91	1.24	1.51	1.74	1.97	2.18	2.41	2.62	2.86	3.08	3.50	3.98	4.31	4.59	4.75	4.83
1.17	0.26	0.60	0.94	1.29	1.56	1.81	2.05	2.26	2.50	2.72	2.96	3.20	3.63	4.13	4.47	4.77	4.93	5.01
1.25	0.27	0.62	0.97	1.33	1.62	1.87	2.12	2.34	2.59	2.81	3.07	3.31	3.76	4.27	4.63	4.93	5.11	5.19
1.33	0.28	0.64	1.00	1.37	1.67	1.93	2.19	2.42	2.67	2.91	3.17	3.42	3.88	4.41	4.78	5.09	5.27	5.36
1.42	0.29	0.66	1.04	1.42	1.72	1.99	2.26	2.50	2.75	3.00	3.27	3.52	4.00	4.55	4.93	5.25	5.44	5.52
1.50	0.30	0.68	1.07	1.46	1.77	2.05	2.32	2.57	2.83	3.08	3.36	3.63	4.12	4.68	5.07	5.40	5.59	5.68
1.58	0.30	0.69	1.09	1.50	1.82	2.11	2.39	2.64	2.91	3.17	3.45	3.73	4.23	4.81	5.21	5.55	5.75	5.84
1.67	0.31	0.71	1.12	1.54	1.87	2.16	2.45	2.71	2.99	3.25	3.54	3.82	4.34	4.93	5.35	5.70	5.90	5.99
1.75	0.32	0.73	1.15	1.57	1.91	2.21	2.51	2.77	3.06	3.33	3.63	3.92	4.45	5.06	5.48	5.84	6.04	6.14
1.83	0.33	0.75	1.18	1.61	1.96	2.27	2.57	2.84	3.13	3.41	3.71	4.01	4.55	5.18	5.61	5.97	6.18	6.28
1.92	0.34	0.76	1.20	1.65	2.00	2.32	2.63	2.90	3.20	3.48	3.80	4.10	4.66	5.29	5.73	6.11	6.32	6.42
2.00	0.34	0.78	1.23	1.68	2.05	2.37	2.68	2.96	3.27	3.56	3.88	4.19	4.76	5.41	5.86	6.24	6.46	6.56
2.08	0.35	0.80	1.26	1.72	2.09	2.42	2.74	3.03	3.34	3.63	3.96	4.27	4.85	5.52	5.98	6.37	6.59	6.69
2.17	0.36	0.81	1.28	1.75	2.13	2.46	2.79	3.09	3.41	3.70	4.04	4.36	4.95	5.63	6.10	6.49	6.72	6.83
2.25	0.36	0.83	1.31	1.79	2.17	2.51	2.84	3.14	3.47	3.78	4.11	4.44	5.04	5.73	6.21	6.62	6.85	6.96
2.33	0.37	0.84	1.33	1.82	2.21	2.56	2.90	3.20	3.53	3.84	4.19	4.52	5.14	5.84	6.33	6.74	6.98	7.09
2.42	0.38	0.86	1.35	1.85	2.25	2.60	2.95	3.26	3.60	3.91	4.26	4.60	5.23	5.94	6.44	6.86	7.10	7.21
2.50	0.38	0.87	1.38	1.88	2.29	2.65	3.00	3.31	3.66	3.98	4.34	4.68	5.32	6.04	6.55	6.98	7.22	7.33
2.58	0.39	0.89	1.40	1.91	2.33	2.69	3.05	3.37	3.72	4.05	4.41	4.76	5.40	6.14	6.66	7.09	7.34	7.45
2.67	0.40	0.90	1.42	1.94	2.36	2.73	3.10	3.42	3.78	4.11	4.48	4.84	5.49	6.24	6.76	7.20	7.46	7.57
2.75	0.40	0.91	1.44	1.97	2.40	2.78	3.15	3.48	3.84	4.17	4.55	4.91	5.58	6.34	6.87	7.32	7.57	7.69
2.83	0.41	0.93	1.46	2.00	2.44	2.82	3.19	3.53	3.89	4.24	4.62	4.98	5.66	6.43	6.97	7.43	7.69	7.81

ITRC Water Measurement Tables – 18" Armco-Type Gate, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																							
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50
0.04	0.07	0.16	0.25	0.35	0.44	0.52	0.61	0.68	0.75	0.81	0.87	0.93	1.05	1.17	1.29	1.40	1.54	1.67	1.81	1.95	2.05	2.14	2.17	2.17
0.06	0.08	0.20	0.31	0.43	0.54	0.64	0.74	0.84	0.92	1.00	1.07	1.14	1.29	1.43	1.58	1.72	1.88	2.05	2.22	2.39	2.51	2.62	2.66	2.66
0.08	0.10	0.23	0.36	0.50	0.62	0.74	0.86	0.96	1.06	1.15	1.24	1.31	1.49	1.65	1.82	1.98	2.18	2.36	2.57	2.76	2.90	3.02	3.07	3.07
0.10	0.11	0.25	0.40	0.56	0.70	0.83	0.96	1.08	1.19	1.29	1.38	1.47	1.67	1.85	2.04	2.22	2.43	2.64	2.87	3.09	3.24	3.38	3.43	3.43
0.13	0.12	0.28	0.44	0.61	0.76	0.91	1.05	1.18	1.30	1.41	1.51	1.61	1.83	2.03	2.23	2.43	2.66	2.89	3.14	3.38	3.55	3.70	3.76	3.76
0.15	0.13	0.30	0.48	0.66	0.82	0.98	1.13	1.28	1.40	1.52	1.63	1.73	1.97	2.19	2.41	2.62	2.88	3.12	3.39	3.65	3.84	4.00	4.06	4.06
0.17	0.14	0.32	0.51	0.70	0.88	1.05	1.21	1.36	1.50	1.63	1.75	1.85	2.11	2.34	2.58	2.80	3.08	3.34	3.63	3.90	4.10	4.27	4.34	4.34
0.19	0.15	0.34	0.54	0.75	0.93	1.11	1.28	1.45	1.59	1.73	1.85	1.97	2.24	2.48	2.74	2.97	3.26	3.54	3.85	4.14	4.35	4.53	4.60	4.61
0.21	0.15	0.36	0.57	0.79	0.98	1.17	1.35	1.52	1.68	1.82	1.95	2.07	2.36	2.62	2.88	3.13	3.44	3.74	4.06	4.36	4.58	4.78	4.85	4.85
0.23	0.16	0.37	0.60	0.82	1.03	1.23	1.42	1.60	1.76	1.91	2.05	2.17	2.47	2.74	3.02	3.29	3.61	3.92	4.25	4.58	4.81	5.01	5.08	5.09
0.25	0.17	0.39	0.62	0.86	1.08	1.28	1.48	1.67	1.84	2.00	2.14	2.27	2.58	2.87	3.16	3.43	3.77	4.09	4.44	4.78	5.02	5.23	5.31	5.32
0.27	0.17	0.41	0.65	0.90	1.12	1.34	1.54	1.74	1.91	2.08	2.23	2.36	2.69	2.98	3.29	3.57	3.92	4.26	4.62	4.98	5.23	5.44	5.53	5.54
0.29	0.18	0.42	0.67	0.93	1.16	1.39	1.60	1.80	1.99	2.16	2.31	2.45	2.79	3.10	3.41	3.71	4.07	4.42	4.80	5.16	5.42	5.65	5.74	5.74
0.31	0.19	0.44	0.70	0.96	1.20	1.44	1.66	1.87	2.06	2.23	2.39	2.54	2.89	3.20	3.53	3.84	4.21	4.57	4.97	5.35	5.62	5.85	5.94	5.95
0.33	0.19	0.45	0.72	0.99	1.24	1.48	1.71	1.93	2.12	2.30	2.47	2.62	2.98	3.31	3.65	3.96	4.35	4.72	5.13	5.52	5.80	6.04	6.13	6.14
0.35	0.20	0.46	0.74	1.02	1.28	1.53	1.76	1.99	2.19	2.38	2.55	2.70	3.07	3.41	3.76	4.09	4.48	4.87	5.29	5.69	5.98	6.23	6.32	6.33
0.38	0.21	0.48	0.76	1.05	1.32	1.57	1.82	2.05	2.25	2.44	2.62	2.78	3.16	3.51	3.87	4.20	4.61	5.01	5.44	5.86	6.15	6.41	6.50	6.51
0.40	0.21	0.49	0.78	1.08	1.36	1.62	1.87	2.10	2.31	2.51	2.69	2.86	3.25	3.61	3.98	4.32	4.74	5.15	5.59	6.02	6.32	6.58	6.68	6.69
0.42	0.22	0.50	0.81	1.11	1.39	1.66	1.91	2.16	2.37	2.58	2.76	2.93	3.33	3.70	4.08	4.43	4.86	5.28	5.74	6.17	6.48	6.75	6.86	6.87
0.46	0.23	0.53	0.84	1.17	1.46	1.74	2.01	2.26	2.49	2.70	2.90	3.08	3.50	3.88	4.28	4.65	5.10	5.54	6.02	6.47	6.80	7.08	7.19	7.20
0.50	0.24	0.55	0.88	1.22	1.52	1.82	2.10	2.36	2.60	2.82	3.03	3.21	3.65	4.05	4.47	4.85	5.33	5.79	6.28	6.76	7.10	7.40	7.51	7.52
0.54	0.25	0.57	0.92	1.27	1.59	1.89	2.18	2.46	2.71	2.94	3.15	3.34	3.80	4.22	4.65	5.05	5.55	6.02	6.54	7.04	7.39	7.70	7.82	7.83
0.58	0.26	0.60	0.95	1.31	1.65	1.96	2.26	2.55	2.81	3.05	3.27	3.47	3.94	4.38	4.83	5.24	5.75	6.25	6.79	7.30	7.67	7.99	8.11	8.12
0.63	0.26	0.62	0.99	1.36	1.70	2.03	2.34	2.64	2.91	3.16	3.38	3.59	4.08	4.53	5.00	5.43	5.96	6.47	7.02	7.56	7.94	8.27	8.40	8.41
0.67	0.27	0.64	1.02	1.41	1.76	2.10	2.42	2.73	3.00	3.26	3.49	3.71	4.22	4.68	5.16	5.61	6.15	6.68	7.25	7.81	8.20	8.54	8.67	8.68
0.71	0.28	0.66	1.05	1.45	1.81	2.16	2.50	2.81	3.10	3.36	3.60	3.82	4.35	4.82	5.32	5.78	6.34	6.89	7.48	8.05	8.45	8.81	8.94	8.95
0.75	0.29	0.68	1.08	1.49	1.87	2.23	2.57	2.89	3.19	3.46	3.71	3.93	4.47	4.96	5.47	5.95	6.53	7.09	7.70	8.28	8.70	9.06	9.20	9.21
0.79	0.30	0.69	1.11	1.53	1.92	2.29	2.64	2.97	3.27	3.55	3.81	4.04	4.59	5.10	5.62	6.11	6.70	7.28	7.91	8.51	8.94	9.31	9.45	9.46
0.83	0.31	0.71	1.14	1.57	1.97	2.35	2.71	3.05	3.36	3.64	3.91	4.15	4.71	5.23	5.77	6.27	6.88	7.47	8.11	8.73	9.17	9.55	9.70	9.71
0.92	0.32	0.75	1.19	1.65	2.06	2.46	2.84	3.20	3.52	3.82	4.10	4.35	4.94	5.49	6.05	6.57	7.21	7.83	8.51	9.15	9.62	10.02	10.17	10.18
1.00	0.34	0.78	1.25	1.72	2.15	2.57	2.97	3.34	3.68	3.99	4.28	4.54	5.16	5.73	6.32	6.86	7.53	8.18	8.89	9.56	10.04	10.46	10.62	10.64
1.08	0.35	0.81	1.30	1.79	2.24	2.67	3.09	3.48	3.83	4.15	4.45	4.73	5.37	5.96	6.58	7.15	7.84	8.52	9.25	9.95	10.45	10.89	11.05	11.07
1.17	0.36	0.84	1.35	1.86	2.33	2.78	3.20	3.61	3.97	4.31	4.62	4.91	5.58	6.19	6.83	7.41	8.14	8.84	9.60	10.33	10.85	11.30	11.47	11.49
1.25	0.37	0.87	1.39	1.92	2.41	2.87	3.32	3.73	4.11	4.46	4.78	5.08	5.77	6.41	7.06	7.68	8.42	9.15	9.93	10.69	11.23	11.70	11.87	11.89
1.33	0.39	0.90	1.44	1.99	2.49	2.97	3.42	3.86	4.25	4.61	4.94	5.25	5.96	6.62	7.30	7.93	8.70	9.45	10.26	11.04	11.60	12.08	12.26	12.28
1.42	0.40	0.93	1.49	2.05	2.56	3.06	3.53	3.98	4.38	4.75	5.09	5.41	6.15	6.82	7.52	8.17	8.97	9.74	10.58	11.38	11.96	12.45	12.64	12.66
1.50	0.41	0.96	1.53	2.11	2.64	3.15	3.63	4.09	4.51	4.89	5.24	5.56	6.32	7.02	7.74	8.41	9.23	10.02	10.88	11.71	12.30	12.81	13.01	13.03
1.58	0.42	0.98	1.57	2.17	2.71	3.23	3.73	4.20	4.63	5.02	5.39	5.72	6.50	7.21	7.95	8.64	9.48	10.30	11.18	12.03	12.64	13.17	13.36	13.38
1.67	0.43	1.01	1.61	2.22	2.78	3.32	3.83	4.31	4.75	5.15	5.53	5.86	6.67	7.40	8.16	8.86	9.73	10.56	11.47	12.34	12.97	13.51	13.71	13.73
1.75	0.44	1.03	1.65	2.28	2.85	3.40	3.92	4.42	4.87	5.28	5.66	6.01	6.83	7.58	8.36	9.08	9.97	10.83	11.75	12.65	13.29	13.84	14.05	14.07
1.83	0.45	1.06	1.69	2.33	2.92	3.48	4.01	4.52	4.98	5.40	5.79	6.15	6.99	7.76	8.56	9.29	10.20	11.08	12.03	12.95	13.60	14.17	14.38	14.40
1.92	0.46	1.08	1.73	2.38	2.98	3.56	4.11	4.62	5.09	5.53	5.93	6.29	7.15	7.93	8.75	9.50	10.43	11.33	12.30	13.24	13.91	14.48	14.70	14.72
2.00	0.47	1.10	1.76	2.43	3.05	3.63	4.19	4.72	5.20	5.64	6.05	6.42	7.30	8.10	8.94	9.71	10.66	11.57	12.57	13.52	14.20	14.80	15.02	15.04
2.08	0.48	1.13	1.80	2.48	3.11	3.71	4.28	4.82	5.31	5.76	6.18	6.56	7.45	8.27	9.12	9.91	10.88	11.81	12.83	13.80	14.50	15.10	15.33	15.35
2.17	0.49	1.15	1.84	2.53	3.17	3.78	4.36	4.92	5.41	5.88	6.30	6.69	7.60	8.44	9.30	10.10	11.09	12.05	13.08	14.07	14.79	15.40	15.63	15.66
2.25	0.50	1.17	1.87	2.58	3.23	3.85	4.45	5.01	5.52	5.99	6.42	6.81	7.75	8.60	9.48	10.30	11.30	12.27	13.33	14.34	15.07	15.69	15.93	15.95
2.33	0.51	1.19	1.91	2.63	3.29	3.93	4.53	5.10	5.62	6.10	6.54	6.94	7.89	8.75	9.65	10.49	11.51	12.50	13.57	14.61	15.34	15.98	16.22	16.25
2.42	0.52	1.21	1.94	2.68	3.35	3.99	4.61	5.19	5.72	6.21	6.65	7.06	8.03	8.91	9.82	10.67	11.71	12.72	13.81	14.86	15.61	16.26	16.51	16.53
2.50	0.53	1.23	1.97	2.72	3.41	4.06	4.69	5.28	5.82	6.31	6.77	7.18	8.16	9.06	9.99	10.85	11.91	12.94	14.05	15.12	15.88	16.54	16.79	16.82
2.58	0.54	1.26	2.01	2.77	3.46	4.13	4.77	5.37	5.91	6.42	6.88	7.30	8.30	9.21	10.16	11.03	12.11	13.15	14.28	15.37	16.14	16.82	17.07	17.09
2.67	0.55	1.28	2.04	2.81	3.52	4.20	4.84	5.45	6.01	6.52	6.99	7.42	8.43	9.36	10.32	11.21	12.30	13.36	14.51	15.61	16.40	17.09	17.34	17.37
2.75	0.56	1.30	2.07	2.85	3.57	4.26	4.92	5.54	6.10	6.62	7.10	7.53	8.56	9.50	10.48	11.38	12.50	13.57	14.73	15.86	16.66	17.35	17.61	17.64
2.83	0.56	1.31	2.10	2.90	3.63	4.33	4.99	5.62	6.19	6.72	7.20	7.65	8.69	9.65	10.64	11.56	12.68	13.77	14.96	16.09	16.91	17.61	17.88	17.90

ITRC Water Measurement Tables – 24" Armco-Type Gate, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																												
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
0.04	0.10	0.22	0.35	0.49	0.61	0.73	0.84	0.95	1.05	1.14	1.23	1.31	1.49	1.65	1.81	1.96	2.14	2.32	2.45	2.57	2.71	2.85	3.01	3.16	3.30	3.51	3.68	3.71	3.77	3.57
0.06	0.12	0.27	0.43	0.60	0.75	0.89	1.03	1.17	1.29	1.40	1.51	1.61	1.82	2.02	2.22	2.40	2.63	2.84	3.00	3.14	3.32	3.49	3.68	3.87	4.04	4.30	4.51	4.54	4.62	4.37
0.08	0.14	0.31	0.50	0.69	0.86	1.03	1.19	1.35	1.49	1.62	1.74	1.85	2.10	2.33	2.56	2.78	3.03	3.28	3.46	3.63	3.84	4.03	4.25	4.47	4.67	4.97	5.20	5.24	5.34	5.04
0.10	0.15	0.35	0.56	0.77	0.96	1.15	1.33	1.51	1.66	1.81	1.95	2.07	2.35	2.61	2.87	3.10	3.39	3.67	3.87	4.06	4.29	4.51	4.76	4.99	5.22	5.56	5.82	5.86	5.97	5.64
0.13	0.17	0.39	0.61	0.84	1.06	1.26	1.46	1.65	1.82	1.98	2.13	2.27	2.58	2.86	3.14	3.40	3.71	4.02	4.24	4.44	4.70	4.94	5.21	5.47	5.72	6.09	6.37	6.42	6.54	6.18
0.15	0.18	0.42	0.66	0.91	1.14	1.36	1.58	1.78	1.97	2.14	2.30	2.45	2.78	3.09	3.39	3.67	4.01	4.34	4.58	4.80	5.07	5.33	5.63	5.91	6.17	6.57	6.88	6.93	7.06	6.67
0.17	0.19	0.44	0.71	0.97	1.22	1.46	1.69	1.91	2.10	2.29	2.46	2.62	2.98	3.30	3.63	3.93	4.29	4.64	4.90	5.13	5.43	5.70	6.02	6.32	6.60	7.03	7.36	7.41	7.55	7.13
0.19	0.20	0.47	0.75	1.03	1.29	1.55	1.79	2.02	2.23	2.43	2.61	2.78	3.16	3.50	3.85	4.17	4.55	4.92	5.20	5.44	5.75	6.05	6.38	6.70	7.00	7.45	7.81	7.86	8.01	7.56
0.21	0.22	0.50	0.79	1.09	1.36	1.63	1.89	2.13	2.35	2.56	2.75	2.93	3.33	3.69	4.05	4.39	4.80	5.19	5.48	5.74	6.07	6.38	6.73	7.06	7.38	7.86	8.23	8.29	8.44	7.97
0.23	0.23	0.52	0.83	1.14	1.43	1.71	1.98	2.23	2.47	2.68	2.89	3.07	3.49	3.87	4.25	4.61	5.03	5.44	5.74	6.02	6.36	6.69	7.05	7.41	7.74	8.24	8.63	8.69	8.85	8.36
0.25	0.24	0.54	0.87	1.19	1.49	1.78	2.07	2.33	2.58	2.80	3.02	3.21	3.65	4.04	4.44	4.81	5.25	5.68	6.00	6.28	6.64	6.98	7.37	7.74	8.08	8.61	9.01	9.08	9.24	8.74
0.27	0.25	0.57	0.90	1.24	1.55	1.86	2.15	2.43	2.68	2.92	3.14	3.34	3.79	4.21	4.62	5.01	5.47	5.92	6.24	6.54	6.92	7.27	7.67	8.05	8.41	8.96	9.38	9.45	9.62	9.09
0.29	0.26	0.59	0.94	1.29	1.61	1.93	2.23	2.52	2.78	3.03	3.26	3.47	3.94	4.37	4.80	5.20	5.67	6.14	6.48	6.79	7.18	7.54	7.96	8.36	8.73	9.30	9.74	9.80	9.98	9.43
0.31	0.26	0.61	0.97	1.33	1.67	2.00	2.31	2.61	2.88	3.13	3.37	3.59	4.08	4.52	4.96	5.38	5.87	6.36	6.71	7.03	7.43	7.81	8.24	8.65	9.04	9.62	10.08	10.15	10.33	9.77
0.33	0.27	0.63	1.00	1.38	1.72	2.06	2.38	2.69	2.97	3.24	3.48	3.71	4.21	4.67	5.13	5.55	6.07	6.56	6.93	7.26	7.67	8.06	8.51	8.93	9.33	9.94	10.41	10.48	10.67	10.09
0.35	0.28	0.65	1.03	1.42	1.78	2.12	2.46	2.78	3.07	3.34	3.59	3.82	4.34	4.81	5.29	5.72	6.25	6.77	7.14	7.48	7.91	8.31	8.77	9.21	9.62	10.25	10.73	10.80	11.00	10.40
0.38	0.29	0.67	1.06	1.46	1.83	2.19	2.53	2.86	3.16	3.43	3.69	3.93	4.46	4.95	5.44	5.89	6.43	6.96	7.35	7.70	8.14	8.55	9.02	9.47	9.90	10.54	11.04	11.12	11.32	10.70
0.40	0.30	0.69	1.09	1.50	1.88	2.25	2.60	2.94	3.24	3.53	3.79	4.04	4.59	5.09	5.59	6.05	6.61	7.15	7.55	7.91	8.36	8.79	9.27	9.73	10.17	10.83	11.34	11.42	11.63	10.99
0.42	0.31	0.70	1.12	1.54	1.93	2.30	2.67	3.01	3.33	3.62	3.89	4.15	4.71	5.22	5.73	6.21	6.78	7.34	7.75	8.11	8.58	9.02	9.51	9.99	10.44	11.11	11.64	11.72	11.93	11.28
0.46	0.32	0.74	1.17	1.61	2.02	2.42	2.80	3.16	3.49	3.80	4.08	4.35	4.94	5.47	6.01	6.51	7.11	7.70	8.12	8.51	9.00	9.46	9.98	10.47	10.94	11.66	12.20	12.29	12.52	11.83
0.50	0.33	0.77	1.22	1.69	2.11	2.52	2.92	3.30	3.64	3.96	4.26	4.54	5.16	5.72	6.28	6.80	7.43	8.04	8.48	8.89	9.40	9.88	10.42	10.94	11.43	12.17	12.75	12.84	13.07	12.35
0.54	0.35	0.80	1.27	1.75	2.20	2.63	3.04	3.44	3.79	4.13	4.44	4.73	5.37	5.95	6.54	7.08	7.73	8.37	8.83	9.25	9.78	10.28	10.85	11.39	11.90	12.67	13.27	13.36	13.61	12.86
0.58	0.36	0.83	1.32	1.82	2.28	2.73	3.15	3.56	3.94	4.28	4.61	4.91	5.57	6.17	6.78	7.35	8.03	8.68	9.16	9.60	10.15	10.67	11.26	11.82	12.35	13.15	13.77	13.87	14.12	13.34
0.63	0.37	0.86	1.37	1.88	2.36	2.82	3.27	3.69	4.07	4.43	4.77	5.08	5.76	6.39	7.02	7.61	8.31	8.99	9.49	9.94	10.51	11.04	11.65	12.23	12.78	13.61	14.25	14.35	14.62	13.81
0.67	0.39	0.89	1.41	1.95	2.44	2.91	3.37	3.81	4.21	4.58	4.92	5.24	5.95	6.60	7.25	7.85	8.58	9.28	9.80	10.26	10.85	11.41	12.03	12.63	13.20	14.06	14.72	14.82	15.10	14.26
0.71	0.40	0.92	1.46	2.01	2.51	3.00	3.48	3.93	4.34	4.72	5.08	5.41	6.14	6.80	7.47	8.10	8.84	9.57	10.10	10.58	11.18	11.76	12.40	13.02	13.61	14.49	15.17	15.28	15.56	14.70
0.75	0.41	0.94	1.50	2.06	2.59	3.09	3.58	4.04	4.46	4.86	5.22	5.56	6.31	7.00	7.69	8.33	9.10	9.85	10.39	10.89	11.51	12.10	12.76	13.40	14.00	14.91	15.61	15.72	16.01	15.13
0.79	0.42	0.97	1.54	2.12	2.66	3.18	3.67	4.15	4.58	4.99	5.37	5.71	6.49	7.19	7.90	8.56	9.35	10.12	10.68	11.18	11.82	12.43	13.11	13.77	14.38	15.32	16.04	16.15	16.45	15.54
0.83	0.43	0.99	1.58	2.18	2.73	3.26	3.77	4.26	4.70	5.12	5.50	5.86	6.66	7.38	8.11	8.78	9.59	10.38	10.95	11.47	12.13	12.75	13.45	14.12	14.76	15.72	16.46	16.57	16.88	15.95
0.92	0.45	1.04	1.66	2.28	2.86	3.42	3.95	4.47	4.93	5.37	5.77	6.15	6.98	7.74	8.50	9.21	10.06	10.88	11.49	12.03	12.72	13.37	14.11	14.81	15.48	16.48	17.26	17.38	17.70	16.73
1.00	0.47	1.09	1.73	2.38	2.99	3.57	4.13	4.67	5.15	5.61	6.03	6.42	7.29	8.08	8.88	9.62	10.51	11.37	12.00	12.57	13.29	13.97	14.74	15.47	16.17	17.22	18.03	18.15	18.49	17.47
1.08	0.49	1.13	1.80	2.48	3.11	3.72	4.30	4.86	5.36	5.84	6.28	6.69	7.59	8.41	9.24	10.01	10.94	11.83	12.49	13.08	13.83	14.54	15.34	16.10	16.83	17.92	18.76	18.90	19.24	18.18
1.17	0.51	1.18	1.87	2.57	3.23	3.86	4.46	5.04	5.57	6.06	6.51	6.94	7.87	8.73	9.59	10.39	11.35	12.28	12.96	13.58	14.35	15.09	15.92	16.71	17.46	18.60	19.47	19.61	19.97	18.87
1.25	0.53	1.22	1.94	2.66	3.34	3.99	4.62	5.22	5.76	6.27	6.74	7.18	8.15	9.04	9.93	10.76	11.75	12.71	13.41	14.05	14.86	15.62	16.48	17.30	18.07	19.25	20.15	20.30	20.67	19.53
1.33	0.55	1.26	2.00	2.75	3.45	4.12	4.77	5.39	5.95	6.47	6.96	7.42	8.42	9.33	10.26	11.11	12.13	13.13	13.85	14.51	15.34	16.13	17.02	17.87	18.67	19.88	20.81	20.96	21.35	20.17
1.42	0.56	1.30	2.06	2.84	3.56	4.25	4.92	5.56	6.13	6.67	7.18	7.64	8.68	9.62	10.57	11.45	12.51	13.53	14.28	14.96	15.82	16.63	17.54	18.42	19.24	20.49	21.46	21.61	22.00	20.79
1.50	0.58	1.33	2.12	2.92	3.66	4.37	5.06	5.72	6.31	6.87	7.39	7.87	8.93	9.90	10.88	11.78	12.87	13.92	14.70	15.40	16.28	17.11	18.05	18.95	19.80	21.09	22.08	22.24	22.64	21.40
1.58	0.59	1.37	2.18	3.00	3.76	4.49	5.20	5.87	6.48	7.06	7.59	8.08	9.17	10.17	11.18	12.10	13.22	14.31	15.10	15.82	16.72	17.58	18.54	19.47	20.34	21.66	22.68	22.84	23.26	21.98
1.67	0.61	1.41	2.24	3.08	3.86	4.61	5.33	6.03	6.65	7.24	7.79	8.29	9.41	10.44	11.47	12.42	13.56	14.68	15.49	16.23	17.16	18.03	19.03	19.97	20.87	22.23	23.27	23.44	23.87	22.55
1.75	0.63	1.44	2.29	3.15	3.95	4.72	5.46	6.17	6.82	7.42	7.98	8.50	9.64	10.69	11.75	12.73	13.90	15.04	15.87	16.63	17.58	18.48	19.50	20.47	21.39	22.77	23.85	24.02	24.46	23.11
1.83	0.64	1.48	2.35	3.23	4.04	4.83	5.59	6.32	6.98	7.59	8.17	8.70	9.87	10.95	12.03	13.03	14.23	15.39	16.25	17.02	17.99	18.91	19.95	20.95	21.89	23.31	24.41	24.58	25.03	23.65
1.92	0.65	1.51	2.40	3.30	4.14	4.94	5.72	6.46	7.13	7.76	8.35	8.89	10.09	11.19	12.30	13.32	14.55	15.74	16.61	17.40	18.40	19.34	20.40	21.42	22.38	23.83	24.96	25.13	25.60	24.19
2.00	0.67	1.54	2.45	3.37	4.22	5.05	5.84	6.60	7.29	7.93	8.53	9.08	10.31	11.43	12.56	13.60	14.86	16.08	16.97	17.78	18.79	19.75	20.84	21.88	22.86	24.35	25.49	25.67	26.15	24.71
2.08	0.68	1.57	2.50	3.44	4.31	5.15	5.96	6.74	7.44	8.09	8.70	9.27	10.52	11.67	12.82	13.88	15.17	16.41	17.32	18.14	19.18	20.16	21.27	22.33	23.33	24.85	26.02	26.20	26.68	25.22
2.17	0.70	1.60	2.55	3.51	4.40	5.25	6.08	6.87	7.58	8.25	8.88	9.45	10.73	11.90	13.07	14.16	15.47	16.73	17.66	18.50	19.56	20.56	21.69	22.77	23.80	25.34	26.53	26.72	27.21	25.72
2.25	0.71	1.63	2.60	3.58	4.48	5.35	6.20	7.00	7.73	8.41	9.05	9.63	10.94	12.13	13.32	14.43	15.76	17.05	18.00	18.85	19.93	20.95	22.11	23.21	24.25	25.82	27.04	27.23	27.73	26.21
2.33	0.72	1.66	2.65	3.64	4.56	5.45	6.31	7.13	7.87	8.56	9.21	9.81	11.14	12.35	13.57	14.69	16.05	17.37	18.33	19.20	20.30	21.34	22.51	23.63	24.69	26.30	27.54	27.73	28.24	26.69
2.42	0.73	1.69	2.69	3.71	4.64	5.55	6.42	7.26	8.01	8.72	9.37	9.98	11.33	12.57	13.81	14.95	16.33	17.67	18.65	19.54	20.66	21.71	22.91	24.05	25.13	26.76	28.02	28.22	28.74	27.16
2.50	0.75	1.72	2.74	3.77	4.72	5.64	6.53	7.38	8.15	8.87	9.53	10.16	11.53	12.78	14.04	15.21	16.61	17.98	18.97	19.87	21.01	22.09	23.30	24.46	25.56	27.22	28.50	28.71	29.23	27.62
2.58	0.76	1.75	2.78	3.83	4.80	5.74	6.64	7.50	8.28	9.01	9.69	10.32	11.72	12.99	14.28	15.46	16.89	18.27	19.29	20.20	21.36	22.45	23.69	24.87	25.98	27.67	28.97	29.18	29.71	28.08
2.67	0.77	1.78	2.83	3.89	4.88	5.83	6.74	7.62	8.41	9.16	9.85	10.49	11.91	13.20	14.50	15.71	17.16	18.56	19.59	20.53	21.70	22.81	24.07	25.27	26.40	28.11	29.44	29.65	30.19	28.53
2.75	0.78	1.81	2.87	3.95	4.95	5.92	6.85	7.74	8.54	9.30	10.00	10.65	12.09	13.41	14.73	15.95	17.42	18.85	19.90	20.84	22.04	23.16	24.44	25.66	26.81	28.55	29.89	30.11	30.66	28.97
2.83	0.80	1.83	2.92	4.01	5.03	6.01	6.95	7.86	8.67	9.44	10.15	10.81	12.27	13.61	14.95	16.19	17.69	19.14	20.20	21.16	22.37	23.51	24.81	26.04	27.21	28.98	30.34	30.56	31.12	29.41

Preliminary Tables for

Round Gates on Round Pipes

Discharge Values in CFS

Normal submerged metergate operation

These tables are from the original ARMCO Flow Measurement Tables and will be replaced as these gate sizes are tested by ITRC

Armco-Type Metergate Tables - Preliminary

8-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)												
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.54	0.58	0.63	0.67
	Discharge (CFS)												
0.08	0.27	0.32	0.38	0.42	0.46	0.51	0.55	0.57	0.59	0.61	0.62	0.63	0.64
0.10	0.30	0.36	0.42	0.46	0.51	0.56	0.60	0.63	0.65	0.68	0.70	0.71	0.71
0.13	0.32	0.39	0.46	0.50	0.56	0.61	0.67	0.69	0.72	0.75	0.77	0.78	0.78
0.15	0.35	0.42	0.49	0.54	0.60	0.66	0.72	0.75	0.78	0.81	0.83	0.84	0.85
0.17	0.37	0.44	0.52	0.58	0.64	0.70	0.76	0.80	0.83	0.86	0.89	0.90	0.91
0.19	0.39	0.46	0.54	0.61	0.67	0.74	0.80	0.84	0.88	0.92	0.94	0.96	0.97
0.21	0.41	0.49	0.57	0.64	0.70	0.77	0.85	0.89	0.93	0.96	1.00	1.01	1.02
0.23	0.42	0.51	0.60	0.66	0.74	0.81	0.88	0.93	0.97	1.01	1.04	1.06	1.07
0.25	0.44	0.53	0.62	0.70	0.76	0.84	0.92	0.97	1.02	1.06	1.09	1.11	1.12
0.27	0.46	0.55	0.64	0.72	0.79	0.87	0.95	1.01	1.06	1.10	1.13	1.15	1.16
0.29	0.47	0.57	0.67	0.74	0.82	0.90	0.99	1.05	1.10	1.14	1.18	1.20	1.21
0.31	0.49	0.59	0.69	0.77	0.85	0.93	1.02	1.08	1.14	1.18	1.22	1.24	1.26
0.33	0.50	0.60	0.71	0.79	0.88	0.96	1.05	1.12	10.18	1.22	1.26	1.28	1.30
0.35	0.52	0.62	0.73	0.82	0.90	0.99	1.08	1.15	1.22	1.26	1.30	1.33	1.34
0.38	0.53	0.64	0.75	0.84	0.92	1.02	1.11	1.19	1.25	1.30	1.34	1.37	1.38
0.40	0.54	0.65	0.76	0.86	0.95	1.04	1.14	1.22	1.29	1.34	1.38	1.41	1.42
0.42	0.56	0.67	0.78	0.88	0.97	1.07	1.17	1.25	1.32	1.37	1.42	1.44	1.46
0.46	0.58	0.70	0.81	0.91	1.01	1.12	1.22	1.31	1.38	1.44	1.49	1.52	1.54
0.50	0.60	0.72	0.84	0.95	1.06	1.17	1.27	1.36	1.44	1.50	1.55	1.58	1.60
0.54	0.62	0.75	0.87	0.99	1.10	1.22	1.32	1.42	1.50	1.56	1.61	1.65	1.67
0.58	0.64	0.77	0.90	1.03	1.15	1.26	1.37	1.47	1.55	1.62	1.67	1.71	1.74
0.63	0.66	0.80	0.94	1.06	1.19	1.31	1.42	1.53	1.61	1.68	1.73	1.77	1.80
0.67	0.68	0.82	0.96	1.10	1.22	1.35	1.47	1.58	1.66	1.73	1.79	1.83	1.86
0.71	0.70	0.85	1.00	1.13	1.26	1.39	1.52	1.62	1.71	1.78	1.84	1.88	1.92
0.75	0.72	0.87	1.02	1.16	1.30	1.43	1.56	14.67	1.76	1.84	1.89	1.94	1.97
0.79	0.74	0.90	1.05	1.19	1.33	1.47	1.60	1.72	1.81	1.89	1.94	1.99	2.02
0.83	0.76	0.92	1.08	1.22	1.37	1.51	1.64	1.76	1.85	1.94	1.99	2.04	2.08
0.92	0.79	0.96	1.13	1.28	1.44	1.58	1.72	1.85	1.94	2.03	2.09	2.14	2.18
1.00	0.83	1.01	1.18	1.34	1.50	1.66	1.80	1.93	2.03	2.12	2.18	2.24	2.27
1.08	0.86	1.05	1.23	1.40	1.56	1.72	1.87	2.01	2.12	2.21	2.29	2.33	2.37
1.17	0.89	1.09	1.28	1.45	1.62	1.79	1.94	2.08	2.20	2.29	2.36	2.42	2.46
1.25	0.92	1.13	1.32	1.50	1.68	1.85	2.01	2.16	2.27	2.37	2.44	2.50	2.54
1.33	0.95	1.16	1.37	1.55	1.73	1.91	2.08	2.23	2.35	2.45	2.52	2.58	2.62
1.42	0.98	1.20	1.41	1.60	1.78	1.97	2.14	2.30	2.42	2.52	2.60	2.66	2.71
1.50	1.01	1.23	1.45	1.64	1.84	2.03	2.20	2.36	2.49	2.60	2.68	2.74	2.79

Armco-Type Metergate Tables - Preliminary

15-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																	
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25
	Discharge (CFS)																	
0.08	0.46	0.57	0.66	0.75	0.83	0.91	0.98	1.07	1.14	1.30	1.43	1.58	1.71	1.84	1.94	2.04	2.13	2.18
0.10	0.51	0.62	0.73	0.83	0.92	1.02	1.09	1.19	1.27	1.44	1.59	1.75	1.90	2.05	2.17	2.29	2.38	2.43
0.13	0.55	0.67	0.79	0.91	1.00	1.11	1.19	1.30	1.38	1.57	1.74	1.91	2.08	2.24	2.38	2.51	2.62	2.67
0.15	0.59	0.72	0.85	0.98	1.08	1.19	1.28	1.39	1.49	1.68	1.87	2.06	2.24	2.41	2.57	2.72	2.83	2.90
0.17	0.63	0.77	0.90	1.04	1.15	1.27	1.37	1.48	1.59	1.79	1.99	2.20	2.39	2.58	2.75	2.90	3.03	3.09
0.19	0.67	0.81	0.95	1.10	1.22	1.34	1.45	1.57	1.48	1.89	2.11	2.33	2.54	2.73	2.91	3.07	3.22	3.28
0.21	0.70	0.85	1.00	1.15	1.28	1.41	1.53	1.65	1.76	1.99	2.22	2.45	2.68	2.87	3.07	3.24	3.40	3.46
0.23	0.73	0.89	1.05	1.20	1.33	1.48	1.60	1.73	1.84	2.09	2.33	2.57	2.81	3.01	3.21	3.40	3.57	6.64
0.25	0.76	3.93	1.09	1.25	1.38	1.54	1.67	1.80	1.92	2.18	2.43	2.69	2.93	3.14	3.35	3.54	3.73	3.81
0.27	0.79	0.97	1.13	1.29	1.43	1.60	1.73	1.87	2.00	2.27	2.53	2.80	3.05	3.27	3.49	3.68	3.88	3.97
0.29	0.82	1.00	1.17	1.33	1.48	1.65	1.79	1.94	2.08	2.36	2.63	2.90	3.17	3.39	3.62	3.82	4.01	4.11
0.31	0.85	1.03	1.21	1.37	1.53	1.70	1.85	2.01	2.15	2.44	2.72	3.00	3.28	3.51	3.75	3.96	4.14	4.25
0.33	0.88	1.06	1.25	1.41	1.58	1.75	1.91	2.07	1.22	2.52	2.81	3.10	3.39	3.63	3.87	4.09	4.27	4.39
0.35	0.91	1.09	1.29	1.45	1.63	1.80	1.97	2.13	2.29	2.60	2.90	3.20	3.49	3.74	3.99	4.21	4.40	4.53
0.38	0.93	1.12	1.32	1.49	1.68	1.85	2.03	2.19	2.36	2.68	2.98	3.29	3.59	3.85	4.10	4.33	4.53	4.67
0.40	0.95	1.15	1.35	1.53	1.73	1.90	2.09	2.25	2.42	2.75	3.06	3.38	3.69	3.96	4.21	4.45	4.65	4.80
0.42	0.97	1.18	1.38	1.57	1.77	1.95	2.14	2.31	2.48	2.82	3.14	3.47	3.79	4.06	2.32	4.57	4.77	4.92
0.46	1.01	1.23	1.44	1.64	1.85	2.05	2.24	2.43	2.60	2.96	3.30	3.63	3.97	4.26	4.54	4.79	5.00	5.14
0.50	1.05	1.28	1.50	1.71	1.93	2.14	2.34	2.54	2.72	3.09	3.44	3.79	4.15	4.44	4.74	5.00	5.22	5.36
0.54	1.09	1.33	1.56	1.78	2.01	2.23	2.44	2.64	2.83	3.22	3.58	3.95	4.32	4.62	4.93	5.20	5.43	5.58
0.58	1.13	1.38	1.62	1.85	2.09	2.31	2.53	2.74	2.93	3.34	3.72	4.10	4.48	4.79	5.11	5.40	5.64	5.79
0.63	1.17	1.42	1.68	1.92	2.16	2.39	2.62	2.84	3.03	3.46	2.85	4.25	4.64	4.96	5.29	5.59	5.84	5.99
0.67	1.21	1.46	1.73	1.98	2.23	2.47	2.71	2.93	3.13	3.57	2.98	4.39	4.79	5.13	5.47	5.78	6.03	6.19
0.71	1.24	1.50	1.78	2.04	2.30	2.55	2.79	3.02	3.23	3.68	4.10	4.52	4.93	5.29	5.64	5.95	6.22	6.38
0.75	1.27	1.54	1.83	2.10	2.37	2.62	2.87	3.11	3.33	3.79	4.22	4.65	5.07	5.44	5.80	6.12	6.40	6.56
0.79	1.30	1.58	1.88	2.16	2.43	2.69	2.95	3.19	3.42	3.89	4.34	4.78	5.21	5.59	5.96	6.29	6.58	6.74
0.83	1.33	1.62	1.93	2.22	2.49	2.76	3.03	3.27	3.51	3.99	4.45	4.91	5.35	5.73	6.11	6.46	6.75	6.92
0.92	1.39	1.70	2.03	2.32	2.61	2.90	3.17	3.43	3.68	4.18	4.66	5.14	5.61	6.01	6.41	6.77	7.07	7.26
1.00	1.45	1.78	2.12	2.42	2.73	3.03	3.31	3.59	3.84	4.37	4.87	5.37	5.86	6.29	6.70	7.07	7.39	7.59
1.08	1.50	1.85	2.21	2.52	2.84	3.15	3.45	3.73	4.00	4.55	5.07	5.59	6.10	6.54	6.97	7.36	7.69	7.89
1.17	1.55	1.92	2.29	2.62	2.95	2.37	3.58	3.87	4.15	4.72	5.26	5.80	6.34	6.79	7.24	7.64	7.98	8.19
1.25	1.60	1.99	2.37	2.71	3.05	3.38	3.70	4.01	4.30	4.88	5.44	6.00	6.56	7.03	7.49	7.91	8.26	8.47
1.33	1.65	2.05	2.45	2.80	3.15	3.49	3.82	4.14	4.44	5.04	5.62	6.20	6.77	7.26	7.73	8.17	8.53	8.75
1.42	1.70	2.11	2.52	2.89	3.25	3.60	3.94	4.27	4.57	5.20	5.80	6.39	6.98	7.48	7.97	8.42	8.80	9.02
1.50	1.75	2.17	2.59	2.97	3.34	3.70	4.05	4.39	4.70	5.35	5.96	6.58	7.18	7.69	8.20	8.66	9.05	9.28

Armco-Type Metergate Tables - Preliminary

16-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																		
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33
	Discharge (CFS)																		
0.08	0.49	0.59	0.70	0.79	0.89	0.97	1.05	1.14	1.22	1.37	1.53	1.68	1.83	1.96	2.10	2.24	2.35	2.43	2.47
0.10	0.55	0.66	0.77	0.88	0.98	1.08	1.16	1.27	1.36	1.52	1.70	1.87	2.04	2.19	2.34	2.50	2.63	2.72	2.78
0.13	0.59	0.72	0.84	0.96	1.07	1.18	1.27	1.39	1.48	1.66	1.86	2.04	2.22	2.39	2.56	2.74	2.89	2.98	3.05
0.15	0.63	0.77	0.90	1.03	1.15	1.27	1.37	1.49	1.59	1.79	1.99	2.20	2.40	2.57	2.76	2.96	3.12	3.23	3.31
0.17	0.67	0.82	0.96	1.10	1.23	1.35	1.46	1.59	1.69	1.91	2.12	2.34	2.56	2.74	2.94	3.16	3.31	3.46	3.54
0.19	0.71	0.86	1.02	1.16	1.30	1.43	1.54	1.68	1.79	2.02	2.25	2.48	2.71	2.91	3.11	3.33	3.50	3.66	3.75
0.21	0.75	0.90	1.07	1.21	1.36	1.50	1.62	1.76	1.89	2.13	2.37	2.61	2.85	3.08	3.28	3.50	3.68	3.85	3.95
0.23	0.78	0.94	1.12	1.26	1.42	1.57	1.69	1.84	1.98	2.23	2.49	2.74	2.99	3.23	3.44	3.67	3.86	4.03	4.14
0.25	0.81	0.98	1.16	1.31	1.48	1.64	1.76	1.92	2.06	2.33	2.60	2.86	3.12	3.37	3.59	3.83	4.04	4.20	4.33
0.27	0.84	1.02	1.20	1.36	1.54	1.70	1.84	2.00	2.14	2.43	2.71	2.98	3.25	3.51	3.74	3.99	4.20	4.37	4.51
0.29	0.87	1.06	1.24	1.41	1.59	1.75	1.91	2.08	2.22	2.52	2.81	3.09	3.37	3.64	3.88	4.14	4.36	4.53	4.69
0.31	0.90	1.09	1.28	1.46	1.64	1.81	1.98	2.15	2.30	2.61	2.91	3.20	3.49	3.77	4.02	4.28	4.52	4.69	4.86
0.33	0.93	1.12	1.32	1.51	1.69	1.87	2.05	2.22	2.38	2.69	3.00	3.31	3.61	3.89	4.15	4.42	4.67	4.85	5.02
0.35	0.96	1.15	1.36	1.56	1.74	1.93	2.11	2.29	2.45	2.77	3.09	3.41	3.72	4.01	4.28	4.56	4.81	5.00	5.18
0.38	0.99	1.18	1.40	1.61	1.79	1.99	2.17	2.36	2.52	2.85	3.18	3.51	3.83	4.13	4.40	4.69	4.95	5.15	5.32
0.40	1.02	1.21	1.44	1.65	1.84	2.04	2.23	2.42	2.59	2.93	3.27	3.61	3.94	4.24	4.52	4.82	5.09	5.29	5.46
0.42	1.04	1.24	1.48	1.69	1.89	2.09	2.29	2.48	2.66	3.01	3.36	3.70	4.04	4.35	4.64	4.95	5.22	5.43	5.59
0.46	1.08	1.30	1.55	1.76	1.98	2.19	2.40	2.60	2.79	3.16	3.52	3.88	4.24	4.56	4.87	5.19	5.47	5.69	5.85
0.50	1.12	1.36	1.61	1.83	2.07	2.28	2.50	2.71	2.91	3.30	3.68	4.05	4.42	4.76	5.08	5.42	5.71	5.94	6.10
0.54	1.16	1.41	1.67	1.90	2.15	2.37	2.60	2.82	3.03	3.43	3.83	4.21	4.60	4.96	5.29	5.64	5.95	6.18	6.35
0.58	1.20	1.46	1.73	1.97	2.23	2.46	2.70	2.93	3.14	3.56	3.97	4.37	4.77	5.15	5.49	5.85	6.18	6.41	6.59
0.63	1.24	1.51	1.79	2.04	2.31	2.55	2.80	3.04	3.25	3.69	4.11	4.53	4.94	5.33	5.68	6.06	6.39	6.64	6.82
0.67	1.28	1.56	1.85	2.11	2.39	2.63	2.89	3.14	3.36	3.81	4.25	4.68	5.11	5.50	5.87	6.26	6.60	6.86	7.05
0.71	1.31	1.60	1.90	2.18	2.46	2.71	2.98	3.24	3.46	3.93	4.38	4.82	5.26	5.67	6.05	6.45	6.81	7.07	7.27
0.75	1.34	1.64	1.95	2.24	2.53	2.79	3.07	3.33	3.56	4.04	4.51	4.96	5.41	5.83	6.23	6.64	7.01	7.27	7.48
0.79	1.37	1.68	2.00	2.30	2.60	2.87	3.15	3.42	3.66	4.15	4.63	5.10	5.56	5.99	6.40	6.83	7.20	7.47	7.68
0.83	1.40	1.72	2.05	2.36	2.67	2.95	3.23	3.51	3.75	4.26	4.75	5.23	5.71	6.15	6.56	7.00	7.39	7.67	7.88
0.92	1.46	1.80	2.15	2.48	2.80	3.09	3.39	3.68	3.93	4.46	4.98	5.48	5.98	6.45	6.88	7.34	7.74	8.04	8.26
1.00	1.52	1.88	2.25	2.59	2.92	3.23	3.54	3.84	4.11	4.66	5.20	5.73	6.25	6.74	7.19	7.66	8.09	8.40	8.63
1.08	1.58	1.96	2.34	2.69	3.04	3.36	3.68	4.00	4.28	4.85	5.41	5.96	6.50	7.01	7.48	7.98	8.41	8.74	8.98
1.17	1.64	2.04	2.43	2.79	3.15	3.49	3.82	4.15	4.44	5.03	5.61	6.19	6.75	7.28	7.76	8.27	8.73	9.07	9.32
1.25	1.70	2.11	2.51	2.89	3.26	3.61	3.96	4.29	4.60	5.21	5.81	6.40	6.99	7.54	8.04	8.56	9.04	9.39	9.65
1.33	1.76	2.18	2.59	2.99	3.37	3.73	4.09	4.43	4.75	5.38	6.00	6.61	7.22	7.79	8.30	8.85	9.34	9.70	9.96
1.42	1.81	2.25	2.67	3.08	3.48	3.84	4.22	4.57	4.90	5.55	6.19	6.82	7.44	8.03	8.56	9.13	9.63	10.00	10.27
1.50	1.86	2.31	2.75	3.16	3.58	3.95	4.34	4.70	5.04	5.71	6.37	7.01	7.65	8.25	8.80	9.39	9.90	10.28	10.56

Armco-Type Metergate Tables - Preliminary

20-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																						
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67
	Discharge (CFS)																						
0.08	0.58	0.73	0.86	0.96	1.10	1.21	1.32	1.43	1.54	1.75	1.92	2.12	2.29	2.48	2.66	2.84	3.01	3.16	3.31	3.44	3.57	3.68	3.71
0.10	0.66	0.81	0.96	1.09	1.23	1.35	1.42	1.60	1.72	1.95	2.16	2.37	2.56	2.77	2.98	3.18	3.37	3.54	3.71	3.86	4.01	4.14	4.19
0.13	0.72	0.88	1.04	1.18	1.35	1.47	1.61	1.74	1.88	2.12	2.35	2.58	2.79	3.03	3.25	3.47	3.69	3.88	4.06	4.23	4.39	4.52	4.61
0.15	0.77	0.95	1.11	1.27	1.44	1.58	1.72	1.87	2.02	2.27	2.52	2.77	3.00	3.26	3.50	3.73	3.95	4.18	3.36	4.55	4.71	4.86	4.97
0.17	0.82	1.01	1.18	1.36	1.53	1.68	1.83	1.99	2.15	2.42	2.69	2.95	3.21	3.48	3.73	3.97	4.20	4.46	4.66	4.85	5.02	5.20	5.31
0.19	0.87	1.07	1.25	1.44	1.62	1.78	1.94	2.11	2.27	2.56	2.86	3.13	3.42	3.69	3.96	4.21	4.45	4.72	4.95	5.15	5.33	5.53	5.65
0.21	0.91	1.12	1.31	1.51	1.70	1.87	2.04	2.21	2.38	2.70	3.02	3.31	3.62	3.89	4.18	4.45	4.70	4.97	5.21	5.43	5.63	5.83	5.95
0.23	0.95	1.17	1.37	1.58	1.78	1.96	2.13	2.31	2.49	2.84	3.16	3.49	3.80	4.08	4.39	4.66	4.95	5.21	5.46	5.70	5.91	6.13	6.24
0.25	0.99	1.22	1.43	1.65	1.85	2.04	2.22	2.41	2.60	2.96	3.30	3.64	3.96	4.26	4.58	4.86	5.16	5.44	5.70	5.95	6.17	6.41	6.52
0.27	1.03	1.27	1.49	1.71	1.92	2.12	2.31	2.51	2.71	3.08	3.44	3.79	4.12	4.44	4.77	5.06	5.37	5.66	5.94	6.20	6.43	6.68	6.80
0.29	1.07	1.31	1.54	1.77	1.99	2.19	2.40	2.61	2.82	3.20	5.56	3.93	4.28	4.60	4.95	5.25	5.57	5.88	6.16	6.43	6.67	6.92	7.08
0.31	1.10	1.35	1.59	1.83	2.06	2.26	2.49	2.70	2.92	3.31	3.68	4.07	4.43	4.76	5.13	5.44	5.77	6.09	6.38	6.65	6.90	7.15	7.32
0.33	1.13	1.39	1.64	1.88	2.12	2.33	2.57	2.79	3.02	3.42	3.80	4.20	4.57	4.92	5.29	5.62	5.96	6.29	6.58	6.87	7.12	7.38	7.56
0.35	1.16	1.43	1.69	1.93	2.18	2.40	2.65	2.88	3.12	3.52	3.92	4.33	4.71	5.07	5.45	5.79	6.14	6.48	6.78	7.08	7.34	7.61	7.79
0.38	1.19	1.47	1.73	1.98	2.24	2.47	2.73	2.96	3.21	3.62	4.04	4.46	4.85	5.22	5.61	5.96	6.32	6.67	6.98	7.29	7.56	7.84	8.02
0.40	1.22	1.51	1.77	2.03	2.30	2.54	2.80	3.04	3.29	3.72	4.16	4.58	4.99	5.36	6.76	6.13	6.50	6.85	7.18	7.50	7.77	8.05	8.25
0.42	1.25	1.55	1.81	2.08	2.36	2.61	2.87	3.12	3.37	3.82	4.26	4.70	5.12	5.50	5.91	6.29	6.66	7.03	7.36	7.69	7.97	8.26	8.46
0.46	1.31	1.61	1.89	2.18	2.48	2.74	3.02	3.28	3.53	1.01	4.47	4.93	5.36	5.77	6.20	6.59	6.98	7.37	7.72	8.06	8.36	8.66	8.87
0.50	1.37	1.67	1.97	2.28	2.59	2.86	3.15	3.42	3.69	4.19	4.67	5.15	5.60	6.04	6.48	6.89	7.30	7.70	8.06	8.41	8.73	9.05	9.26
0.54	1.42	1.73	2.05	2.38	2.69	2.98	3.28	3.56	3.85	4.36	4.86	5.37	5.84	6.28	6.76	7.17	7.60	8.02	8.40	8.76	9.10	9.44	9.65
0.58	1.47	1.79	2.12	2.47	2.79	3.09	3.40	3.70	3.99	4.53	5.05	5.57	6.06	6.51	7.01	7.45	7.89	8.32	8.72	9.10	9.43	9.78	10.02
0.63	1.52	1.85	2.19	2.56	2.89	3.20	3.52	3.82	4.13	4.68	5.22	5.76	6.26	6.74	7.25	7.70	8.16	8.61	9.02	9.42	9.76	10.12	10.37
0.67	1.57	1.91	2.26	2.65	2.98	3.30	3.63	3.94	4.26	4.83	5.39	5.95	6.46	6.96	7.48	7.95	8.43	8.88	9.31	9.72	10.08	10.44	10.70
0.71	1.61	1.97	2.33	2.73	3.07	3.40	3.74	4.06	4.39	4.98	5.55	6.13	6.66	7.17	7.70	8.19	8.69	9.15	9.60	10.01	10.40	10.76	11.03
0.75	1.65	2.02	2.40	2.80	3.16	3.50	3.85	4.18	4.52	5.13	5.71	6.31	6.86	7.38	7.92	8.43	8.95	9.42	9.88	10.30	10.70	11.08	11.34
0.79	1.69	2.07	2.47	2.87	3.25	3.60	3.96	4.30	4.65	5.27	5.87	6.49	7.06	7.59	8.14	8.67	9.20	9.69	10.15	10.59	11.00	11.40	11.65
0.83	1.73	2.12	2.54	2.94	3.34	3.70	4.07	4.42	4.77	5.41	6.03	6.65	7.25	7.79	8.36	8.90	9.44	9.95	10.41	10.88	11.28	11.69	11.96
0.92	1.81	2.22	2.67	3.08	3.50	3.87	4.28	4.63	5.00	5.67	6.31	6.97	7.60	8.16	8.76	9.32	9.88	10.42	10.91	11.44	11.82	12.24	12.53
1.00	1.88	2.32	2.79	3.22	3.66	4.04	4.47	4.84	5.22	5.92	6.59	7.29	7.93	8.53	9.16	9.74	10.32	10.89	11.41	11.93	12.34	12.79	13.10
1.08	1.95	2.42	2.91	3.36	3.81	4.21	4.64	5.04	5.44	6.17	6.87	7.60	8.26	8.88	9.55	10.13	10.76	11.33	11.88	12.40	12.86	13.32	13.65
1.17	2.02	2.52	3.02	3.49	3.95	4.38	4.81	5.23	5.64	6.40	7.13	7.89	8.57	9.21	9.90	10.52	11.16	11.77	12.32	12.87	13.33	13.82	14.17
1.25	2.08	2.61	3.12	3.61	4.09	4.53	4.97	5.41	5.84	6.62	7.38	8.15	8.86	9.53	10.24	10.88	11.53	12.18	12.74	13.30	13.80	14.30	14.65
1.33	2.14	2.70	3.22	3.73	4.22	4.67	5.13	5.58	6.03	6.84	7.62	8.41	9.15	9.85	10.58	11.23	11.90	12.56	13.16	13.72	14.25	14.78	15.13
1.42	2.20	2.78	3.32	3.84	4.35	4.81	5.29	5.75	6.22	7.05	7.85	8.67	9.43	10.15	10.90	11.58	12.27	12.94	13.58	14.14	14.69	15.24	15.59
1.50	2.26	2.86	3.41	3.95	4.47	4.95	5.45	5.92	6.40	7.25	8.08	8.93	9.70	10.44	11.22	11.92	12.64	13.32	13.98	14.56	15.11	15.68	16.05

Armco-Type Metergate Tables - Preliminary

30-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																									
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50
	Discharge (CFS)																									
0.08	0.84	1.05	1.25	1.45	1.63	1.84	2.00	2.20	2.34	2.69	3.03	3.35	3.64	3.92	4.20	4.48	4.75	5.03	5.28	5.84	6.34	6.76	7.10	7.46	7.70	7.86
0.10	0.93	1.17	1.39	1.62	1.82	2.04	2.23	2.45	2.61	2.99	3.36	3.71	4.04	4.36	4.67	4.99	5.30	5.61	5.89	6.49	7.04	7.51	7.90	8.31	8.58	8.77
0.13	1.01	1.27	1.52	1.76	1.97	2.22	2.43	2.66	2.85	3.25	3.63	4.05	4.41	4.75	5.11	5.46	5.80	6.12	6.46	7.08	7.67	8.19	8.65	9.07	9.40	9.59
0.15	1.08	1.37	1.63	1.89	2.12	2.39	2.62	2.87	3.06	3.50	3.88	4.37	4.73	5.11	5.49	5.86	6.22	6.57	6.94	7.60	8.25	8.81	9.29	9.72	10.15	10.32
0.17	1.16	1.46	1.74	2.02	2.27	2.54	2.80	3.05	3.27	3.73	4.13	4.64	5.03	5.45	5.86	6.26	6.63	7.02	7.41	8.11	8.78	9.40	9.91	10.34	10.88	11.04
0.19	1.23	1.55	1.85	2.14	2.40	2.69	2.96	3.22	3.46	3.95	4.38	4.90	5.33	5.78	6.21	6.64	7.04	7.45	7.86	8.61	9.31	9.94	10.48	10.94	11.56	11.74
0.21	1.30	1.63	1.94	2.25	2.52	2.84	3.11	3.38	3.63	4.15	4.63	5.15	5.61	6.09	6.55	7.00	7.41	7.85	8.29	9.07	9.81	10.48	11.03	11.52	12.16	12.40
0.23	1.36	1.70	2.03	2.35	2.64	2.98	3.25	3.53	3.80	4.34	4.86	5.40	5.89	6.39	6.87	7.34	7.78	8.23	8.69	9.51	10.28	19.98	11.56	12.08	12.68	13.00
0.25	1.41	1.77	2.11	2.45	2.75	3.11	3.38	3.67	3.95	4.53	5.08	5.64	6.16	6.68	7.17	7.67	8.13	8.60	9.08	9.94	10.75	11.47	12.07	12.62	13.18	13.55
0.27	1.46	1.84	2.19	2.55	2.86	3.22	3.50	3.81	4.10	4.71	5.29	5.87	6.41	6.95	7.46	7.98	8.46	8.95	9.45	10.34	11.20	11.95	12.57	13.15	13.68	14.05
0.29	1.51	1.90	2.27	2.64	2.96	3.33	3.62	3.94	4.25	4.88	5.49	6.09	6.65	7.21	7.75	8.28	8.78	9.29	9.81	10.74	11.62	12.40	13.06	13.65	14.18	14.52
0.31	1.56	1.96	2.35	2.72	3.06	3.43	3.74	4.07	4.40	5.05	5.68	6.30	6.88	7.47	8.02	8.57	9.09	9.62	10.14	11.12	12.03	12.83	13.50	14.12	14.67	14.98
0.33	1.61	2.02	2.42	2.80	3.15	3.53	3.85	4.20	4.54	5.21	5.86	6.51	7.10	7.71	8.28	8.85	9.38	9.93	10.47	11.48	12.42	13.25	13.94	15.58	15.15	15.44
0.35	1.65	2.08	2.49	2.88	3.24	3.63	3.96	4.33	4.68	5.38	6.04	6.71	7.32	7.95	8.54	9.12	9.67	10.23	10.80	11.83	12.80	13.66	14.37	15.03	15.61	15.90
0.38	1.69	2.14	2.56	2.96	3.33	3.73	4.07	4.45	4.82	5.54	6.22	6.91	7.54	8.18	8.79	9.39	9.95	10.53	11.12	12.17	13.17	14.06	14.80	15.47	16.07	16.36
0.40	1.73	2.20	2.62	3.04	3.42	3.82	4.18	4.57	4.95	5.69	6.39	7.10	7.75	8.40	9.03	9.65	13.23	10.82	11.43	12.51	13.54	14.45	15.20	15.90	16.52	16.82
0.42	1.77	2.25	2.68	3.11	3.50	3.91	4.29	4.69	5.08	5.84	6.56	7.29	7.95	8.62	9.26	9.90	10.50	11.11	11.73	12.84	13.90	14.83	15.60	16.32	16.95	17.26
0.46	1.85	2.35	2.80	3.25	3.66	4.09	4.50	4.92	5.33	6.12	6.88	7.64	8.34	9.05	9.72	10.38	11.02	11.65	12.30	13.47	14.57	15.56	16.36	17.10	17.77	18.10
0.50	1.93	2.45	2.92	3.39	3.82	4.27	4.70	5.14	5.56	6.39	7.19	7.98	8.70	9.45	10.14	10.84	11.50	12.16	12.83	14.06	15.20	16.23	17.08	17.85	18.55	18.90
0.54	2.01	2.55	3.04	3.53	3.97	4.44	4.89	5.35	5.79	6.65	7.48	8.31	9.06	9.84	10.56	11.29	11.96	12.66	13.36	14.63	15.83	16.90	17.77	18.58	19.30	19.65
0.58	2.09	2.64	3.15	3.64	4.13	4.61	5.07	5.55	6.01	6.90	7.76	8.62	9.40	10.20	10.96	11.72	12.42	13.14	13.87	15.19	16.43	17.53	18.45	19.30	20.04	20.40
0.63	2.16	2.72	3.25	3.76	4.27	4.77	5.25	5.75	6.21	7.15	8.03	8.92	9.74	10.56	11.35	12.13	12.85	13.60	14.36	15.72	17.00	18.15	19.10	19.97	20.74	21.12
0.67	2.23	2.80	3.34	3.88	4.41	4.92	5.42	5.94	6.42	7.38	8.30	9.21	10.06	10.90	11.72	12.52	13.27	14.04	14.83	16.23	17.56	18.73	19.72	20.62	21.42	21.82
0.71	2.30	2.88	3.43	3.99	4.54	5.07	5.59	6.12	6.61	7.60	8.55	9.49	10.36	11.23	12.08	12.91	13.68	14.47	15.29	16.73	18.10	19.30	20.32	21.26	22.08	22.52
0.75	2.36	2.96	3.52	4.10	4.67	5.22	5.75	6.30	6.81	7.82	8.80	9.76	10.66	11.56	12.44	13.28	14.07	14.90	15.74	17.21	18.62	19.87	20.91	21.87	22.72	23.17
0.79	2.42	3.04	3.61	4.21	4.80	5.36	5.91	6.47	7.00	8.04	9.04	10.03	10.95	11.89	19.79	13.64	14.46	15.30	16.15	17.68	19.14	20.41	21.49	22.47	23.34	23.80
0.83	2.48	3.12	3.70	4.32	4.93	5.50	6.06	6.64	7.18	8.26	9.28	10.30	11.24	12.20	13.12	14.00	14.85	15.70	16.60	18.15	19.65	20.95	22.06	23.06	23.95	24.40
0.92	2.59	3.27	3.88	4.53	5.17	5.78	6.36	6.96	7.53	8.66	9.73	10.80	11.78	12.79	13.74	14.69	15.57	16.47	17.40	19.03	20.50	21.96	23.13	24.20	25.12	25.58
1.00	2.70	3.40	4.05	4.74	5.4	6.04	6.64	7.27	7.86	9.04	10.16	11.28	12.31	13.36	14.35	15.33	16.26	17.20	18.16	19.88	21.50	22.95	24.15	25.25	26.23	26.72
1.08	2.81	3.52	4.21	4.93	5.62	6.28	6.91	7.57	8.19	9.40	10.57	11.74	12.82	13.90	14.94	15.96	16.93	17.90	18.90	20.70	22.40	23.90	25.15	26.28	27.30	27.80
1.17	2.91	3.64	4.37	5.11	5.84	6.51	7.17	7.86	8.49	9.76	10.97	12.18	13.30	14.43	15.50	15.56	17.56	18.57	19.60	21.48	23.23	24.80	26.10	27.28	28.32	28.85
1.25	3.01	3.76	4.52	5.29	6.04	6.74	7.42	8.13	8.79	10.10	11.37	12.62	13.76	14.93	16.04	17.14	18.18	19.23	20.30	22.23	24.05	25.66	27.00	28.23	29.32	29.86
1.33	3.11	3.88	4.67	5.47	6.24	6.96	7.66	8.40	9.08	10.43	11.74	13.03	14.22	15.42	16.57	17.70	18.77	19.86	20.97	22.95	24.84	26.50	27.87	29.15	30.30	30.84
1.42	3.20	3.99	4.81	5.64	6.43	7.18	7.90	8.66	9.36	10.76	12.10	13.43	14.65	15.90	17.08	18.26	19.36	20.48	21.62	23.66	25.60	27.32	28.73	30.06	31.25	31.80
1.50	3.28	4.10	4.95	5.79	6.61	7.39	8.13	8.91	9.63	11.06	12.43	13.81	15.08	16.36	17.57	18.78	19.90	21.05	22.25	24.34	26.34	28.10	29.56	30.92	32.15	32.70

Armco-Type Metergate Tables - Preliminary

36-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																												
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50	2.67	2.83	3.00
	Discharge (CFS)																												
0.08	0.96	1.22	1.47	1.71	1.94	2.16	2.41	2.61	2.82	3.24	3.67	4.05	4.42	4.77	5.10	5.47	5.83	6.13	6.50	7.12	7.86	8.43	8.92	9.37	9.84	10.10	10.35	10.56	10.74
0.10	1.07	1.35	1.62	1.89	2.15	2.41	2.69	2.90	3.12	3.59	4.05	4.50	4.91	5.31	5.67	6.10	6.49	6.82	7.22	7.87	8.67	9.30	9.88	10.38	10.89	11.20	11.50	11.74	11.92
0.13	1.17	1.47	1.77	2.06	2.34	2.63	2.94	3.16	3.40	3.92	4.43	4.93	5.36	5.79	6.20	6.68	7.08	7.44	7.89	8.59	9.44	10.14	10.81	11.33	11.86	12.24	12.57	12.84	13.02
0.15	1.26	1.59	1.92	2.22	2.53	2.84	3.18	3.42	3.67	4.24	4.77	5.32	4.79	6.25	6.70	7.20	7.63	8.04	8.52	9.28	10.17	10.95	11.65	12.25	12.80	13.24	13.60	13.91	14.09
0.17	1.34	1.70	2.05	2.36	2.69	3.04	3.39	3.66	3.92	4.53	5.08	5.68	6.18	6.66	7.17	7.67	8.13	8.60	9.10	9.95	10.87	11.71	12.43	13.09	13.67	14.16	14.54	14.87	15.05
0.19	1.42	1.80	2.17	2.50	2.85	3.21	3.58	3.87	4.14	4.79	5.38	6.00	6.52	7.04	7.61	8.12	8.62	9.12	9.65	10.57	11.52	12.42	13.18	13.86	14.47	15.00	15.39	15.74	15.95
0.21	1.50	1.89	2.28	2.63	3.00	3.37	3.76	4.07	4.35	5.04	5.65	6.30	6.85	7.42	8.02	8.56	9.09	9.61	10.18	11.13	12.16	13.10	13.88	14.60	15.21	15.76	16.17	16.54	16.78
0.23	1.57	1.98	2.39	2.76	3.14	3.52	3.93	4.26	4.55	5.28	5.91	6.60	7.18	7.79	8.42	8.98	9.54	10.07	10.68	11.68	12.76	13.73	14.55	15.31	15.93	16.50	16.94	17.34	17.60
0.25	1.63	2.06	2.49	2.88	3.28	3.67	4.10	4.45	4.75	5.50	6.17	6.89	7.50	8.13	8.79	9.37	9.95	10.52	11.15	12.20	13.31	14.35	15.20	16.00	16.64	17.23	17.68	18.10	18.38
0.27	1.69	2.14	2.59	3.00	3.41	3.82	4.27	4.63	1.95	5.72	6.42	7.17	7.81	8.46	9.15	9.76	10.35	10.96	11.60	12.70	13.86	14.95	15.83	16.66	17.33	17.94	18.40	18.85	19.14
0.29	1.75	2.21	2.68	3.11	3.53	3.95	4.42	4.79	5.13	5.93	6.66	7.44	8.10	8.78	9.49	10.12	10.74	11.37	12.04	13.18	14.37	15.50	16.42	17.28	17.98	18.61	19.08	19.54	19.85
0.31	1.81	2.28	2.76	3.22	3.65	4.08	4.56	4.95	5.31	6.14	6.90	7.70	8.39	9.09	9.82	10.48	11.11	11.77	12.46	13.63	14.89	16.04	16.99	17.89	18.60	19.27	19.74	20.23	20.55
0.33	1.86	2.35	2.84	3.31	3.76	4.20	4.68	5.11	5.49	6.34	7.13	7.95	8.66	9.38	10.14	10.83	11.48	12.15	12.87	14.08	15.37	169.56	17.55	18.46	19.20	19.90	20.40	20.89	21.25
0.35	1.91	1.42	2.92	3.40	3.86	4.32	4.81	5.27	5.66	6.54	7.35	8.20	8.93	9.67	10.45	11.16	11.83	12.52	13.27	14.51	15.84	17.08	18.10	19.03	19.80	20.50	21.05	21.53	21.90
0.38	1.96	2.49	3.00	3.49	3.96	4.44	4.94	5.42	5.82	6.73	7.56	8.44	9.19	9.95	10.76	11.49	12.18	12.89	13.66	14.94	16.31	17.57	18.61	19.60	20.38	21.10	21.65	22.17	22.55
0.40	2.01	2.56	3.08	3.58	4.06	4.56	5.07	5.57	5.98	6.92	7.77	8.67	9.45	10.22	11.06	11.80	12.52	13.25	14.04	15.35	16.76	18.05	19.13	20.15	20.95	21.68	22.25	22.80	23.20
0.42	2.06	2.62	3.16	3.67	4.16	4.68	5.19	5.72	6.14	7.10	7.97	8.89	9.70	10.49	11.34	12.10	12.85	13.60	14.40	15.75	17.20	18.53	19.64	20.65	21.50	22.25	22.80	23.40	23.80
0.46	2.16	2.74	3.31	3.84	4.36	4.90	5.43	6.00	6.43	7.44	8.36	9.33	10.17	11.00	11.90	12.70	13.47	14.25	15.10	16.52	18.03	19.43	20.60	21.65	22.55	23.35	23.90	24.50	24.90
0.50	2.26	2.86	3.45	4.00	4.55	5.11	5.67	6.26	4.71	7.77	8.73	9.73	10.61	11.50	12.42	13.26	14.07	14.88	15.77	17.25	18.82	20.28	21.50	22.62	23.55	24.39	24.95	25.60	26.00
0.54	2.35	2.98	3.59	4.16	4.72	5.32	5.91	6.52	6.99	8.09	9.09	10.13	11.04	11.97	12.93	13.80	14.64	15.50	16.41	17.97	19.60	21.13	22.40	23.65	24.50	26.39	26.00	26.65	27.10
0.58	2.44	3.09	3.72	4.31	4.89	5.52	6.14	6.76	7.25	8.39	9.43	10.51	11.46	12.41	13.42	14.32	15.20	16.09	17.03	18.64	20.35	21.94	23.25	24.44	25.43	26.33	27.00	27.67	28.15
0.63	2.53	3.19	3.85	4.45	5.06	5.72	6.36	7.00	7.51	8.69	9.76	10.89	11.87	12.85	13.90	14.83	15.74	16.67	17.64	19.30	21.08	22.72	24.08	25.30	26.34	27.25	27.95	28.65	19.15
0.67	2.61	3.29	3.97	4.59	5.23	5.91	6.57	7.23	7.76	8.97	10.09	11.24	12.26	13.28	14.35	15.32	16.25	17.20	18.21	19.92	21.75	23.45	24.84	26.13	27.20	28.13	28.85	29.55	30.10
0.71	2.69	3.38	4.08	4.72	5.39	6.09	6.77	7.45	8.00	9.25	10.40	11.59	12.63	13.68	14.79	15.79	16.74	17.72	18.77	20.54	22.42	24.15	25.60	26.95	28.05	29.00	29.75	3.0.45	31.00
0.75	2.76	3.47	4.19	4.85	5.55	6.27	6.97	7.60	8.23	9.52	10.70	11.93	13.00	14.08	15.21	16.25	17.23	18.23	19.31	21.15	23.07	24.85	26.33	27.73	28.85	29.84	30.62	31.35	31.88
0.79	2.83	3.56	4.30	4.98	5.70	6.44	7.16	7.87	8.45	9.78	11.00	12.26	13.37	14.47	15.63	16.68	17.70	18.73	19.84	21.72	23.70	15.55	27.05	28.47	29.63	30.65	31.45	32.20	32.75
0.83	2.90	3.65	4.41	5.11	5.85	6.61	7.35	8.07	8.67	10.03	11.28	12.58	13.71	14.83	16.03	17.10	18.17	19.21	20.35	22.27	24.30	26.20	27.75	29.20	30.40	31.45	32.25	33.05	33.60
0.92	3.05	3.82	4.60	5.36	6.13	6.92	7.70	8.46	9.10	10.52	11.82	13.18	14.37	15.55	16.81	17.93	19.05	20.14	21.33	23.35	25.47	27.45	29.10	30.60	31.85	32.95	33.80	34.65	35.20
1.00	3.16	3.98	4.79	5.61	6.40	7.23	8.05	8.85	9.51	10.99	12.35	13.78	15.01	16.25	17.58	18.74	19.90	21.05	22.30	24.40	26.62	18.70	30.40	32.00	33.30	34.45	35.35	36.20	36.80
1.08	3.28	4.14	4.98	5.85	6.67	7.52	8.39	9.22	9.89	11.44	12.85	14.35	15.62	16.93	18.30	19.53	20.72	21.92	23.22	25.40	27.75	29.87	31.65	33.32	34.65	35.85	36.80	37.68	38.30
1.17	3.39	4.29	5.16	6.06	6.91	7.81	8.70	9.56	10.26	11.88	13.33	14.88	16.21	17.58	18.99	20.25	21.50	22.75	24.10	26.35	28.80	31.00	32.85	34.60	35.98	37.20	38.18	39.10	39.75
1.25	3.50	4.43	5.34	6.27	7.15	8.08	9.00	9.89	10.62	12.30	13.80	15.40	16.78	18.19	19.64	20.95	22.24	23.54	24.93	27.30	29.80	32.10	34.00	35.80	37.25	28.50	39.50	40.45	41.15
1.33	3.61	4.56	5.51	6.48	7.39	8.34	9.29	10.22	10.98	12.69	14.27	15.90	17.33	18.78	20.29	54.65	22.98	24.30	25.75	28.20	30.75	33.15	35.10	36.95	38.45	29.80	40.80	41.80	42.50
1.42	3.72	4.69	5.68	6.68	7.62	8.60	9.58	10.54	11.32	13.08	14.70	16.39	17.86	19.34	20.92	22.32	23.69	25.05	26.55	29.03	31.70	34.15	36.20	38.10	39.60	41.10	42.05	43.10	43.80
1.50	3.82	4.82	5.85	6.87	7.84	8.85	9.86	10.84	11.64	13.45	15.12	16.88	18.39	19.89	21.54	22.97	24.36	25.78	27.33	29.85	32.63	35.15	37.25	39.20	40.75	42.30	43.25	44.35	45.10

ITRC Water Measurement Tables for
FREE FLOW Armco-Type Gates on Round Pipes
Discharge Values in CFS

Upstream head is measured from the top of the turnout pipe

Upstream Head (feet)	ITRC Water Measurement Tables – 12" Armco-Type Gate, FREE FLOW [Blue center represents best accuracy range] (Flows in CFS) Net Gate Opening (feet)																	
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00
1.00	0.24	0.55	0.87	1.17	1.47	1.75	2.04	2.31	2.53	2.74	2.89	3.01	3.31	3.58	3.79	3.99	4.11	4.16
1.04	0.25	0.57	0.88	1.20	1.50	1.79	2.08	2.36	2.59	2.79	2.95	3.08	3.38	3.65	3.87	4.07	4.19	4.25
1.08	0.25	0.58	0.90	1.22	1.53	1.82	2.12	2.41	2.64	2.85	3.00	3.14	3.44	3.72	3.94	4.15	4.28	4.33
1.13	0.26	0.59	0.92	1.25	1.56	1.86	2.16	2.45	2.69	2.90	3.06	3.20	3.51	3.79	4.02	4.23	4.36	4.41
1.17	0.26	0.60	0.94	1.27	1.59	1.89	2.20	2.50	2.74	2.95	3.12	3.25	3.57	3.86	4.09	4.31	4.44	4.49
1.21	0.27	0.61	0.95	1.29	1.61	1.92	2.24	2.54	2.79	3.01	3.17	3.31	3.64	3.93	4.17	4.39	4.52	4.57
1.25	0.27	0.62	0.97	1.31	1.64	1.96	2.28	2.59	2.83	3.06	3.23	3.37	3.70	4.00	4.24	4.46	4.59	4.65
1.29	0.28	0.63	0.98	1.33	1.67	1.99	2.31	2.63	2.88	3.11	3.28	3.42	3.76	4.06	4.31	4.54	4.67	4.73
1.33	0.28	0.64	1.00	1.36	1.70	2.02	2.35	2.67	2.93	3.16	3.33	3.48	3.82	4.13	4.38	4.61	4.74	4.80
1.38	0.29	0.65	1.02	1.38	1.72	2.05	2.39	2.71	2.97	3.21	3.39	3.53	3.88	4.19	4.44	4.68	4.82	4.88
1.42	0.29	0.66	1.03	1.40	1.75	2.08	2.42	2.75	3.02	3.26	3.44	3.59	3.94	4.26	4.51	4.75	4.89	4.95
1.46	0.29	0.67	1.05	1.42	1.77	2.11	2.46	2.79	3.06	3.30	3.49	3.64	4.00	4.32	4.58	4.82	4.96	5.02
1.50	0.30	0.68	1.06	1.44	1.80	2.14	2.49	2.83	3.10	3.35	3.54	3.69	4.05	4.38	4.64	4.89	5.03	5.09
1.54	0.30	0.69	1.08	1.46	1.82	2.17	2.53	2.87	3.15	3.40	3.58	3.74	4.11	4.44	4.71	4.96	5.10	5.16
1.58	0.31	0.70	1.09	1.48	1.85	2.20	2.56	2.91	3.19	3.44	3.63	3.79	4.16	4.50	4.77	5.02	5.17	5.23
1.63	0.31	0.71	1.10	1.50	1.87	2.23	2.60	2.95	3.23	3.49	3.68	3.84	4.22	4.56	4.83	5.09	5.24	5.30
1.67	0.31	0.71	1.12	1.52	1.90	2.26	2.63	2.99	3.27	3.53	3.73	3.89	4.27	4.62	4.89	5.15	5.30	5.37
1.71	0.32	0.72	1.13	1.53	1.92	2.29	2.66	3.02	3.31	3.58	3.77	3.94	4.32	4.67	4.95	5.22	5.37	5.44
1.75	0.32	0.73	1.15	1.55	1.94	2.32	2.69	3.06	3.35	3.62	3.82	3.99	4.38	4.73	5.01	5.28	5.44	5.50
1.79	0.33	0.74	1.16	1.57	1.97	2.34	2.73	3.10	3.39	3.66	3.86	4.03	4.43	4.79	5.07	5.34	5.50	5.57
1.83	0.33	0.75	1.17	1.59	1.99	2.37	2.76	3.13	3.43	3.70	3.91	4.08	4.48	4.84	5.13	5.40	5.56	5.63
1.88	0.33	0.76	1.19	1.61	2.01	2.40	2.79	3.17	3.47	3.75	3.95	4.13	4.53	4.90	5.19	5.46	5.63	5.70
1.92	0.34	0.77	1.20	1.63	2.03	2.42	2.82	3.20	3.51	3.79	4.00	4.17	4.58	4.95	5.25	5.53	5.69	5.76
1.96	0.34	0.77	1.21	1.64	2.05	2.45	2.85	3.24	3.55	3.83	4.04	4.22	4.63	5.01	5.30	5.59	5.75	5.82
2.00	0.34	0.78	1.22	1.66	2.08	2.48	2.88	3.27	3.58	3.87	4.08	4.26	4.68	5.06	5.36	5.64	5.81	5.88
2.04	0.35	0.79	1.24	1.68	2.10	2.50	2.91	3.30	3.62	3.91	4.13	4.31	4.73	5.11	5.41	5.70	5.87	5.94
2.08	0.35	0.80	1.25	1.69	2.12	2.53	2.94	3.34	3.66	3.95	4.17	4.35	4.78	5.16	5.47	5.76	5.93	6.00
2.13	0.35	0.81	1.26	1.71	2.14	2.55	2.97	3.37	3.69	3.99	4.21	4.39	4.82	5.21	5.52	5.82	5.99	6.06
2.17	0.36	0.81	1.27	1.73	2.16	2.58	3.00	3.40	3.73	4.03	4.25	4.44	4.87	5.26	5.58	5.87	6.05	6.12
2.21	0.36	0.82	1.29	1.74	2.18	2.60	3.03	3.44	3.77	4.07	4.29	4.48	4.92	5.32	5.63	5.93	6.11	6.18
2.25	0.36	0.83	1.30	1.76	2.20	2.63	3.05	3.47	3.80	4.10	4.33	4.52	4.96	5.37	5.68	5.99	6.16	6.24
2.33	0.37	0.85	1.32	1.79	2.24	2.67	3.11	3.53	3.87	4.18	4.41	4.60	5.05	5.46	5.79	6.10	6.28	6.35
2.42	0.38	0.86	1.35	1.83	2.28	2.72	3.16	3.60	3.94	4.25	4.49	4.68	5.14	5.56	5.89	6.20	6.39	6.47
2.50	0.38	0.88	1.37	1.86	2.32	2.77	3.22	3.66	4.01	4.33	4.56	4.76	5.23	5.66	5.99	6.31	6.50	6.58
2.58	0.39	0.89	1.39	1.89	2.36	2.81	3.27	3.72	4.07	4.40	4.64	4.84	5.32	5.75	6.09	6.41	6.60	6.69
2.67	0.40	0.90	1.41	1.92	2.40	2.86	3.32	3.78	4.14	4.47	4.71	4.92	5.40	5.84	6.19	6.52	6.71	6.79
2.75	0.40	0.92	1.44	1.95	2.43	2.90	3.38	3.84	4.20	4.54	4.79	5.00	5.49	5.93	6.28	6.62	6.81	6.90
2.83	0.41	0.93	1.46	1.98	2.47	2.95	3.43	3.89	4.27	4.60	4.86	5.07	5.57	6.02	6.38	6.72	6.92	7.00
2.92	0.42	0.95	1.48	2.01	2.51	2.99	3.48	3.95	4.33	4.67	4.93	5.15	5.65	6.11	6.47	6.82	7.02	7.10
3.00	0.42	0.96	1.50	2.03	2.54	3.03	3.53	4.01	4.39	4.74	5.00	5.22	5.73	6.20	6.56	6.91	7.12	7.20
3.08	0.43	0.97	1.52	2.06	2.58	3.07	3.57	4.06	4.45	4.80	5.07	5.29	5.81	6.28	6.65	7.01	7.21	7.30
3.17	0.43	0.99	1.54	2.09	2.61	3.12	3.62	4.12	4.51	4.87	5.14	5.36	5.89	6.36	6.74	7.10	7.31	7.40
3.25	0.44	1.00	1.56	2.12	2.65	3.16	3.67	4.17	4.57	4.93	5.20	5.43	5.97	6.45	6.83	7.19	7.41	7.50
3.33	0.44	1.01	1.58	2.14	2.68	3.20	3.72	4.22	4.63	4.99	5.27	5.50	6.04	6.53	6.92	7.29	7.50	7.59
3.42	0.45	1.02	1.60	2.17	2.71	3.24	3.76	4.28	4.68	5.06	5.34	5.57	6.12	6.61	7.00	7.38	7.59	7.69
3.50	0.46	1.04	1.62	2.20	2.75	3.28	3.81	4.33	4.74	5.12	5.40	5.64	6.19	6.69	7.09	7.47	7.69	7.78
3.58	0.46	1.05	1.64	2.22	2.78	3.31	3.85	4.38	4.80	5.18	5.47	5.70	6.26	6.77	7.17	7.55	7.78	7.87
3.67	0.47	1.06	1.66	2.25	2.81	3.35	3.90	4.43	4.85	5.24	5.53	5.77	6.34	6.85	7.26	7.64	7.87	7.96
3.75	0.47	1.07	1.68	2.27	2.84	3.39	3.94	4.48	4.91	5.30	5.59	5.83	6.41	6.93	7.34	7.73	7.96	8.05
3.83	0.48	1.08	1.70	2.30	2.87	3.43	3.99	4.53	4.96	5.36	5.65	5.90	6.48	7.00	7.42	7.81	8.04	8.14
3.92	0.48	1.10	1.71	2.32	2.91	3.46	4.03	4.58	5.01	5.41	5.71	5.96	6.55	7.08	7.50	7.90	8.13	8.23
4.00	0.49	1.11	1.73	2.35	2.94	3.50	4.07	4.63	5.07	5.47	5.77	6.03	6.62	7.15	7.58	7.98	8.22	8.32

Upstream Head (feet)	ITRC Water Measurement Tables – 18" Armco-Type Gate, FREE FLOW [Blue center represents best accuracy range] (Flows in CFS) Net Gate Opening (feet)																						
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50
1.50	0.42	0.99	1.58	2.18	2.78	3.39	3.99	4.59	5.03	5.43	5.79	6.11	6.89	7.59	8.30	8.95	9.50	9.97	10.44	10.85	11.15	11.36	11.55	11.59
1.54	0.43	1.00	1.60	2.21	2.82	3.44	4.05	4.65	5.10	5.51	5.87	6.20	6.99	7.69	8.42	9.08	9.63	10.11	10.59	11.00	11.30	11.52	11.71	11.75
1.58	0.44	1.02	1.62	2.24	2.86	3.48	4.10	4.72	5.17	5.58	5.95	6.28	7.08	7.79	8.53	9.20	9.76	10.24	10.73	11.14	11.46	11.67	11.87	11.91
1.63	0.44	1.03	1.65	2.27	2.90	3.53	4.15	4.78	5.24	5.65	6.03	6.36	7.17	7.90	8.64	9.32	9.89	10.38	10.87	11.29	11.61	11.83	12.03	12.06
1.67	0.45	1.04	1.67	2.30	2.94	3.57	4.21	4.84	5.30	5.72	6.10	6.44	7.26	8.00	8.75	9.44	10.01	10.51	11.01	11.43	11.75	11.98	12.18	12.22
1.71	0.45	1.06	1.69	2.33	2.97	3.62	4.26	4.90	5.37	5.80	6.18	6.52	7.36	8.10	8.86	9.55	10.14	10.64	11.15	11.57	11.90	12.13	12.33	12.37
1.75	0.46	1.07	1.71	2.36	3.01	3.66	4.31	4.96	5.43	5.87	6.25	6.60	7.44	8.19	8.97	9.67	10.26	10.77	11.28	11.72	12.04	12.27	12.48	12.52
1.79	0.46	1.08	1.73	2.38	3.04	3.70	4.36	5.02	5.50	5.94	6.33	6.68	7.53	8.29	9.07	9.78	10.38	10.89	11.42	11.85	12.19	12.42	12.63	12.67
1.83	0.47	1.09	1.75	2.41	3.08	3.75	4.41	5.07	5.56	6.00	6.40	6.76	7.62	8.39	9.18	9.90	10.50	11.02	11.55	11.99	12.33	12.56	12.77	12.81
1.88	0.47	1.11	1.77	2.44	3.11	3.79	4.46	5.13	5.62	6.07	6.47	6.83	7.71	8.48	9.28	10.01	10.62	11.14	11.68	12.13	12.47	12.70	12.92	12.96
1.92	0.48	1.12	1.79	2.47	3.15	3.83	4.51	5.19	5.69	6.14	6.55	6.91	7.79	8.57	9.39	10.12	10.74	11.27	11.81	12.26	12.60	12.84	13.06	13.10
1.96	0.49	1.13	1.81	2.49	3.18	3.87	4.56	5.24	5.75	6.21	6.62	6.98	7.88	8.67	9.49	10.23	10.85	11.39	11.93	12.39	12.74	12.98	13.20	13.24
2.00	0.49	1.14	1.83	2.52	3.22	3.91	4.61	5.30	5.81	6.27	6.69	7.06	7.96	8.76	9.59	10.34	10.97	11.51	12.06	12.52	12.88	13.12	13.34	13.38
2.04	0.50	1.15	1.84	2.55	3.25	3.95	4.66	5.36	5.87	6.34	6.76	7.13	8.04	8.85	9.69	10.44	11.08	11.63	12.19	12.65	13.01	13.26	13.48	13.52
2.08	0.50	1.17	1.86	2.57	3.28	3.99	4.70	5.41	5.93	6.40	6.82	7.20	8.12	8.94	9.79	10.55	11.20	11.75	12.31	12.78	13.14	13.39	13.62	13.66
2.13	0.51	1.18	1.88	2.60	3.31	4.03	4.75	5.46	5.99	6.46	6.89	7.27	8.20	9.03	9.88	10.65	11.31	11.86	12.43	12.91	13.27	13.52	13.75	13.79
2.17	0.51	1.19	1.90	2.62	3.35	4.07	4.80	5.52	6.05	6.53	6.96	7.34	8.28	9.12	9.98	10.76	11.42	11.98	12.55	13.04	13.40	13.66	13.89	13.93
2.21	0.52	1.20	1.92	2.65	3.38	4.11	4.84	5.57	6.10	6.59	7.03	7.41	8.36	9.20	10.07	10.86	11.53	12.10	12.67	13.16	13.53	13.79	14.02	14.06
2.25	0.52	1.21	1.94	2.67	3.41	4.15	4.89	5.62	6.16	6.65	7.09	7.48	8.44	9.29	10.17	10.96	11.63	12.21	12.79	13.28	13.66	13.92	14.15	14.19
2.33	0.53	1.23	1.97	2.72	3.47	4.23	4.98	5.73	6.27	6.77	7.22	7.62	8.60	9.46	10.36	11.17	11.85	12.43	13.03	13.53	13.91	14.17	14.41	14.45
2.42	0.54	1.26	2.01	2.77	3.53	4.30	5.07	5.83	6.38	6.89	7.35	7.76	8.75	9.63	10.54	11.36	12.06	12.65	13.26	13.77	14.15	14.42	14.67	14.71
2.50	0.55	1.28	2.04	2.82	3.60	4.37	5.15	5.93	6.49	7.01	7.48	7.89	8.90	9.79	10.72	11.56	12.26	12.87	13.48	14.00	14.40	14.67	14.92	14.96
2.58	0.56	1.30	2.08	2.86	3.65	4.45	5.24	6.02	6.60	7.13	7.60	8.02	9.04	9.95	10.90	11.75	12.47	13.08	13.71	14.23	14.63	14.91	15.16	15.21
2.67	0.57	1.32	2.11	2.91	3.71	4.52	5.32	6.12	6.71	7.24	7.72	8.15	9.19	10.11	11.07	11.94	12.67	13.29	13.93	14.46	14.87	15.15	15.41	15.45
2.75	0.57	1.34	2.14	2.95	3.77	4.59	5.40	6.22	6.81	7.35	7.84	8.27	9.33	10.27	11.24	12.12	12.86	13.50	14.14	14.69	15.10	15.39	15.64	15.69
2.83	0.58	1.36	2.17	3.00	3.83	4.66	5.48	6.31	6.91	7.46	7.96	8.40	9.47	10.43	11.41	12.30	13.06	13.70	14.36	14.91	15.33	15.62	15.88	15.93
2.92	0.59	1.38	2.20	3.04	3.88	4.72	5.56	6.40	7.01	7.57	8.07	8.52	9.61	10.58	11.58	12.48	13.25	13.90	14.56	15.12	15.55	15.84	16.11	16.16
3.00	0.60	1.40	2.24	3.09	3.94	4.79	5.64	6.49	7.11	7.68	8.19	8.64	9.75	10.73	11.74	12.66	13.43	14.10	14.77	15.34	15.77	16.07	16.34	16.39
3.08	0.61	1.42	2.27	3.13	3.99	4.86	5.72	6.58	7.21	7.79	8.30	8.76	9.88	10.88	11.90	12.83	13.62	14.29	14.98	15.55	15.99	16.29	16.57	16.62
3.17	0.62	1.44	2.30	3.17	4.05	4.92	5.80	6.67	7.31	7.89	8.41	8.88	10.01	11.02	12.06	13.01	13.80	14.48	15.18	15.76	16.20	16.51	16.79	16.84
3.25	0.63	1.46	2.33	3.21	4.10	4.99	5.87	6.76	7.40	7.99	8.52	8.99	10.14	11.17	12.22	13.18	13.98	14.67	15.37	15.97	16.41	16.73	17.01	17.06
3.33	0.63	1.48	2.36	3.25	4.15	5.05	5.95	6.84	7.50	8.10	8.63	9.11	10.27	11.31	12.38	13.34	14.16	14.86	15.57	16.17	16.62	16.94	17.22	17.28
3.42	0.64	1.49	2.39	3.29	4.20	5.11	6.02	6.93	7.59	8.20	8.74	9.22	10.40	11.45	12.53	13.51	14.34	15.04	15.76	16.37	16.83	17.15	17.44	17.49
3.50	0.65	1.51	2.42	3.33	4.25	5.18	6.10	7.01	7.68	8.30	8.85	9.33	10.53	11.59	12.68	13.67	14.51	15.23	15.95	16.57	17.03	17.36	17.65	17.70
3.58	0.66	1.53	2.44	3.37	4.30	5.24	6.17	7.09	7.77	8.39	8.95	9.44	10.65	11.72	12.83	13.84	14.68	15.41	16.14	16.76	17.23	17.56	17.86	17.91
3.67	0.66	1.55	2.47	3.41	4.35	5.30	6.24	7.18	7.86	8.49	9.05	9.55	10.78	11.86	12.98	14.00	14.85	15.59	16.33	16.96	17.43	17.77	18.06	18.12
3.75	0.67	1.56	2.50	3.45	4.40	5.36	6.31	7.26	7.95	8.59	9.16	9.66	10.90	11.99	13.13	14.15	15.02	15.76	16.51	17.15	17.63	17.97	18.27	18.33
3.83	0.68	1.58	2.53	3.49	4.45	5.42	6.38	7.34	8.04	8.68	9.26	9.77	11.02	12.13	13.27	14.31	15.19	15.94	16.70	17.34	17.83	18.17	18.47	18.53
3.92	0.69	1.60	2.56	3.53	4.50	5.48	6.45	7.42	8.13	8.78	9.36	9.87	11.14	12.26	13.42	14.47	15.35	16.11	16.88	17.53	18.02	18.36	18.67	18.73
4.00	0.69	1.62	2.58	3.56	4.55	5.53	6.52	7.50	8.21	8.87	9.46	9.98	11.25	12.39	13.56	14.62	15.51	16.28	17.06	17.71	18.21	18.56	18.87	18.93
4.08	0.70	1.63	2.61	3.60	4.59	5.59	6.58	7.57	8.30	8.96	9.55	10.08	11.37	12.52	13.70	14.77	15.67	16.45	17.23	17.90	18.40	18.75	19.06	19.12
4.17	0.71	1.65	2.64	3.64	4.64	5.65	6.65	7.65	8.38	9.05	9.65	10.18	11.49	12.64	13.84	14.92	15.83	16.61	17.41	18.08	18.58	18.94	19.26	19.32
4.25	0.71	1.67	2.66	3.67	4.69	5.70	6.72	7.73	8.47	9.14	9.75	10.29	11.60	12.77	13.98	15.07	15.99	16.78	17.58	18.26	18.77	19.13	19.45	19.51
4.33	0.72	1.68	2.69	3.71	4.73	5.76	6.78	7.80	8.55	9.23	9.84	10.39	11.71	12.89	14.11	15.22	16.15	16.94	17.75	18.43	18.95	19.31	19.64	19.70
4.42	0.73	1.70	2.71	3.74	4.78	5.81	6.85	7.88	8.63	9.32	9.94	10.49	11.83	13.02	14.25	15.36	16.30	17.11	17.92	18.61	19.13	19.50	19.83	19.89
4.50	0.74	1.71	2.74	3.78	4.82	5.87	6.91	7.95	8.71	9.41	10.03	10.58	11.94	13.14	14.38	15.51	16.45	17.27	18.09	18.79	19.31	19.68	20.01	20.07
4.58	0.74	1.73	2.76	3.81	4.87	5.92	6.98	8.02	8.79	9.49	10.12	10.68	12.05	13.26	14.51	15.65	16.61	17.42	18.26	18.96	19.49	19.86	20.20	20.26
4.67	0.75	1.75	2.79	3.85	4.91	5.98	7.04	8.10	8.87	9.58	10.21	10.78	12.16	13.38	14.64	15.79	16.76	17.58	18.42	19.13	19.67	20.04	20.38	20.44
4.75	0.76	1.76	2.81	3.88	4.96	6.03	7.10	8.17	8.95	9.66	10.30	10.87	12.26	13.50	14.78	15.93	16.90	17.74	18.59	19.30	19.84	20.22	20.56	20.62
4.83	0.76	1.78	2.84	3.92	5.00	6.08	7.16	8.24	9.03	9.75	10.39	10.97	12.37	13.62	14.90	16.07	17.05	17.89	18.75	19.47	20.02	20.40	20.74	20.80
4.92	0.77	1.79	2.86	3.95	5.04	6.13	7.22	8.31	9.11	9.83	10.48	11.06	12.48	13.73	15.03	16.21	17.20	18.05	18.91	19.64	20.19	20.57	20.92	20.98
5.00	0.78	1.81	2.89	3.98	5.08	6.19	7.29	8.38	9.18	9.91	10.57	11.16	12.58	13.85	15.16	16.34	17.34	18.20	19.07	19.80	20.36	20.75	21.09	21.16

Upstream Head (feet)	ITRC Water Measurement Tables – 24" Armco-Type Gate, FREE FLOW [Blue center represents best accuracy range] (Flows in CFS) Net Gate Opening (feet)																													
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
2.00	0.67	1.54	2.45	3.37	4.29	5.20	6.11	7.01	7.82	8.60	9.35	10.1	11.6	13.0	14.2	15.2	16.5	17.8	18.8	19.7	20.5	21.2	21.9	22.6	23.1	23.5	23.8	24.2	24.4	24.5
2.04	0.68	1.56	2.48	3.41	4.33	5.25	6.17	7.09	7.90	8.69	9.45	10.2	11.7	13.2	14.3	15.3	16.7	18.0	19.0	19.9	20.7	21.4	22.2	22.8	23.4	23.8	24.1	24.5	24.6	24.8
2.08	0.68	1.57	2.50	3.44	4.38	5.31	6.24	7.16	7.98	8.78	9.54	10.3	11.8	13.3	14.5	15.5	16.9	18.2	19.2	20.1	20.9	21.7	22.4	23.0	23.6	24.0	24.3	24.7	24.9	25.0
2.13	0.69	1.59	2.53	3.47	4.42	5.36	6.30	7.23	8.06	8.87	9.64	10.4	11.9	13.4	14.6	15.6	17.0	18.4	19.4	20.3	21.1	21.9	22.6	23.3	23.8	24.2	24.6	25.0	25.1	25.3
2.17	0.70	1.60	2.55	3.51	4.46	5.41	6.36	7.30	8.14	8.95	9.73	10.5	12.1	13.6	14.7	15.8	17.2	18.5	19.6	20.5	21.4	22.1	22.8	23.5	24.1	24.5	24.8	25.2	25.4	25.5
2.21	0.70	1.62	2.57	3.54	4.50	5.47	6.42	7.37	8.22	9.04	9.83	10.6	12.2	13.7	14.9	15.9	17.4	18.7	19.8	20.7	21.6	22.3	23.1	23.7	24.3	24.7	25.0	25.5	25.6	25.8
2.25	0.71	1.63	2.60	3.58	4.55	5.52	6.48	7.44	8.30	9.12	9.92	10.7	12.3	13.8	15.0	16.1	17.5	18.9	20.0	20.9	21.8	22.5	23.3	23.9	24.5	25.0	25.3	25.7	25.9	26.0
2.29	0.72	1.65	2.62	3.61	4.59	5.57	6.54	7.51	8.37	9.21	10.01	10.8	12.4	13.9	15.2	16.2	17.7	19.1	20.1	21.1	22.0	22.7	23.5	24.2	24.7	25.2	25.5	25.9	26.1	26.3
2.33	0.72	1.66	2.65	3.64	4.63	5.62	6.60	7.58	8.45	9.29	10.10	10.9	12.5	14.1	15.3	16.4	17.8	19.2	20.3	21.3	22.2	22.9	23.7	24.4	25.0	25.4	25.7	26.2	26.3	26.5
2.38	0.73	1.68	2.67	3.67	4.67	5.67	6.66	7.64	8.52	9.37	10.19	11.0	12.6	14.2	15.4	16.5	18.0	19.4	20.5	21.5	22.4	23.1	23.9	24.6	25.2	25.6	26.0	26.4	26.6	26.7
2.42	0.73	1.69	2.69	3.71	4.71	5.72	6.72	7.71	8.60	9.45	10.28	11.1	12.7	14.3	15.6	16.7	18.2	19.6	20.7	21.7	22.5	23.3	24.1	24.8	25.4	25.9	26.2	26.6	26.8	27.0
2.46	0.74	1.71	2.72	3.74	4.75	5.77	6.77	7.78	8.67	9.54	10.37	11.2	12.8	14.4	15.7	16.8	18.3	19.8	20.9	21.8	22.7	23.5	24.3	25.0	25.6	26.1	26.4	26.9	27.0	27.2
2.50	0.75	1.72	2.74	3.77	4.79	5.81	6.83	7.84	8.74	9.62	10.45	11.3	13.0	14.6	15.8	17.0	18.5	19.9	21.0	22.0	22.9	23.7	24.5	25.2	25.8	26.3	26.6	27.1	27.3	27.4
2.54	0.75	1.74	2.76	3.80	4.83	5.86	6.89	7.91	8.82	9.70	10.54	11.4	13.1	14.7	16.0	17.1	18.6	20.1	21.2	22.2	23.1	23.9	24.7	25.5	26.1	26.5	26.9	27.3	27.5	27.7
2.58	0.76	1.75	2.78	3.83	4.87	5.91	6.94	7.97	8.89	9.77	10.63	11.4	13.2	14.8	16.1	17.2	18.8	20.3	21.4	22.4	23.3	24.1	24.9	25.7	26.3	26.7	27.1	27.5	27.7	27.9
2.63	0.77	1.77	2.81	3.86	4.91	5.96	7.00	8.04	8.96	9.85	10.71	11.5	13.3	14.9	16.2	17.4	18.9	20.4	21.5	22.6	23.5	24.3	25.1	25.9	26.5	27.0	27.3	27.8	27.9	28.1
2.67	0.77	1.78	2.83	3.89	4.95	6.01	7.06	8.10	9.03	9.93	10.80	11.6	13.4	15.0	16.4	17.5	19.1	20.6	21.7	22.8	23.7	24.5	25.3	26.1	26.7	27.2	27.5	28.0	28.2	28.3
2.71	0.78	1.79	2.85	3.92	4.99	6.05	7.11	8.16	9.10	10.01	10.88	11.7	13.5	15.2	16.5	17.6	19.2	20.7	21.9	22.9	23.9	24.7	25.5	26.3	26.9	27.4	27.7	28.2	28.4	28.5
2.75	0.78	1.81	2.87	3.95	5.03	6.10	7.17	8.23	9.17	10.09	10.97	11.8	13.6	15.3	16.6	17.8	19.4	20.9	22.1	23.1	24.1	24.9	25.7	26.5	27.1	27.6	27.9	28.4	28.6	28.8
2.79	0.79	1.82	2.89	3.98	5.06	6.14	7.22	8.29	9.24	10.16	11.05	11.9	13.7	15.4	16.7	17.9	19.5	21.1	22.2	23.3	24.2	25.1	25.9	26.7	27.3	27.8	28.2	28.6	28.8	29.0
2.83	0.80	1.83	2.92	4.01	5.10	6.19	7.27	8.35	9.31	10.24	11.13	12.0	13.8	15.5	16.9	18.0	19.7	21.2	22.4	23.5	24.4	25.3	26.1	26.9	27.5	28.0	28.4	28.8	29.0	29.2
2.88	0.80	1.85	2.94	4.04	5.14	6.24	7.33	8.41	9.38	10.31	11.21	12.1	13.9	15.6	17.0	18.2	19.8	21.4	22.6	23.6	24.6	25.4	26.3	27.1	27.7	28.2	28.6	29.1	29.2	29.4
2.92	0.81	1.86	2.96	4.07	5.18	6.28	7.38	8.47	9.45	10.39	11.29	12.2	14.0	15.7	17.1	18.3	19.9	21.5	22.7	23.8	24.8	25.6	26.5	27.3	27.9	28.4	28.8	29.3	29.4	29.6
2.96	0.81	1.87	2.98	4.10	5.21	6.33	7.43	8.53	9.51	10.46	11.37	12.3	14.1	15.8	17.2	18.4	20.1	21.7	22.9	24.0	24.9	25.8	26.7	27.5	28.1	28.6	29.0	29.5	29.7	29.8
3.00	0.82	1.89	3.00	4.13	5.25	6.37	7.48	8.59	9.58	10.53	11.45	12.3	14.2	16.0	17.3	18.6	20.2	21.8	23.0	24.1	25.1	26.0	26.9	27.7	28.3	28.8	29.2	29.7	29.9	30.0
3.04	0.82	1.90	3.02	4.16	5.29	6.41	7.54	8.65	9.65	10.61	11.53	12.4	14.3	16.1	17.5	18.7	20.4	22.0	23.2	24.3	25.3	26.2	27.1	27.8	28.5	29.0	29.4	29.9	30.1	30.2
3.08	0.83	1.91	3.04	4.19	5.32	6.46	7.59	8.71	9.71	10.68	11.61	12.5	14.4	16.2	17.6	18.8	20.5	22.1	23.4	24.5	25.5	26.3	27.2	28.0	28.7	29.2	29.6	30.1	30.3	30.5
3.13	0.84	1.93	3.06	4.21	5.36	6.50	7.64	8.77	9.78	10.75	11.69	12.6	14.5	16.3	17.7	19.0	20.6	22.3	23.5	24.6	25.6	26.5	27.4	28.2	28.9	29.4	29.8	30.3	30.5	30.7
3.17	0.84	1.94	3.08	4.24	5.39	6.54	7.69	8.83	9.84	10.82	11.77	12.7	14.6	16.4	17.8	19.1	20.8	22.4	23.7	24.8	25.8	26.7	27.6	28.4	29.1	29.6	30.0	30.5	30.7	30.9
3.21	0.85	1.95	3.10	4.27	5.43	6.59	7.74	8.88	9.91	10.89	11.84	12.8	14.7	16.5	17.9	19.2	20.9	22.6	23.8	25.0	26.0	26.9	27.8	28.6	29.3	29.8	30.2	30.7	30.9	31.1
3.25	0.85	1.96	3.12	4.30	5.46	6.63	7.79	8.94	9.97	10.96	11.92	12.8	14.8	16.6	18.1	19.3	21.1	22.7	24.0	25.1	26.1	27.1	28.0	28.8	29.5	30.0	30.4	30.9	31.1	31.3
3.29	0.86	1.98	3.14	4.32	5.50	6.67	7.84	9.00	10.03	11.03	12.00	12.9	14.9	16.7	18.2	19.5	21.2	22.9	24.1	25.3	26.3	27.2	28.2	29.0	29.7	30.2	30.6	31.1	31.3	31.5
3.33	0.86	1.99	3.16	4.35	5.53	6.71	7.89	9.06	10.10	11.10	12.07	13.0	15.0	16.8	18.3	19.6	21.3	23.0	24.3	25.4	26.5	27.4	28.3	29.2	29.8	30.4	30.8	31.3	31.5	31.7
3.38	0.87	2.00	3.18	4.38	5.57	6.76	7.94	9.11	10.16	11.17	12.15	13.1	15.1	16.9	18.4	19.7	21.5	23.1	24.4	25.6	26.6	27.6	28.5	29.3	30.0	30.6	31.0	31.5	31.7	31.9
3.42	0.87	2.01	3.20	4.41	5.60	6.80	7.99	9.17	10.22	11.24	12.22	13.2	15.1	17.0	18.5	19.8	21.6	23.3	24.6	25.8	26.8	27.7	28.7	29.5	30.2	30.7	31.2	31.7	31.9	32.1
3.50	0.88	2.04	3.24	4.46	5.67	6.88	8.08	9.28	10.35	11.38	12.37	13.3	15.3	17.2	18.7	20.1	21.8	23.6	24.9	26.1	27.1	28.1	29.0	29.9	30.6	31.1	31.5	32.1	32.3	32.4
3.58	0.89	2.06	3.28	4.51	5.74	6.96	8.18	9.39	10.47	11.51	12.52	13.5	15.5	17.4	19.0	20.3	22.1	23.9	25.2	26.4	27.5	28.4	29.4	30.2	30.9	31.5	31.9	32.4	32.6	32.8
3.67	0.91	2.09	3.32	4.56	5.80	7.04	8.27	9.50	10.59	11.65	12.66	13.6	15.7	17.6	19.2	20.5	22.4	24.1	25.5	26.7	27.8	28.7	29.7	30.6	31.3	31.9	32.3	32.8	33.0	33.2
3.75	0.92	2.11	3.35	4.62	5.87	7.12	8.37	9.61	10.71	11.78	12.80	13.8	15.9	17.8	19.4	20.8	22.6	24.4	25.8	27.0	28.1	29.1	30.1	30.9	31.7	32.2	32.6	33.2	33.4	33.6
3.83	0.93	2.13	3.39	4.67	5.94	7.20	8.46	9.71	10.83	11.91	12.95	13.9	16.0	18.0	19.6	21.0	22.9	24.7	26.0	27.3	28.4	29.4	30.4	31.3	32.0	32.6	33.0	33.5	33.8	34.0
3.92	0.94	2.16	3.43	4.72	6.00	7.28	8.55	9.82	10.95	12.04	13.09	14.1	16.2	18.2	19.8	21.2	23.1	24.9	26.3	27.6	28.7	29.7	30.7	31.6	32.3	32.9	33.4	33.9	34.1	34.3
4.00	0.95	2.18	3.46	4.77	6.06	7.36	8.64	9.92	11.06	12.16	13.22	14.2	16.4	18.4	20.0	21.4	23.4	25.2	26.6	27.9	29.0	30.0	31.0	31.9	32.7	33.3	33.7	34.3	34.5	34.7
4.08	0.96	2.20	3.50	4.82	6.13	7.43	8.73	10.02	11.18	12.29	13.36	14.4	16.6	18.6	20.2	21.7	23.6	25.5	26.9	28.2	29.3	30.3	31.4	32.3	33.0	33.6	34.1	34.6	34.8	35.0
4.17	0.96	2.22	3.54	4.87	6.19	7.51	8.82	10.12	11.29	12.41	13.50	14.5	16.7	18.8	20.4	21.9	23.8	25.7	27.1	28.4	29.6	30.6	31.7	32.6	33.4	34.0	34.4	35.0	35.2	35.4
4.25	0.97	2.25	3.57	4.91	6.25	7.58	8.91	10.23	11.40	12.54	13.63	14.7	16.9	19.0	20.6	22.1	24.1	26.0	27.4	28.7	29.9	30.9	32.0	32.9	33.7	34.3	34.7	35.3	35.5	35.8
4.33	0.98	2.27	3.61	4.96	6.31	7.66	8.99	10.33	11.51	12.66	13.76	14.8	17.1	19.2	20.8	22.3	24.3	26.2	27.7	29.0	30.2	31.2	32.3	33.2	34.0	34.6	35.1	35.7	35.9	36.1
4.42	0.99	2.29	3.64	5.01	6.37	7.73	9.08	10.42	11.62	12.78	13.90	15.0	17.2	19.4	21.0	22.5	24.5	26.5	28.0	29.3	30.5	31.5	32.6	33.6	34.4	35.0	35.4	36.0	36.2	36.5
4.50	1.00	2.31	3.67	5.06	6.43	7.80	9.17	10.52	11.73	12.90	14.03	15.1	17.4	19.5	21.2	22.7	24.8	26.7	28.2	29.6	30.8	31.8	32.9	33.9	34.7	35.3	35.7	36.3	36.6	36.8
4.58	1.01	2.33	3.71	5.10	6.49	7.87	9.25	10.62	11.84	13.02	14.16	15.2	17.5	19.7	21.4	23.0	25.0	27.0	28.5	29.8	31.1	32.1	33.2	34.2	35.0	35.6	36.1	36.7	36.9	37.1
4.67	1.02	2.35	3.74	5.15	6.55	7.94	9.33	10.72	11.95	13.14	14.28	15.4	17.7	19.9	21.6	23.2	25.2	27.2	28.7	30.1	31.3	32.4	33.5	34.5	35.3	35.9	36.4	37.0	37.2	37.5
4.75	1.03	2.38	3.78	5.19	6.61	8.02	9.42	10.81	12.05	13.25	14.41	15.5	17.9	20.1	21.8	23.4	25.5	27.5	29.0	30.4	31.6	32.7	33.8	34.8	35.6	36.3	36.7	37.3	37.6	37.8
4.83	1.04	2.40	3.81	5.24	6.66	8.09	9.50	10.90	12.16	13.37	14.54	15.7	18.0	20.3	22.0	23.6	25.7	27.7	29.2	30.6	31.9	33.0	34.1	35.1	35.9	36.6	37.1	37.7	37.9	38.1
4.92	1.05	2.42	3.84	5.28	6.72	8.15	9.58	11.00	12.26	13.48	14.66	15.8	18.2	20.4	22.2	23.8	25.9	27.9	29.5	30.9	32.2	33.3	34.4	35.4	36.2	36.9	37.4	38.0	38.2	38.5
5.00	1.06	2.44	3.87	5.33	6.78	8.22	9.66	11.09	12.37	13.60	14.79	15.9	18.3	20.6	22.4	24.0	26.1	28.2	29.7	31.2	32.4	33.6	34.7	35.7	36.6	37.2	37.7	38.3	38.6	38.8

ITRC Water Measurement Tables for
RECTANGULAR Gates on Round Pipes
Discharge Values in CFS

Normal submerged metergate operation

ITRC Water Measurement Tables – 18" Rectangular Gate, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																							
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50
	Discharge (CFS)																							
0.04	0.02	0.05	0.09	0.13	0.18	0.23	0.28	0.34	0.40	0.46	0.52	0.58	0.72	0.86	1.01	1.17	1.34	1.51	1.71	1.92	2.07	2.21	2.26	2.28
0.06	0.02	0.06	0.11	0.16	0.22	0.28	0.35	0.42	0.49	0.56	0.64	0.71	0.88	1.05	1.24	1.43	1.64	1.85	2.10	2.36	2.54	2.70	2.77	2.79
0.08	0.02	0.07	0.12	0.19	0.25	0.33	0.40	0.48	0.56	0.65	0.73	0.82	1.01	1.21	1.43	1.65	1.89	2.13	2.43	2.72	2.93	3.12	3.20	3.22
0.10	0.03	0.08	0.14	0.21	0.28	0.37	0.45	0.54	0.63	0.72	0.82	0.92	1.13	1.36	1.60	1.85	2.11	2.39	2.71	3.04	3.28	3.49	3.58	3.60
0.13	0.03	0.08	0.15	0.23	0.31	0.40	0.49	0.59	0.69	0.79	0.90	1.01	1.24	1.49	1.75	2.02	2.32	2.61	2.97	3.33	3.59	3.82	3.92	3.95
0.15	0.03	0.09	0.16	0.25	0.34	0.43	0.53	0.63	0.74	0.86	0.97	1.09	1.34	1.61	1.89	2.19	2.50	2.82	3.21	3.60	3.88	4.13	4.24	4.26
0.17	0.03	0.09	0.17	0.26	0.36	0.46	0.57	0.68	0.80	0.92	1.04	1.16	1.44	1.72	2.02	2.34	2.67	3.02	3.43	3.85	4.15	4.42	4.53	4.56
0.19	0.04	0.10	0.18	0.28	0.38	0.49	0.60	0.72	0.84	0.97	1.10	1.23	1.52	1.82	2.15	2.48	2.84	3.20	3.64	4.08	4.40	4.68	4.80	4.84
0.21	0.04	0.11	0.19	0.29	0.40	0.52	0.64	0.76	0.89	1.02	1.16	1.30	1.60	1.92	2.26	2.61	2.99	3.37	3.83	4.30	4.63	4.94	5.06	5.10
0.23	0.04	0.11	0.20	0.31	0.42	0.54	0.67	0.79	0.93	1.07	1.22	1.36	1.68	2.01	2.37	2.74	3.14	3.54	4.02	4.51	4.86	5.18	5.31	5.35
0.25	0.04	0.12	0.21	0.32	0.44	0.57	0.70	0.83	0.97	1.12	1.27	1.42	1.76	2.10	2.48	2.86	3.28	3.70	4.20	4.71	5.08	5.41	5.55	5.58
0.27	0.04	0.12	0.22	0.34	0.46	0.59	0.72	0.86	1.01	1.17	1.32	1.48	1.83	2.19	2.58	2.98	3.41	3.85	4.37	4.90	5.28	5.63	5.77	5.81
0.29	0.04	0.13	0.23	0.35	0.48	0.61	0.75	0.90	1.05	1.21	1.37	1.54	1.90	2.27	2.68	3.09	3.54	3.99	4.54	5.09	5.48	5.84	5.99	6.03
0.31	0.05	0.13	0.24	0.36	0.49	0.63	0.78	0.93	1.09	1.25	1.42	1.59	1.97	2.35	2.77	3.20	3.66	4.13	4.70	5.27	5.68	6.05	6.20	6.24
0.33	0.05	0.13	0.24	0.37	0.51	0.65	0.80	0.96	1.12	1.30	1.47	1.64	2.03	2.43	2.86	3.30	3.78	4.27	4.85	5.44	5.86	6.24	6.41	6.45
0.35	0.05	0.14	0.25	0.38	0.52	0.67	0.83	0.99	1.16	1.33	1.51	1.69	2.09	2.50	2.95	3.41	3.90	4.40	5.00	5.61	6.04	6.44	6.60	6.65
0.38	0.05	0.14	0.26	0.40	0.54	0.69	0.85	1.02	1.19	1.37	1.56	1.74	2.15	2.57	3.03	3.50	4.01	4.53	5.14	5.77	6.22	6.62	6.79	6.84
0.40	0.05	0.15	0.27	0.41	0.55	0.71	0.88	1.04	1.23	1.41	1.60	1.79	2.21	2.65	3.12	3.60	4.12	4.65	5.29	5.93	6.39	6.81	6.98	7.03
0.42	0.05	0.15	0.27	0.42	0.57	0.73	0.90	1.07	1.26	1.45	1.64	1.84	2.27	2.71	3.20	3.69	4.23	4.77	5.42	6.08	6.55	6.98	7.16	7.21
0.46	0.06	0.16	0.29	0.44	0.60	0.77	0.94	1.12	1.32	1.52	1.72	1.93	2.38	2.85	3.35	3.87	4.44	5.00	5.69	6.38	6.87	7.32	7.51	7.56
0.50	0.06	0.16	0.30	0.46	0.62	0.80	0.98	1.17	1.38	1.59	1.80	2.01	2.49	2.97	3.50	4.05	4.63	5.23	5.94	6.66	7.18	7.65	7.84	7.90
0.54	0.06	0.17	0.31	0.48	0.65	0.83	1.03	1.22	1.43	1.65	1.87	2.10	2.59	3.09	3.65	4.21	4.82	5.44	6.18	6.93	7.47	7.96	8.16	8.22
0.58	0.06	0.18	0.32	0.49	0.67	0.86	1.06	1.27	1.49	1.71	1.94	2.17	2.69	3.21	3.78	4.37	5.00	5.65	6.42	7.20	7.75	8.26	8.47	8.53
0.63	0.07	0.18	0.33	0.51	0.70	0.90	1.10	1.31	1.54	1.77	2.01	2.25	2.78	3.32	3.92	4.52	5.18	5.84	6.64	7.45	8.03	8.55	8.77	8.83
0.67	0.07	0.19	0.35	0.53	0.72	0.92	1.14	1.36	1.59	1.83	2.08	2.32	2.87	3.43	4.05	4.67	5.35	6.04	6.86	7.69	8.29	8.83	9.06	9.12
0.71	0.07	0.20	0.36	0.54	0.74	0.95	1.17	1.40	1.64	1.89	2.14	2.40	2.96	3.54	4.17	4.82	5.51	6.22	7.07	7.93	8.55	9.10	9.34	9.40
0.75	0.07	0.20	0.37	0.56	0.76	0.98	1.21	1.44	1.69	1.94	2.20	2.47	3.04	3.64	4.29	4.96	5.67	6.40	7.28	8.16	8.79	9.37	9.61	9.67
0.79	0.07	0.21	0.38	0.57	0.78	1.01	1.24	1.48	1.73	2.00	2.26	2.53	3.13	3.74	4.41	5.09	5.83	6.58	7.47	8.38	9.03	9.62	9.87	9.94
0.83	0.08	0.21	0.39	0.59	0.81	1.03	1.27	1.52	1.78	2.05	2.32	2.60	3.21	3.84	4.52	5.22	5.98	6.75	7.67	8.60	9.27	9.87	10.13	10.20
0.92	0.08	0.22	0.41	0.62	0.84	1.08	1.33	1.59	1.87	2.15	2.43	2.73	3.37	4.03	4.74	5.48	6.27	7.08	8.04	9.02	9.72	10.36	10.62	10.69
1.00	0.08	0.23	0.42	0.65	0.88	1.13	1.39	1.66	1.95	2.24	2.54	2.85	3.52	4.20	4.96	5.72	6.55	7.39	8.40	9.42	10.15	10.82	11.09	11.17
1.08	0.09	0.24	0.44	0.67	0.92	1.18	1.45	1.73	2.03	2.33	2.65	2.96	3.66	4.38	5.16	5.96	6.82	7.69	8.74	9.81	10.57	11.26	11.55	11.62
1.17	0.09	0.25	0.46	0.70	0.95	1.22	1.50	1.79	2.10	2.42	2.75	3.08	3.80	4.54	5.35	6.18	7.08	7.98	9.07	10.18	10.97	11.68	11.98	12.06
1.25	0.09	0.26	0.47	0.72	0.99	1.27	1.56	1.86	2.18	2.51	2.84	3.18	3.93	4.70	5.54	6.40	7.33	8.26	9.39	10.53	11.35	12.09	12.40	12.49
1.33	0.10	0.27	0.49	0.75	1.02	1.31	1.61	1.92	2.25	2.59	2.94	3.29	4.06	4.86	5.72	6.61	7.57	8.53	9.70	10.88	11.72	12.49	12.81	12.90
1.42	0.10	0.28	0.50	0.77	1.05	1.35	1.66	1.98	2.32	2.67	3.03	3.39	4.18	5.00	5.90	6.81	7.80	8.80	10.00	11.21	12.09	12.87	13.20	13.29
1.50	0.10	0.28	0.52	0.79	1.08	1.39	1.71	2.03	2.39	2.75	3.11	3.49	4.31	5.15	6.07	7.01	8.02	9.05	10.29	11.54	12.44	13.25	13.59	13.68
1.58	0.10	0.29	0.53	0.81	1.11	1.42	1.75	2.09	2.45	2.82	3.20	3.58	4.42	5.29	6.24	7.20	8.24	9.30	10.57	11.86	12.78	13.61	13.96	14.05
1.67	0.11	0.30	0.55	0.83	1.14	1.46	1.80	2.14	2.52	2.90	3.28	3.68	4.54	5.43	6.40	7.39	8.46	9.54	10.85	12.16	13.11	13.96	14.32	14.42
1.75	0.11	0.31	0.56	0.85	1.17	1.50	1.84	2.20	2.58	2.97	3.36	3.77	4.65	5.56	6.56	7.57	8.67	9.78	11.11	12.46	13.43	14.31	14.68	14.77
1.83	0.11	0.31	0.57	0.87	1.19	1.53	1.89	2.25	2.64	3.04	3.44	3.85	4.76	5.69	6.71	7.75	8.87	10.01	11.37	12.76	13.75	14.65	15.02	15.12
1.92	0.11	0.32	0.59	0.89	1.22	1.57	1.93	2.30	2.70	3.11	3.52	3.94	4.87	5.82	6.86	7.92	9.07	10.23	11.63	13.04	14.06	14.97	15.36	15.46
2.00	0.12	0.33	0.60	0.91	1.25	1.60	1.97	2.35	2.76	3.17	3.60	4.03	4.97	5.95	7.01	8.09	9.27	10.45	11.88	13.32	14.36	15.30	15.69	15.79
2.08	0.12	0.34	0.61	0.93	1.27	1.63	2.01	2.40	2.81	3.24	3.67	4.11	5.07	6.07	7.15	8.26	9.46	10.67	12.13	13.60	14.66	15.61	16.01	16.12
2.17	0.12	0.34	0.62	0.95	1.30	1.67	2.05	2.44	2.87	3.30	3.74	4.19	5.18	6.19	7.29	8.42	9.64	10.88	12.37	13.87	14.95	15.92	16.33	16.44
2.25	0.12	0.35	0.64	0.97	1.32	1.70	2.09	2.49	2.92	3.36	3.81	4.27	5.27	6.31	7.43	8.58	9.83	11.09	12.60	14.13	15.23	16.22	16.64	16.75
2.33	0.13	0.36	0.65	0.99	1.35	1.73	2.13	2.54	2.98	3.43	3.88	4.35	5.37	6.42	7.57	8.74	10.01	11.29	12.83	14.39	15.51	16.52	16.95	17.06
2.42	0.13	0.36	0.66	1.00	1.37	1.76	2.17	2.58	3.03	3.49	3.95	4.43	5.47	6.54	7.70	8.90	10.19	11.49	13.06	14.65	15.78	16.81	17.25	17.36
2.50	0.13	0.37	0.67	1.02	1.39	1.79	2.20	2.63	3.08	3.55	4.02	4.50	5.56	6.65	7.84	9.05	10.36	11.69	13.28	14.90	16.05	17.10	17.54	17.66
2.58	0.13	0.37	0.68	1.04	1.42	1.82	2.24	2.67	3.13	3.61	4.09	4.58	5.65	6.76	7.96	9.20	10.53	11.88	13.50	15.14	16.32	17.38	17.83	17.95
2.67	0.14	0.38	0.69	1.05	1.44	1.85	2.27	2.71	3.18	3.66	4.15	4.65	5.74	6.87	8.09	9.34	10.70	12.07	13.72	15.39	16.58	17.66	18.12	18.24
2.75	0.14	0.39	0.70	1.07	1.46	1.88	2.31	2.75	3.23	3.72	4.22	4.72	5.83	6.97	8.22	9.49	10.87	12.26	13.93	15.62	16.84	17.94	18.40	18.52
2.83	0.14	0.39	0.71	1.09	1.48	1.91	2.34	2.80	3.28	3.78	4.28	4.79	5.92	7.08	8.34	9.63	11.03	12.44	14.14	15.86	17.09	18.21	18.67	18.80

ITRC Water Measurement Tables – 24" Rectangular Gate, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																													
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
	Discharge (CFS)																													
0.04	0.04	0.07	0.12	0.18	0.25	0.31	0.38	0.44	0.52	0.60	0.68	0.76	0.93	1.11	1.30	1.49	1.68	1.86	2.06	2.25	2.45	2.65	2.87	3.08	3.28	3.70	3.89	4.05	4.06	4.07
0.06	0.04	0.08	0.15	0.23	0.30	0.38	0.46	0.54	0.64	0.73	0.83	0.93	1.14	1.36	1.60	1.83	2.06	2.28	2.52	2.75	3.00	3.25	3.51	3.77	4.02	4.54	4.76	4.96	4.97	4.98
0.08	0.05	0.09	0.17	0.26	0.35	0.44	0.54	0.63	0.74	0.85	0.96	1.07	1.32	1.57	1.84	2.11	2.38	2.64	2.91	3.18	3.47	3.75	4.06	4.36	4.64	5.24	5.50	5.73	5.74	5.75
0.10	0.06	0.10	0.19	0.29	0.39	0.50	0.60	0.70	0.82	0.95	1.07	1.20	1.48	1.76	2.06	2.36	2.66	2.95	3.25	3.55	3.88	4.20	4.54	4.87	5.19	5.85	6.15	6.41	6.42	6.43
0.13	0.06	0.11	0.21	0.32	0.43	0.54	0.66	0.77	0.90	1.04	1.18	1.32	1.62	1.93	2.26	2.59	2.91	3.23	3.56	3.89	4.25	4.60	4.97	5.33	5.69	6.41	6.73	7.02	7.03	7.04
0.15	0.07	0.12	0.23	0.34	0.46	0.59	0.71	0.83	0.97	1.12	1.27	1.42	1.75	2.08	2.44	2.80	3.14	3.49	3.85	4.20	4.59	4.96	5.37	5.76	6.14	6.93	7.27	7.58	7.59	7.61
0.17	0.07	0.13	0.24	0.37	0.50	0.63	0.76	0.89	1.04	1.20	1.36	1.52	1.87	2.23	2.60	2.99	3.36	3.73	4.11	4.49	4.90	5.31	5.74	6.16	6.57	7.41	7.77	8.10	8.12	8.13
0.19	0.08	0.14	0.26	0.39	0.53	0.66	0.80	0.94	1.10	1.27	1.44	1.61	1.98	2.36	2.76	3.17	3.56	3.96	4.36	4.77	5.20	5.63	6.09	6.53	6.97	7.86	8.24	8.59	8.61	8.62
0.21	0.08	0.15	0.27	0.41	0.55	0.70	0.85	0.99	1.16	1.34	1.52	1.70	2.09	2.49	2.91	3.34	3.76	4.17	4.60	5.02	5.48	5.93	6.41	6.89	7.34	8.28	8.69	9.06	9.07	9.09
0.23	0.08	0.15	0.28	0.43	0.58	0.73	0.89	1.04	1.22	1.41	1.59	1.78	2.19	2.61	3.05	3.50	3.94	4.37	4.82	5.27	5.75	6.22	6.73	7.22	7.70	8.68	9.11	9.50	9.52	9.53
0.25	0.09	0.16	0.30	0.45	0.61	0.77	0.93	1.09	1.28	1.47	1.66	1.86	2.29	2.73	3.19	3.66	4.12	4.57	5.04	5.50	6.00	6.50	7.03	7.54	8.05	9.07	9.52	9.92	9.94	9.96
0.27	0.09	0.17	0.31	0.47	0.63	0.80	0.97	1.13	1.33	1.53	1.73	1.94	2.38	2.84	3.32	3.81	4.28	4.75	5.24	5.73	6.25	6.77	7.31	7.85	8.37	9.44	9.91	10.33	10.35	10.37
0.29	0.10	0.17	0.32	0.49	0.66	0.83	1.00	1.18	1.38	1.59	1.80	2.01	2.47	2.95	3.45	3.95	4.45	4.93	5.44	5.94	6.49	7.02	7.59	8.15	8.69	9.80	10.28	10.72	10.74	10.76
0.31	0.10	0.18	0.33	0.50	0.68	0.86	1.04	1.22	1.43	1.64	1.86	2.08	2.56	3.05	3.57	4.09	4.60	5.11	5.63	6.15	6.71	7.27	7.86	8.43	8.99	10.14	10.64	11.09	11.11	11.13
0.33	0.10	0.19	0.34	0.52	0.70	0.89	1.07	1.26	1.47	1.70	1.92	2.15	2.64	3.15	3.68	4.23	4.75	5.27	5.82	6.35	6.93	7.51	8.11	8.71	9.29	10.47	10.99	11.46	11.48	11.50
0.35	0.11	0.19	0.35	0.54	0.72	0.91	1.11	1.29	1.52	1.75	1.98	2.22	2.72	3.25	3.80	4.36	4.90	5.44	6.00	6.55	7.15	7.74	8.36	8.98	9.58	10.80	11.33	11.81	11.83	11.85
0.38	0.11	0.20	0.36	0.55	0.74	0.94	1.14	1.33	1.56	1.80	2.04	2.28	2.80	3.34	3.91	4.48	5.04	5.59	6.17	6.74	7.35	7.96	8.61	9.24	9.85	11.11	11.66	12.15	12.17	12.20
0.40	0.11	0.20	0.37	0.57	0.76	0.97	1.17	1.37	1.61	1.85	2.09	2.34	2.88	3.43	4.01	4.61	5.18	5.75	6.34	6.92	7.55	8.18	8.84	9.49	10.12	11.41	11.98	12.49	12.51	12.53
0.42	0.11	0.21	0.38	0.58	0.78	0.99	1.20	1.40	1.65	1.90	2.15	2.40	2.96	3.52	4.12	4.73	5.31	5.90	6.50	7.10	7.75	8.39	9.07	9.74	10.39	11.71	12.29	12.81	12.83	12.86
0.46	0.12	0.22	0.40	0.61	0.82	1.04	1.26	1.47	1.73	1.99	2.25	2.52	3.10	3.69	4.32	4.96	5.57	6.18	6.82	7.45	8.13	8.80	9.51	10.21	10.89	12.28	12.89	13.44	13.46	13.48
0.50	0.13	0.23	0.42	0.64	0.86	1.09	1.31	1.54	1.80	2.08	2.35	2.63	3.24	3.86	4.51	5.18	5.82	6.46	7.12	7.78	8.49	9.19	9.94	10.67	11.38	12.83	13.46	14.03	14.06	14.08
0.54	0.13	0.24	0.43	0.66	0.89	1.13	1.37	1.60	1.88	2.16	2.45	2.74	3.37	4.01	4.70	5.39	6.06	6.72	7.42	8.10	8.84	9.57	10.34	11.10	11.84	13.35	14.01	14.61	14.63	14.66
0.58	0.14	0.25	0.45	0.69	0.93	1.17	1.42	1.66	1.95	2.24	2.54	2.84	3.50	4.17	4.87	5.59	6.29	6.98	7.70	8.40	9.17	9.93	10.73	11.52	12.29	13.85	14.54	15.16	15.18	15.21
0.63	0.14	0.26	0.47	0.71	0.96	1.21	1.47	1.72	2.02	2.32	2.63	2.94	3.62	4.31	5.04	5.79	6.51	7.22	7.97	8.70	9.49	10.28	11.11	11.93	12.72	14.34	15.05	15.69	15.72	15.75
0.67	0.14	0.26	0.48	0.74	0.99	1.25	1.52	1.78	2.08	2.40	2.72	3.04	3.74	4.45	5.21	5.98	6.72	7.46	8.23	8.98	9.80	10.61	11.47	12.32	13.14	14.81	15.55	16.20	16.23	16.26
0.71	0.15	0.27	0.50	0.76	1.02	1.29	1.56	1.83	2.15	2.47	2.80	3.13	3.85	4.59	5.37	6.16	6.93	7.69	8.48	9.26	10.11	10.94	11.83	12.70	13.54	15.27	16.02	16.70	16.73	16.76
0.75	0.15	0.28	0.51	0.78	1.05	1.33	1.61	1.88	2.21	2.54	2.88	3.22	3.97	4.72	5.53	6.34	7.13	7.91	8.73	9.53	10.40	11.26	12.17	13.07	13.93	15.71	16.49	17.19	17.22	17.25
0.79	0.16	0.29	0.53	0.80	1.08	1.37	1.65	1.94	2.27	2.61	2.96	3.31	4.07	4.85	5.68	6.51	7.32	8.13	8.97	9.79	10.68	11.57	12.50	13.42	14.32	16.14	16.94	17.66	17.69	17.72
0.83	0.16	0.30	0.54	0.82	1.11	1.40	1.70	1.99	2.33	2.68	3.04	3.40	4.18	4.98	5.82	6.68	7.52	8.34	9.20	10.05	10.96	11.87	12.83	13.77	14.69	16.56	17.38	18.12	18.15	18.18
0.92	0.17	0.31	0.57	0.86	1.16	1.47	1.78	2.08	2.44	2.81	3.19	3.57	4.38	5.22	6.11	7.01	7.88	8.75	9.65	10.54	11.50	12.45	13.45	14.44	15.41	17.37	18.23	19.00	19.03	19.07
1.00	0.18	0.32	0.59	0.90	1.21	1.53	1.86	2.18	2.55	2.94	3.33	3.72	4.58	5.45	6.38	7.32	8.23	9.14	10.08	11.00	12.01	13.00	14.05	15.09	16.09	18.14	19.04	19.85	19.88	19.92
1.08	0.18	0.34	0.61	0.94	1.26	1.60	1.93	2.26	2.66	3.06	3.46	3.88	4.77	5.68	6.64	7.62	8.57	9.51	10.49	11.45	12.50	13.53	14.63	15.70	16.75	18.88	19.82	20.66	20.69	20.73
1.17	0.19	0.35	0.64	0.98	1.31	1.66	2.01	2.35	2.76	3.17	3.59	4.02	4.95	5.89	6.89	7.91	8.89	9.87	10.88	11.89	12.97	14.04	15.18	16.30	17.38	19.59	20.57	21.44	21.47	21.51
1.25	0.20	0.36	0.66	1.01	1.36	1.72	2.08	2.43	2.85	3.28	3.72	4.16	5.12	6.10	7.13	8.18	9.20	10.21	11.27	12.30	13.43	14.53	15.71	16.87	17.99	20.28	21.29	22.19	22.23	22.27
1.33	0.20	0.37	0.68	1.04	1.40	1.77	2.14	2.51	2.95	3.39	3.84	4.30	5.29	6.30	7.37	8.45	9.51	10.55	11.63	12.71	13.87	15.01	16.23	17.42	18.58	20.95	21.99	22.92	22.95	23.00
1.42	0.21	0.39	0.70	1.07	1.45	1.83	2.21	2.59	3.04	3.49	3.96	4.43	5.45	6.49	7.59	8.71	9.80	10.87	11.99	13.10	14.29	15.47	16.73	17.96	19.15	21.59	22.66	23.62	23.66	23.71
1.50	0.22	0.40	0.72	1.11	1.49	1.88	2.27	2.66	3.13	3.60	4.08	4.56	5.61	6.68	7.81	8.97	10.08	11.19	12.34	13.48	14.71	15.92	17.21	18.48	19.71	22.22	23.32	24.31	24.35	24.39
1.58	0.22	0.41	0.74	1.14	1.53	1.93	2.34	2.74	3.21	3.69	4.19	4.69	5.76	6.86	8.03	9.21	10.36	11.50	12.68	13.85	15.11	16.36	17.68	18.98	20.25	22.83	23.96	24.97	25.01	25.06
1.67	0.23	0.42	0.76	1.17	1.57	1.98	2.40	2.81	3.29	3.79	4.30	4.81	5.91	7.04	8.24	9.45	10.63	11.79	13.01	14.21	15.50	16.78	18.14	19.48	20.77	23.42	24.58	25.62	25.66	25.71
1.75	0.23	0.43	0.78	1.19	1.61	2.03	2.46	2.88	3.38	3.88	4.40	4.93	6.06	7.22	8.44	9.68	10.89	12.08	13.33	14.56	15.89	17.20	18.59	19.96	21.29	24.00	25.19	26.25	26.30	26.35
1.83	0.24	0.44	0.80	1.22	1.64	2.08	2.51	2.95	3.45	3.98	4.51	5.04	6.20	7.38	8.64	9.91	11.15	12.37	13.64	14.90	16.26	17.60	19.03	20.43	21.79	24.56	25.78	26.87	26.92	26.97
1.92	0.24	0.45	0.82	1.25	1.68	2.13	2.57	3.01	3.53	4.07	4.61	5.16	6.34	7.55	8.83	10.14	11.40	12.65	13.95	15.23	16.62	18.00	19.46	20.89	22.28	25.11	26.36	27.48	27.52	27.57
2.00	0.25	0.46	0.84	1.28	1.72	2.17	2.63	3.08	3.61	4.15	4.71	5.27	6.47	7.71	9.02	10.35	11.64	12.92	14.25	15.56	16.98	18.39	19.87	21.34	22.76	25.65	26.93	28.07	28.11	28.17
2.08	0.26	0.47	0.85	1.30	1.75	2.22	2.68	3.14	3.68	4.24	4.80	5.37	6.61	7.87	9.21	10.57	11.88	13.19	14.54	15.88	17.33	18.76	20.28	21.78	23.22	26.18	27.48	28.65	28.69	28.75
2.17	0.26	0.48	0.87	1.33	1.79	2.26	2.73	3.20	3.76	4.32	4.90	5.48	6.74	8.03	9.39	10.78	12.12	13.45	14.83	16.20	17.68	19.14	20.69	22.21	23.68	26.70	28.03	29.21	29.26	29.32
2.25	0.27	0.49	0.89	1.35	1.82	2.30	2.79	3.26	3.83	4.40	4.99	5.59	6.87	8.18	9.57	10.98	12.35	13.70	15.11	16.51	18.01	19.50	21.08	22.63	24.14	27.21	28.56	29.77	29.82	29.88
2.33	0.27	0.49	0.90	1.38	1.86	2.34	2.84	3.32	3.90	4.49	5.08	5.69	6.99	8.33	9.75	11.18	12.58	13.95	15.39	16.81	18.34	19.86	21.47	23.05	24.58	27.71	29.08	30.32	30.37	30.42
2.42	0.27	0.50	0.92	1.40	1.89	2.39	2.89	3.38	3.97	4.56	5.17	5.79	7.12	8.48	9.92	11.38	12.80	14.20	15.66	17.11	18.67	20.21	21.85	23.45	25.01	28.20	29.60	30.85	30.90	30.96
2.50	0.28	0.51	0.93	1.43	1.92	2.43	2.94	3.44	4.03	4.64	5.26	5.89	7.24	8.62	10.09	11.58	13.02	14.44	15.93	17.40	18.99	20.56	22.22	23.85	25.44	28.68	30.11	31.38	31.43	31.49
2.58	0.28	0.52	0.95	1.45	1.95	2.47	2.99	3.50	4.10	4.72	5.35	5.99	7.36	8.77	10.25	11.77	13.23	14.68	16.19	17.69	19.30	20.90	22.59	24.25	25.86	29.16	30.60	31.90	31.95	32.01
2.67	0.29	0.53	0.96	1.47	1.98	2.51	3.03	3.55	4.17	4.80	5.43	6.08	7.48	8.91	10.42	11.95	13.44	14.92	16.45	17.97	19.61	21.23	22.95	24.64	26.28	29.62	31.09	32.41	32.46	32.52
2.75	0.29	0.54	0.98	1.50	2.01	2.55	3.08	3.61	4.23	4.87	5.52	6.18	7.59	9.04	10.58	12.14	13.65	15.15	16.71	18.25	19.91	21.56	23.30	25.02	26.68	30.08	31.57	32.91	32.97	33.03
2.83	0.30	0.54	0.99	1.52	2.04	2.58	3.13	3.66	4.29	4.94	5.60	6.27	7.71	9.18	10.74	12.32	13.86	15.38	16.96	18.52	20.21	21.88	23.65	25.39	27.08	30.53	32.05	33.41	33.46	33.52

Glenn-Colusa Irrigation District SB X7-7 Water Measurement Compliance Program

Glenn-Colusa Irrigation District

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Glenn-Colusa Irrigation District
Serving Our Lands and Environment Sustainably
Water Rights Established in 1883

December 2016 Update

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Glenn-Colusa Irrigation District

SB X7-7 Water Measurement Compliance Program

Purpose

In accordance with California Water Code §10106.48(b), Article 2, §597.1(a), GCID is proposing to implement a program to comply with specified requirements within the Agricultural Water Measurement Regulation. This SB X7-7 Water Measurement Compliance Program (Program), which will become a component of the District's Agricultural Water Management Plan, describes how GCID will comply with the SB X7-7 water measurement requirements and adopted regulations, attached hereto as "Exhibit 4." This Program will provide the following pursuant to §597.4 (e):

1. Documentation as required to demonstrate compliance with §597, as outlined in section §597.3 and §597.4.
2. A description of best professional practices about, but not limited to, the (1) collection of water measurement data, (2) frequency of measurements, (3) method for determining irrigated acres, and (4) quality control and quality assurance procedures.
3. If a water measurement device measures flow rate, velocity or water elevation, and does not report the total volume of water delivered, the agricultural water supplier must document in its Agricultural Water Management Plan how it converted the measured value to volume. The protocols must follow best professional practices and include the following methods for determining volumetric deliveries:
    a. For devices that measure flow-rate, documentation shall describe protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.
    b. For devices that measure velocity only, the documentation shall describe protocols associated with the measurement of the cross-sectional area of flow and duration of water delivery, where volume is derived by the following formula: Volume = velocity x cross-section flow area x duration of delivery.

   c. For devices that measure water elevation at the device (e.g. flow over a weir or differential elevation on either side of a device), the documentation shall describe protocols associated with the measurement of elevation that was used to derive flow rate at the device. The documentation will also describe the method or formula used to derive volume from the measured elevation value(s).

4. If an existing measurement device is determined to be out of compliance with §597.3, and the agricultural water supplier is unable to bring it into compliance before submitting its Agricultural Water Management Plan, the agricultural water supplier shall provide in its plan, a schedule, budget and finance plan for taking corrective action in three years or less.

Program Components

To comply with the SB X7-7 water measurement requirements and adopted regulations, the Program will include the following critical components:

- Proposed physical measurement alternatives and criteria.
- Proposed measurement protocols, customer billing, and reporting.
- Proposition 218 compliance to address new infrastructure costs and new rate methodologies incorporating in-part volumetric pricing.

Proposed Physical Measurement Alternatives and Criteria

The Program will employ water measurement using a combination of lateral level (upstream) turnout measurement to multiple customers, and measurement to individual customer turnouts referred to as farm-gates in §597.2(a)(8). In development of the Program, the District will develop a master plan overview of existing and proposed measurement facilities identifying the water delivery service area served by the lateral level (upstream) measurement turnouts and the service area served by individual turnouts. This master plan will also identify the measurement device at the lateral level (upstream) turnout measurement point (main canal metered laterals, main canal unmetered laterals, main canal lift pumps/pump ditches, pump recapture sites, and gravity recapture sites), or individual turnout measurement points (main canal and certain individual customer turnouts that serve individual fields). The information regarding the proposed metering methods and equipment necessary to comply with the volumetric pricing requirement, are further discussed in "Exhibit 3" which provides general, non-exclusive options for the types of devices that could be utilized to meet §597.3(a), §597.3(b)(1), and elements of §597.4 (e)(2).

A combination of lateral level (upstream) turnout measurement and individual turnout measurement is required because the options in §597.3(a) cannot be met at numerous farm-gate delivery points. In such circumstances, installation, measurement, operation, and monitoring of measurement devices at each downstream individual customer delivery point is not possible due to either one or both of the following conditions:

- GCID lacks legal access to the delivery points of individual customers or group of customers. Such cases shall be certified pursuant to §597.3(b)(2)(A).
- Small differentials in water levels from laterals to the fields, and large fluctuations in flow rate that result in poorly functioning devices. This determination shall be evaluated and certified by an engineer in accordance with §597.3(b)(2)(B).

GCID's water conveyance system presents a wide range of physical conditions that make planning for and complying with the SB X7-7 water measurement requirements challenging. In order to address these challenges, GCID will conduct a Pilot Project (See "Exhibit 1") by installing measurement devices at representative sites to identify effective metering solutions, infrastructure modification requirements, and refine costs. Site modification and construction requirements, and costing derived from the Pilot Project will provide important information to support funding requirements and the required Proposition 218 process. The Pilot Project is funded from the current GCID budget.

It is anticipated that the Pilot Project and subsequent Water Measurement Compliance Program will employ a combination of metering devices best suited to these various physical conditions. For lateral level (upstream) turnout measurement, the District will use a combination of measurement devices, which may include propeller meters, acoustic doppler meters, portable acoustic doppler meters, weirs with pressure transducers, Irrigation Training & Research Center of California Polytechnic State University San Luis Obispo (ITRC) calibrated metergates, and flumes:

A. Propeller meters with electronic flow rate and total quantity indicators will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(b)(1). The propeller meters measure velocity in pressurized pipes, which based on the cross-sectional area of the pipe is converted to an instantaneous flow rate. The totalizer on the device will report the total volume of water delivered by summing all of the previous measured instantaneous volumes to yield the total volume measured to date. (Best professional practices shall ensure that manufacturer documentation describes protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery).

B. Acoustic doppler velocity meters with electronic flow rate indicator and totalizer will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(b)(1). The acoustic doppler meter averages velocity and cross-sectional area at the measurement site over a specified time interval, which yields an average flow rate for this specified time interval. The totalizer on the device will report the total volume of water delivered by taking this average flow over a period of time. (Best professional practices shall ensure that manufacturer documentation describes protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.)

C. Portable acoustic doppler meters will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(b)(1). The portable acoustic doppler meter averages velocity and cross-sectional area at the measurement site over a specified time interval, which yields an average flow rate for this specified time interval. The average flow rate multiplied by the accumulated time duration at a constant maintained flow will yield the total volume of water delivered during the period of constant flow. (Best professional practices shall ensure that manufacturer documentation describes protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery).

D. Weirs with pressure transducer measurement devices will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(b)(1). Weirs with pressure transducer measurement devices measure water elevation. This data is used in conjunction with industry standard equations and/or methodologies specific to the type of weir utilized with the pressure transducer elevation readings to determine flow. The flow shall be either programmed into a data logging device for direct report of volume, or the data will be processed in spreadsheets to obtain volume. (Best professional practices shall ensure that manufacturer documentation describes protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.) Weir measurement devices, including rectangular or v-notch weir measurement devices, will be certified by an engineer to meet the requirements of §597.4(a).

E. ITRC calibrated metergates will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(b)(1). The ITRC calibrated metergates require measurement of the following parameters: the delivery gate opening, inlet water elevation at the delivery gate, and stilling well water elevation one-foot behind the delivery gate. The measurements will be collected manually with staff gauges, tape measure, and/or survey rod. The head differential from the water elevation measurements in conjunction with the delivery gate opening yields a corresponding empirical flow rate from the respective ITRC flow rating table. The resultant flow rate multiplied by the accumulated time duration at a constant maintained flow will yield the total volume of water delivered during the period of constant flow. The flow shall be either programmed into a data logging device for direct report of volume, or the data will be processed in spreadsheets to obtain volume. (Best professional practices shall ensure that manufacturer documentation describes protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.)

F. Flume measurement devices will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(b)(1). Flumes requires a water surface elevation measurement to be collected at the prescribed location set forth from the associated flume design with the industry standard WinFlume software. The measurements can be collected with the following methods: manually with a staff gauge, pressure transducer, or an ultrasonic measurement device. The flow shall be either programmed into a data logging device for direct report of volume, or the data will be processed in spreadsheets to obtain volume. (Best professional practices shall ensure that manufacturer documentation describes protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.) Flume measurement devices, including rectangular flumes or Replogle Flumes, will be certified by an engineer to meet the requirements of §597.4(a).

Similarly, for individual turnout, farm-gate, measurement, the District will use a combination of measurement devices, which may include propeller meters, acoustic doppler meters, portable acoustic doppler meters, weirs with pressure transducers, and ITRC calibrated metergates:

A. Propeller meters with electronic flow rate and total quantity indicators will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(a).

B. Acoustic doppler meters with electronic flow rate indicator and totalizer will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(a).

C. Portable acoustic doppler meters will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(a).

D. Weir with pressure transducer measurement devices will be used on some existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(a). Rectangular or v-notch weir measurement devices will be certified to meet the water measurement requirements of §597.3(a).

E. ITRC calibrated metergates will be used on existing and future measurement sites consistent with the accuracy standards established in Regulation §597.3(a).

"Exhibit 2" presents the projected timeline for implementation of this Program, factoring in the Pilot Project process, number of metering sites, extraordinary fiscal demand in exceedance of standard operation and maintenance expenses, limited annual construction periods and physical conditions, including weather, during GCID's 6-week winter maintenance period available for the installation of the metering equipment.

Proposed Measurement Protocols, Customer Billing, and Reporting

Currently, GCID has an active and robust measurement program throughout the distribution system including main diversion points, laterals, sub-laterals, spill points, drain water recycling stations, etc. in order to effectuate good water management. Annually, the District completes a Water Measurement Report, which summarizes data on a monthly and yearly basis from all the water flow measurement points. This report is developed using a sophisticated and real-time Access database. The District has also made significant investments in Supervisory Control and Data Acquisition (SCADA), Water Information System (WIS) database, measurement reports, conjunctive use programs, conveyance improvements, and reuse facilities, all for the purpose of managing water supplies under a broad range of hydrology, delivery constraints, and ecosystem needs. This information is provided to the State Water Resources Control Board, Bureau of Reclamation, and Department of Water Resources.

A. Measurement Protocol

For this Program, the District will need to collect monthly measurement records, which will be used to develop billings to individual customers. Measurement records will be batched to the District's Water Information System to provide for a complete record of District deliveries, and then to the Water Accounting Program, which will be used to generate water user billings.

For lateral level (upstream) turnout and individual turnout measurement, the acreage and cropping pattern will be used to allocate and apportion flows to water users within a lateral or individual service area. Currently, the District generates an annual crop report that is included in the Water Measurement Report and also calculates the acreage of each crop within each service area. This information is obtained from water users during the water application process and then is confirmed by District personnel during mid-year field inspections.

B. Customer Billing

Currently, the District utilizes a customer accounting program that bills water users based on a per-acre land based assessment, a standby charge, and volumetric consumption rate based on the planted crop applied water use and evapotranspiration rate. The rates are reviewed on an annual basis and may be increased at the discretion of the Board of Directors, and as approved by landowners pursuant to a Proposition 218 rate setting process.

With a new billing structure required to comply with SB X7-7 water measurement requirements, the District will need to migrate to a new Water Accounting Program that will enable information to be downloaded from the Water Information System and to allow for lateral level and individual turnout measurement, and apportionment processes. Additionally, the District currently bills in five installments but, since in-part volumetric pricing will be required, the billing structure and collection process of the volumetric component may need to change to a monthly billing cycle.

C. Reporting

As required in §531.10(a) of the California Water Code, the District will submit an annual report to the Department that summarizes aggregated farm-gate delivery data on a monthly basis using best professional practices.

Proposition 218 Compliance to Address New Infrastructure Costs and New Rate Methodologies Incorporating In-Part Volumetric Pricing

After the Pilot Project has been completed and the District has selected the type of equipment that will be necessary to comply with SB X7-7 water measurement requirements, the District will undertake a public outreach effort that will include a series of public landowner and water user meetings to educate stakeholders on the costs and the water rate increases that will be necessary to comply with the new law. Through a series of meetings with its water users, the District will ultimately settle on one preferred rate structure, and in accordance with the requirements of California's Proposition 218, an Engineer's Report will be prepared by a registered Civil Engineering Firm. After the Engineer's Report is completed, the District will hold a public meeting to review the Engineer's Report and proposed rate structure. This meeting will trigger the start of a 45-day time period that will allow all landowners to participate in a mail ballot election on the proposed changes to the rate structure. At the end of the 45-day period, the District will hold a hearing to tally the mail ballot results and set the rates.

It is important to note that compliance with the SB X7-7 water measurement requirements will be based on the rate structure being approved by customers under Proposition 218 as required by Article XIIID of the California Constitution. Under Proposition 218, the District is not able to increase water rates or assessments to fund the Program without the approval of its landowners.

EXHIBIT 1: SB X7-7 NON-EXCLUSIVE MEASUREMENT DEVICE ALTERNATIVES PILOT PROJECT CAPITAL COST SUMMARY FOR WATER YEARS 2013-2016 TESTING

Site	Meter Manufacturer	Meter Type	Total Cost Per Site:
12-3-14R	Mace	Doppler Ultrasonic Area/Velocity Sensor	$ 8,850
Lateral 13-3	McCrometer Propeller	M1700 Digital Reverse Propeller Meter	$ 6,764
Lateral 19-1	Mace	Doppler Ultrasonic Area/Velocity Sensor	$ 7,045[2, 3]
Lateral 21-1	WinFlume/GCID	Rectangular Flume with Senix ToughSonic14	$ 76,009
Lateral 21-2	Mace	2x Doppler Ultrasonic Insert Velocity Sensors	$ 10,280
Lateral 21-4	WinFlume/GCID	Rectangular Flume with Mace EchoFlo	$ 78,449
Main Canal-49L	SonTek	IQ Pipe	$ 13,675
Lateral 26-2	SonTek	IQ Plus	$ 13,800
Juney Weir Lift Pump	Mace	Doppler Ultrasonic Insert Velocity Sensor	$ 12,463
Lateral 28-1-1L	Measurement Specialties & Briggs Mfg.	Pressure transducer and data logger with suppressed rectangular weir	$ 6,155
Lateral 29-2	SonTek	IQ Pipe	$ 12,035
Main Canal 91L	Mace	Doppler Ultrasonic Insert Velocity Sensor	$ 7,930
Lateral 35-1	Mace	Doppler Ultrasonic Area/Velocity Sensor	$ 10,220
Lateral 38-1	Mace	Doppler Ultrasonic Velocity Sensor	$ 4,613[2, 3]
Main Canal 192L	SonTek	IQ Pipe	$ 11,570[2, 3]
Lateral 54-1	McCrometer	Digital Reverse Propeller Meter M1736	$ 5,089
31 sites	ITRC Calibrated Metergate	15" ITRC Meter Gate	$ 4,308[1]
20 sites	ITRC Calibrated Metergate	18" ITRC Meter Gate	$ 4,906[1]
4 sites	ITRC Calibrated Metergate	24"ITRC Meter Gate	$ 5,274[1]
34 metergate sites	H2Otech	1x RemoteTracker Acoustic Doppler Velocimeter	$ 24,326[4]
Actual Total Cost of SB X7-7 Pilot Project			**$ 543,158**
Simulated Total Cost **of SB X7-7 Pilot Project including device costs of relocated measurement devices**			**$ 562,037[3]**
Simulated **Average Cost Per Site**			**$ 7,806[3]**

Please note:

I) [1] Total site cost is an average of multiple measurement device sites.
II) [2] Relocated measurement device.
III) [3] Simulated costs replicate the costs of the relocated measurement devices.
IV) [4] Portable device capable of collecting point measurements at multiple sites.

EXHIBIT 2: IMPLEMENTATION TIMELINE

Date	Action
December 2012	Complete SB X7-7 infrastructure planning and cost estimates
December 31, 2012	Complete SB X7-7 Water Measurement Compliance Program in preparation for submission to DWR pending USBR approval of Regional Water Management Plan
February 14, 2013	GCID Board of Directors review and consideration of the Regional Water Management Plan, and SB X7-7 Water Measurement Compliance Program
Phase I - Pilot Project	
March 2013 – December 2016	Conduct pilot program by installing various metering options at representative sites to assess construction requirements, confirm meter accuracy, and refine costs
March 2013 – December 2016	Operate Pilot Project metering site equipment to evaluate overall operation and accuracy
Phase II - Finalize Metering Program	
2017 – 2018	Information from the Pilot Project will be used to: - Identify actual metering solutions by site - Prepare a detailed budget and schedule for implementation
Phase III - Public Outreach and Water Rate Structure	
2019	Hold landowner/public meetings on Project cost
	Develop assessment and water rate structure alternatives and continue to gather feedback from GCID water users
Phase IV – Proposition 218 Process	
2020	Complete Engineering Report in accordance with Proposition 218 assessment and water rate requirements
	Hold landowner/public meetings on results of Engineering Report and proposed rate structure
	Begin 45-day mandatory Proposition 218 notice period
	Hold final Proposition 218 hearing, and set rates

Phase V – Installation of Metering Infrastructure	
Initialization subsequent to completion of Phase IV	Begin full-scale installation of metering infrastructure pending outcome of the Proposition 218 process It is anticipated that a maximum of 30 metering sites can be installed per year due to critical issues that impact design, construction, and installation of metering equipment, including: - Special conditions created by the presence of aquatic weed infestations - Year-round water service confines major construction activities to a 6-week period during January and February, and other limited periods when dry conditions allow - Weather conditions can limit construction activities during the winter months - Installation of metering infrastructure is dependent upon funding and successful completion of the Proposition 218 process

EXHIBIT 3: NON-EXCLUSIVE MEASUREMENT DEVICE ALTERNATIVES

Flow Condition	Measurement Device	Type of Device	Manufacturer Accuracy for New Device	SBX7-7 Accuracy Criteria	Volumetric Conversion Protocol per **§597.4 (e)(3)**	Frequency of Measurements per **§597.4 (e)(2)(2)**	Installation Criteria per **Best Professional Practices**	Collection of Water Measurement Data per **§597.4 (e)(2)(1)**
Open Channel	Measurement Specialties *730S*	Pressure transducer with stilling well	▪ ±0.1 Full Scale Output by Best-Fit Straight Line	As Applicable: New: Requires §597.3 (a)(2)(B); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Industry standard equation for head-discharge relationship: $V = \sum_{i=1}^{n} Q_i T_i$	5-15 minutes unless Best Professional Practices dictate otherwise	Install in a location with minimal turbulence and appropriate pressure measuring range	Real-time remote acquisition and/or monthly physical connection with device storage for download
	SonTek *IQ (Standard or Plus)*	Acoustic doppler current meter	▪ ±1% of measured velocity, ±0.5 cm/s (0.2 in/s) ▪ 0.1% of measured depth or ±0.003 m (0.01 ft) whichever is greater	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices dictate otherwise	Install at least ten channel widths upstream and downstream of any flow disturbances (i.e. gates, curves, abrupt changes in elevation)	Real-time remote acquisition and/or monthly physical connection with device storage for download
	SonTek *SL 1500*	Acoustic doppler current meter	▪ ± 1% of measured velocity, ± 0.015 ft/s ▪ ±0.3cm (0.01 ft) of measured depth ±0.1%	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices dictate otherwise	Install at least ten channel widths along a straight and uniform canal stretch with minimal turbulence	Real-time remote acquisition and/or monthly physical connection with device storage for download
	SonTek *SW*	Acoustic doppler current meter	▪ ±1% of measured velocity, ± 0.015 ft/s ▪ ±0.1% of measured depth, ±0.3 cm (0.01 ft)	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices dictate otherwise	Straight and uniform canal stretch with minimal turbulence	Real-time remote acquisition and/or monthly physical connection with device storage for download
	SonTek *IQ Pipe*	Acoustic doppler current meter	▪ ±1% of measured velocity, ±0.5 cm/s (0.2 in/s) ▪ 0.1% of measured depth or ±0.003 m (0.01 ft) whichever is greater	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices dictate otherwise	10 pipe diameters in either direction from an obstruction or flow diversion	Real-time remote acquisition and/or monthly physical connection with device storage for download
	WinFlume designed Flumes	Flumes with staff ultrasonic stage sensor, pressure transducer, or staff gauge	▪ <5% of measured flow, in accordance with specified design inputs for water elevation measurement	As Applicable: New: Satisfies §597.3 (a)(2)(B); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} Q_i T_i$	5-15 minutes for electronic devices; planned flow changes for staff gauge	Install at least ten channel widths along a straight and uniform canal stretch with minimal turbulence	Real-time remote acquisition, monthly physical connection with device storage for download, or manual transcription

Flow Condition	Measurement Device	Type of Device	Manufacturer Accuracy for New Device	SBX7-7 Accuracy Criteria	Volumetric Conversion Protocol per **§597.4 (e)(3)**	Frequency of Measurements per **§597.4 (e)(2)(2)**	Installation Criteria per **Best Professional Practices**	Collection of Water Measurement Data per **§597.4 (e)(2)(1)**
Full Pipe	McCrometer *Mc Propeller M1700*	Propeller Open Flow meter	▪ ±2% of measured velocity with repeatability of ±0.25%	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices determine otherwise	Positioning: 10 pipe diameters upstream	Real-time remote acquisition and/or monthly physical connection with device storage for download
	McCrometer *Bolt-On Saddle Flowmeter MO300 or M1400*	Propeller meter	▪ ±2% of measured velocity with repeatability of ±0.25%	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices determine otherwise	Positioning: 10 pipe diameters upstream and two diameters downstream of the meter	Real-time remote acquisition and/or monthly physical connection with device storage for download
	Mace *Doppler Velocity Insert*	Doppler ultrasonic velocity sensor	▪ ±1% of measured velocity, up to 10 ft/s	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices determine otherwise	Positioning is valve dependent: 6-15 pipe diameters upstream and 2-6 diameters downstream	Real-time remote acquisition and/or monthly physical connection with device storage for download
	H2Otech RemoteTracker	Acoustic doppler velocimeter	▪ ±4.6%	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	Collect measurements at planned flow changes	Positioning: Weir box at turnout discharge to ensure full pipe flow with bracket to position sensor at center of pipe	Measurements are relayed to a central database via a wide wireless area network (WWAN)
	ITRC calibrated metergate	Metergate	▪ ±5%	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} Q_i T_i$	Collect measurements at planned flow changes	Install metergate assembly perpendicular to canal flow with a stilling well 12" behind the delivery gate	Measurements are manually collected, recorded, then transcribed into a database
	SonTek *IQ Pipe*	Acoustic doppler current meter	▪ ±0.1% of full scale pressure ▪ ±1% of measured velocity, ±0.5 cm/s (0.2 in/s) ▪ 0.1% of measured depth or ±0.003 m (0.01 ft) whichever is greater	As Applicable: New: Satisfies §597.3 (a)(2)(A); (b)(1) Existing: Requires §597.3 (a)(1); (b)(1)	Device reports total volume of water delivered using: $V = \sum_{i=1}^{n} v_i A_i T_i$	5-15 minutes unless Best Professional Practices determine otherwise	10 pipe diameters in either direction from an obstruction or flow diversion	Real-time remote acquisition and/or monthly physical connection with device storage for download

Please Note:

The Volumetric conversion protocol variables are defined below.

$$V = \sum_{i=0}^{n} v_i A_i T_i$$

V (Volume, ft^3)
Σ (summation sign)
n (final reported measurement for the year)
i (measurement number)
v_i (velocity, ft/s)
A_i (cross sectional area, ft^2)
T_i (sample time duration of measurement)

OR

$$V = \sum_{i=0}^{n} Q_i T_i$$

V (Volume, ft^3)
Σ (summation sign)
n (final reported measurement for the year)
i (measurement number)
Q_i (, ft/s)
T (sample time duration of measurement)

Essentially, these equations states that the volume of water measured over a sample time will be totalized with all previous measured volumes to yield the total volume measured thus far at that time in the year.

EXHIBIT 4: AGRICULTURAL WATER MEASUREMENT REGULATION

State of California
The Natural Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Statewide Integrated Water Management
Water Use and Efficiency Branch

Agricultural Water Measurement

A regulation included under the authority of
Section 10608.48(i) (1) and(2) of the California Water Code

July 11, 2012

Edmund G. Brown Jr.
Governor
State of California

John Laird
Secretary for Natural Resources
The Natural Resources Agency

Mark W. Cowin
Director
Department of Water Resources

State of California
Office of Administrative Law

In re: **Department of Water Resources**	NOTICE OF APPROVAL OF REGULATORY ACTION
Regulatory Action:	Government Code Section 11349.3
Title 23, California Code of Regulations	OAL File No. 2012-0531-01 SR
Adopt sections: 597, 597.1, 597.2, 597.3, 597.4 **Amend sections:** **Repeal sections:**	

The Department of Water Resources proposed this action to adopt five sections and create a new article in title 23 of the California Code of Regulations for agricultural water measurement. The purpose of the regulatory action is to provide a range of options that agricultural water suppliers may use or implement to comply with the water measurement requirements in Water Code 10608.48(b)(1). These regulations implement amendments to the Water Code made in S.B. 7 (Stats. 2009, 7th Ex. Sess., ch. 4).

OAL approves this regulatory action pursuant to section 11349.3 of the Government Code. This regulatory action becomes effective on 7/11/2012.

Date: 7/11/2012

Richard L. Smith
Richard L. Smith
Senior Counsel

For: DEBRA M. CORNEZ
Director

Original: Mark Cowin
Copy: Kent Frame

California Code of Regulations
Title 23. Waters
Division 2. Department of Water Resources
Chapter 5.1. Water Conservation Act of 2009
Article 2. Agricultural Water Measurement

§597. Agricultural Water Measurement

Under the authority included under California Water Code §10608.48(i)(1), the Department of Water Resources (Department) is required to adopt regulations that provide for a range of options that agricultural water suppliers may use or implement to comply with the measurement requirements in paragraph (1) of subdivision (b) of §10608.48.

For reference, §10608.48(b) of the California Water Code states that:

> *Agricultural water suppliers shall implement all of the following critical efficient management practices:*
>
> *(1) Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2).*
>
> *(2) Adopt a pricing structure for water customers based at least in part on quantity delivered.*

For further reference, §531.10(a) of the California Water Code requires that:

> *(a) An agricultural water supplier shall submit an annual report to the department that summarizes aggregated farm-gate delivery data, on a monthly or bi-monthly basis, using best professional practices.*

Notes:

(1) Paragraphs (1) and (2) of §10608.48(b) specify agricultural water suppliers' reporting of aggregated farm-gate water delivery and adopting a volumetric water pricing structure as the purposes of water measurement. However, this article only addresses developing a range of options for water measurement.

(2) Agricultural water suppliers reporting agricultural water deliveries measured under this article shall use the "Agricultural Aggregated Farm – Gate Delivery Reporting Format for Article 2" (Rev. 6-20-12), developed for this article and hereby incorporated by reference.

(3) The Department shall report on the availability of new commercially available water measurement technologies and impediments to implementation of this article when reporting to the Legislature the status of adopted Agricultural Water Management Plans in plan submittal years 2012, 2015 and every five years thereafter as required by California Water Code §10845. The Department shall also report the findings to the California Water Commission.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 531.10, 10608.48 (b), 10608.48 (i), 10608.52 (b) and 10845 Water Code.

§597.1. Applicability

(a) An agricultural water supplier providing water to 25,000 irrigated acres or more, excluding acres that receive only recycled water, is subject to this article.

(b) A wholesale agricultural water supplier providing water to another agricultural water supplier (the receiving water supplier) for ultimate resale to customers is subject to this article at the location at which control of the water is transferred to the receiving water supplier. However, the wholesale agricultural water supplier is not required to measure the receiving agricultural water supplier's deliveries to its customers.

(c) A water supplier providing water to wildlife refuges or habitat lands where (1) the refuges or habitat lands are under a contractual relationship with the water supplier, and (2) the water supplier meets the irrigated acreage criteria of Water Code §10608.12(a), is subject to this article.

(d) An agricultural water supplier providing water to less than 10,000 irrigated acres, excluding acres that receive only recycled water, is not subject to this article.

(e) An agricultural water supplier providing water to 10,000 or more irrigated acres but less than 25,000 irrigated acres, excluding acres that receive only recycled water, is not subject to this article unless sufficient funding is provided specifically for that purpose, as stated under Water Code §10853.

(f) A canal authority or other entity that conveys or delivers water through facilities owned by a federal agency is not subject to this article.

(g) Pursuant to Water Code §10608.8(d), an agricultural water supplier "that is a party to the Quantification Settlement Agreement, as defined in subdivision (a) of Section 1 of Chapter 617 of the Statutes of 2002, during the period within which the Quantification Settlement Agreement remains in effect," is not subject to this article.

(h) Pursuant to Water Code §10608.12(a), the Department is not subject to this article.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 10608.12 (a), 10608.48 (d), 10608.48 (f), 10828, and 10853 Water Code.

§597.2. Definitions

(a) For purposes of this article, the terms used are defined in this section.

(1) "Accuracy" means the measured volume relative to the actual volume, expressed as a percent. The percent shall be calculated as 100 x (measured value – actual value) / actual value, where "measured value" is the value indicated by the device or determined through calculations using a measured value by the device, such as flow rate, combined with a duration of flow, and "actual value" is the value as determined through laboratory, design or field testing protocols using best professional practices.

(2) "Agricultural water supplier," as defined in Water Code §10608.12(a), means a water supplier, either publicly or privately owned, providing water to 10,000 or more irrigated acres, excluding acres that receive only recycled water. "Agricultural water supplier" includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells water for ultimate resale to customers. "Agricultural water supplier" does not include the Department.

(3) "Approved by an engineer" means a California-registered Professional Engineer has reviewed, signed and stamped the plans, design, testing, inspection, and/or documentation report for a measurement device as described in this article.

(4) "Best professional practices" means practices attaining to and maintaining accuracy of measurement and reporting devices and methods described in this article, such as operation and maintenance procedures and practices recommended by measurement device manufacturers, designers, and industry professionals.

(5) "Customer" means the purchaser of water from an agricultural water supplier who has a contractual arrangement with the agricultural water supplier for the service of conveying water to the customer delivery point.

(6) "Delivery point" means the location at which the agricultural water supplier transfers control of delivered water to a customer or group of customers. In most instances, the transfer of control occurs at the farm-gate, which is therefore, a delivery point.

(7) "Existing measurement device," means a measurement device that was installed in the field prior to the effective date of this article.

(8) "Farm-gate," as defined in Water Code §531(f), means the point at which water is delivered from the agricultural water supplier's distribution system to each of its customers.

(9) "Irrigated acres," for purposes of applicability of this article, is calculated as the average of the previous five-year acreage within the agricultural water supplier's service area that has received irrigation water from the agricultural water supplier.

(10) "Manufactured device" means a device that is manufactured by a commercial enterprise, often under exclusive legal rights of the manufacturer, for direct off-the-shelf purchase and installation. Such devices are capable of directly measuring flow rate, velocity, or accumulating the volume of water delivered, without the need for additional components that are built on-site or in-house.

(11) "Measurement device" means a device by which an agricultural water supplier determines the numeric value of flow rate, velocity or volume of the water passing a designated delivery point. A measurement device may be a manufactured device, on-site built device or in-house built device.

(12) "New or replacement measurement device" means a measurement device installed after the effective date of this article.

(13) "Recycled water" is defined in subdivision (n) of §13050 of the Water Code as water that, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur, and is therefore considered a valuable resource.

(14) "Type of device" means a measurement device that is manufactured or built to perform similar functions. For example, rectangular, v-notch, and broad crested weirs are one type of device. Similarly, all submerged orifice gates are considered one type of device.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 10608.12 (a), 10608.12 (m), 10608.48, and 10813 Water Code.

§597.3 Range of Options for Agricultural Water Measurement

An agricultural water supplier subject to this article shall measure surface water and groundwater that it delivers to its customers pursuant to the accuracy standards in this section. The supplier may choose any applicable single measurement option or combination of options listed in paragraphs (a) or (b) of this section. Measurement device accuracy and operation shall be certified, tested, inspected and/or analyzed as described in §597.4 of this article.

(a) Measurement Options at the Delivery Point or Farm-gate of a Single Customer

An agricultural water supplier shall measure water delivered at the delivery point or farm-gate of a single customer using one of the following measurement options. The stated numerical accuracy for each measurement option is for the volume delivered. If a device measures a value other than volume, for example, flow rate, velocity or water elevation, the accuracy certification must incorporate the measurements or calculations required to convert the measured value to volume as described in §597.4(e).

(1) An existing measurement device shall be certified to be accurate to within ±12% by volume.

and,

(2) A new or replacement measurement device shall be certified to be accurate to within:

(A) ±5% by volume in the laboratory if using a laboratory certification;

(B) ±10% by volume in the field if using a non-laboratory certification.

(b) Measurement Options at a Location Upstream of the Delivery Points or Farm-gates of Multiple Customers

(1) An agricultural water supplier may measure water delivered at a location upstream of the delivery points or farm-gates of multiple customers using one of the measurement options described in §597.3(a) if the downstream individual customer's delivery points meet either of the following conditions:

(A) The agricultural water supplier does not have legal access to the delivery points of individual customers or group of customers needed to install, measure, maintain, operate, and monitor a measurement device.

Or,

(B) An engineer determines that, due to small differentials in water level or large fluctuations in flow rate or velocity that occur during the delivery season at a single farm-gate, accuracy standards of measurement options in §597.3(a) cannot be met by installing a measurement device or devices (manufactured or on-site built or in-house built devices with or without additional components such as gauging rod, water level control structure at the farm-gate, etc.). If conditions change such that the accuracy standards of measurement options in §597.3(a) at the farm-gate can be met, an agricultural water supplier shall include in its Agricultural Water Management Plan, a schedule, budget and finance plan to demonstrate progress to measure water at the farm-gate in compliance with §597.3(a) of this article.

(2) An agricultural water supplier choosing an option under paragraph (b)(1) of this section shall provide the following current documentation in its Agricultural Water Management Plan(s) submitted pursuant to Water Code §10826:

(A) When applicable, to demonstrate lack of legal access at delivery points of individual customers or group of customers downstream of the point of measurement, the agricultural water supplier's legal counsel shall certify to the Department that it does not have legal access to measure water at customers delivery points and that it has sought and been denied access from its customers to measure water at those points.

(B) When applicable, the agricultural water supplier shall document the water measurement device unavailability and that the water level or flow conditions described in §597.3(b)(1)(B) exist at individual customer's delivery points downstream of the point of measurement as approved by an engineer.

(C) The agricultural water supplier shall document all of the following criteria about the methodology it uses to apportion the volume of water delivered to the individual downstream customers:

(i) How it accounts for differences in water use among the individual customers based on but not limited to the duration of water delivery to the individual customers, annual customer water use patterns, irrigated acreage, crops planted, and on-farm irrigation system,

and;

(ii) That it is sufficient for establishing a pricing structure based at least in part on the volume delivered,

and;

(iii) That it was approved by the agricultural water supplier's governing board or body.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 531.10, 10608.48 *(i)* (1), and 10826 Water Code.

§597.4 Accuracy Certification, Records Retention, Device Performance, and Reporting

(a) Initial Certification of Device Accuracy

The accuracy of an existing, new or replacement measurement device or type of device, as required in §597.3, shall be initially certified and documented as follows:

(1) For existing measurement devices, the device accuracy required in section 597.3(a) shall be initially certified and documented by either:

(A) Field-testing that is completed on a random and statistically representative sample of the existing measurement devices as described in §597.4(b)(1) and §597.4(b)(2). Field-testing shall be performed by individuals trained in the use of field-testing equipment, and documented in a report approved by an engineer.

Or,

(B) Field-inspections and analysis completed for every existing measurement device as described in §597.4(b)(3). Field-inspections and analysis shall be performed by trained individuals in the use of field inspection and analysis, and documented in a report approved by an engineer.

(2) For new or replacement measurement devices, the device accuracy required in sections 597.3 (a)(2) shall be initially certified and documented by either:

(A) Laboratory Certification prior to installation of a measurement device as documented by the manufacturer or an entity, institution or individual that tested the device following industry-established protocols such as the National Institute for Standards and Testing (NIST) traceability standards. Documentation shall include the manufacturer's literature or the results of laboratory testing of an individual device or type of device.

Or,

(B) Non-Laboratory Certification after the installation of a measurement device in the field, as documented by either:

(i) An affidavit approved by an engineer submitted to the agricultural water supplier of either (1) the design and installation of an individual device at a specified location, or (2) the standardized design and installation for a group of measurement devices for each type of device installed at specified locations.

Or,

(ii) A report submitted to the agricultural water supplier and approved by an engineer documenting the field-testing performed on the installed measurement device or type of device, by individuals trained in the use of field testing equipment.

(b) Protocols for Field-Testing and Field-Inspection and Analysis of Existing Devices

(1) Field-testing shall be performed for a sample of existing measurement devices according to manufacturer's recommendations or design specifications and following best professional practices. It is recommended that the sample size be no less than 10% of existing devices, with a minimum of 5, and not to exceed 100 individual devices for any particular device type. Alternatively, the supplier may develop its own sampling plan using an accepted statistical methodology.

(2) If during the field-testing of existing measurement devices, more than one quarter of the samples for any particular device type do not meet the criteria pursuant to §597.3(a), the agricultural water supplier shall provide in its Agricultural Water

Management Plan, a plan to test an additional 10% of its existing devices, with a minimum of 5, but not to exceed an additional 100 individual devices for the particular device type. This second round of field-testing and corrective actions shall be completed within three years of the initial field-testing.

(3) Field-inspections and analysis protocols shall be performed and the results shall be approved by an engineer for every existing measurement device to demonstrate that the design and installation standards used for the installation of existing measurement devices meet the accuracy standards of §597.3(a) and operation and maintenance protocols meet best professional practices.

(c) Records Retention

Records documenting compliance with the requirements in §597.3 and §597.4 shall be maintained by the agricultural water supplier for ten years or two Agricultural Water Management Plan cycles.

(d) Performance Requirements

(1) All measurement devices shall be correctly installed, maintained, operated, inspected, and monitored as described by the manufacturer, the laboratory or the registered Professional Engineer that has signed and stamped certification of the device, and pursuant to best professional practices.

(2) If an installed measurement device no longer meets the accuracy requirements of §597.3(a) based on either field-testing or field-inspections and analysis as defined in sections 597.4 (a) and (b) for either the initial accuracy certification or during operations and maintenance, then the agricultural water supplier shall take appropriate corrective action, including but not limited to, repair or replacement to achieve the requirements of this article.

(e) Reporting in Agricultural Water Management Plans

Agricultural water suppliers shall report the following information in their Agricultural Water Management Plan(s):

(1) Documentation as required to demonstrate compliance with §597.3 (b), as outlined in section §597.3(b)(2), and §597.4(b)(2).

(2) A description of best professional practices about, but not limited to, the (1) collection of water measurement data, (2) frequency of measurements, (3) method for determining irrigated acres, and (4) quality control and quality assurance procedures.

(3) If a water measurement device measures flow rate, velocity or water elevation, and does not report the total volume of water delivered, the agricultural water supplier must document in its Agricultural Water Management Plan how it converted the

measured value to volume. The protocols must follow best professional practices and include the following methods for determining volumetric deliveries:

(A) For devices that measure flow-rate, documentation shall describe protocols used to measure the duration of water delivery where volume is derived by the following formula: Volume = flow rate x duration of delivery.

(B) For devices that measure velocity only, the documentation shall describe protocols associated with the measurement of the cross-sectional area of flow and duration of water delivery, where volume is derived by the following formula: Volume = velocity x cross-section flow area x duration of delivery.

(C) For devices that measure water elevation at the device (e.g. flow over a weir or differential elevation on either side of a device), the documentation shall describe protocols associated with the measurement of elevation that was used to derive flow rate at the device. The documentation will also describe the method or formula used to derive volume from the measured elevation value(s).

(4) If an existing water measurement device is determined to be out of compliance with §597.3, and the agricultural water supplier is unable to bring it into compliance before submitting its Agricultural Water Management Plan in December 2012, the agricultural water supplier shall provide in its 2012 plan, a schedule, budget and finance plan for taking corrective action in three years or less.

Note: Authority cited: Section 10608.48, Water Code. Reference: Sections 531.10, 10608.48 *(i)* (1), and 10826 Water Code.

Agricultural Aggregated Farm-Gate[1] Delivery Reporting Format for Article 2

Due annually beginning no later than July 31, 2013 from agricultural water suppliers subject to Title 23, Division 2, Chapter 5.1, Article 2 of the CCR - Agricultural Water Measurement

1. Water Supplier Information

Name:

Address:

Phone Number:

Fax:

Total Number of Farm-Gates:

Number of Measured Farm-Gates:

Service Area Acreage:

2. Contact information

Name:

Title:

Address:

Phone Number:

Fax:

E-mail:

Submittal date:

3. Aggregated Farm-Gate Delivery Data[2]: (*provide monthly or bimonthly data, acre-feet*)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Monthly Deliveries													

	Jul-Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun	Total
Bimonthly Deliveries							

4. Explanations, Comments and Best Professional Practices[3]:

Note: An agricultural water supplier's total water use may be different from Aggregated Farm-Gate deliveries because measurement at these points may not account for other practices (such as groundwater recharge/conjunctive use, water transfers, wheeling to other agencies, urban use, etc).

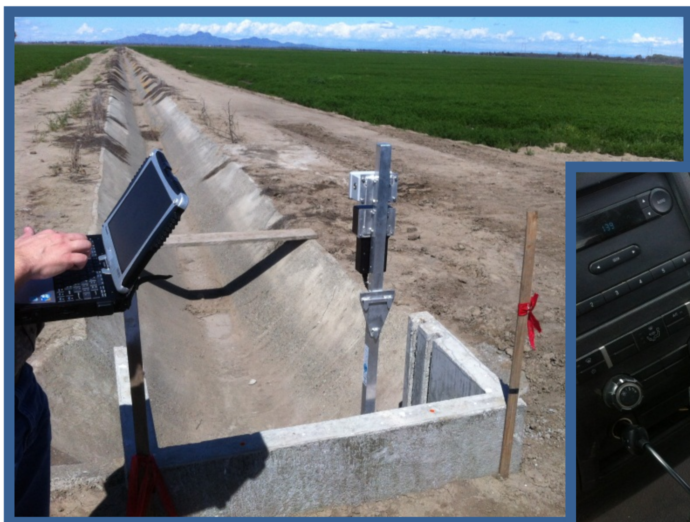
1. "Farm-gate" means the point at which water is delivered from the agricultural water supplier's distribution system to each of its individual customers as specified in the Agricultural Water Measurement Regulation (Title 23, Division 2, Chapter 5.1, Article 2 of the CCR).
2. "Aggregated farm-gate delivery data" means information reflecting the total volume of water an agricultural water supplier provides to its customers and is calculated by totaling its deliveries to customers.
3. "Best Professional Practices" is defined in Title 23, Division 2, Chapter 5.1, Article 2 of the CCR, Section 597.2.

Reclamation District No. 108 RemoteTracker Volumetric Accuracy Certification Colusa and Yolo Counties, California

Reclamation District No. 108

RemoteTracker Volumetric Accuracy Certification

Colusa and Yolo Counties, California



Prepared by

DAVIDS ENGINEERING, INC

October 2012

Contents

Abbreviations

%	Percent
AF	acre-feet
Avg	Average
CCR	California Code of Regulations
cfs	cubic feet per second
DEL	Delivery
DWR	California Department of Water Resources
ft	feet/foot
ft/s	feet per second
gpm	gallons per minute
GT	Gate
Max	Maximum
Min	Minimum

RD 108	Reclamation District No. 108
RT	RemoteTracker
Std Dev	Standard Deviation
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WMM	Water Measurement Manual
WR	Weir
WWVS	Wireless Water Velocity Sensor

List of Figures

A-1.0 Introduction and Summary

This document (1) provides an overview of the RemoteTracker system (Section A-2.0), (2) presents results of initial laboratory and field testing (Section A-3.0) and (3) develops a volumetric accuracy analysis to support compliance of RemoteTracker system with California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 (CCR 23 §597) (Section A-4.0). Based on the analysis in Section A.3, the expected accuracy in volumetric measurements performed with the RemoteTracker system is ±4.6 percent. Because the RemoteTracker system utilizes a laboratory certified acoustic doppler velocimeter manufactured by SonTek to measure water velocity, the ±5 percent by volume laboratory certification option presented in CCR 23 §597.3(a)(2)(B) applies. Thus, the demonstrated accuracy of the RemoteTracker complies with the ±5 percent by laboratory certification standard. Documentation of the protocols associated with the measurement of the cross-section flow area and duration of delivery, as required by §597.4(e)(3)(B), is presented in Section A-4.0.

A-2.0 RemoteTracker System Overview

The RemoteTracker is an integrated turnout flow measurement, data management and volumetric accounting system developed by H2oTech[1] specifically for agricultural water suppliers in response to CCR 23 §597. The RemoteTracker system is comprised of (1) a wirelessly controlled water velocity sensor, (2) a ruggedized tablet PC in the operator's vehicle and (3) a database running on a file server connected to the internet. The user interface on the tablet PC enables operators to view real time flow data from the wirelessly controlled water velocity sensor via a Bluetooth radio connection while adjusting flows at the turnout gate. Data is automatically transferred over a wireless wide area network (WWAN) to a centralized file server at the District headquarters where it is automatically loaded into a custom database application. The database performs quality control and quality assurance procedures on the data and then develops daily volumes for each customer delivery point (turnout or delivery) within the District.

The wireless water velocity sensor (WWVS) is held in place at a precise location at the pipe outlet by an aluminum or stainless steel mounting bracket. The user interface, shown in Figure A-1, was designed with simplicity and ease of use in mind. If 'Auto Locate' is selected, the program automatically populates the three site identification pull-downs at the top of the screen. If the operator needs to select a different site, the pull-downs can be manually changed. The site selection hierarchy is a three digit abbreviation of 'Operator Route' (i.e. ride, beat or division) on the left, a three digit abbreviation of 'Canal' in the middle and site name on the right. The most recently measured flow, and any pending orders are shown on the 'Home' tab. Many useful reports, including (1) Delivery History, (2) Pending Orders, (3) Fulfilled Orders and (4) Canal Management are available on the 'Reports' tab. These reports can be sorted at any spatial or temporal scale. The data sharing and management framework allows water order and delivery data collected by any operator to be automatically available for viewing by other operators or management staff in a matter of minutes.

[1] H2oTech is a company based in Chico, California that focuses on the development of innovative technologies to solve water management challenges.

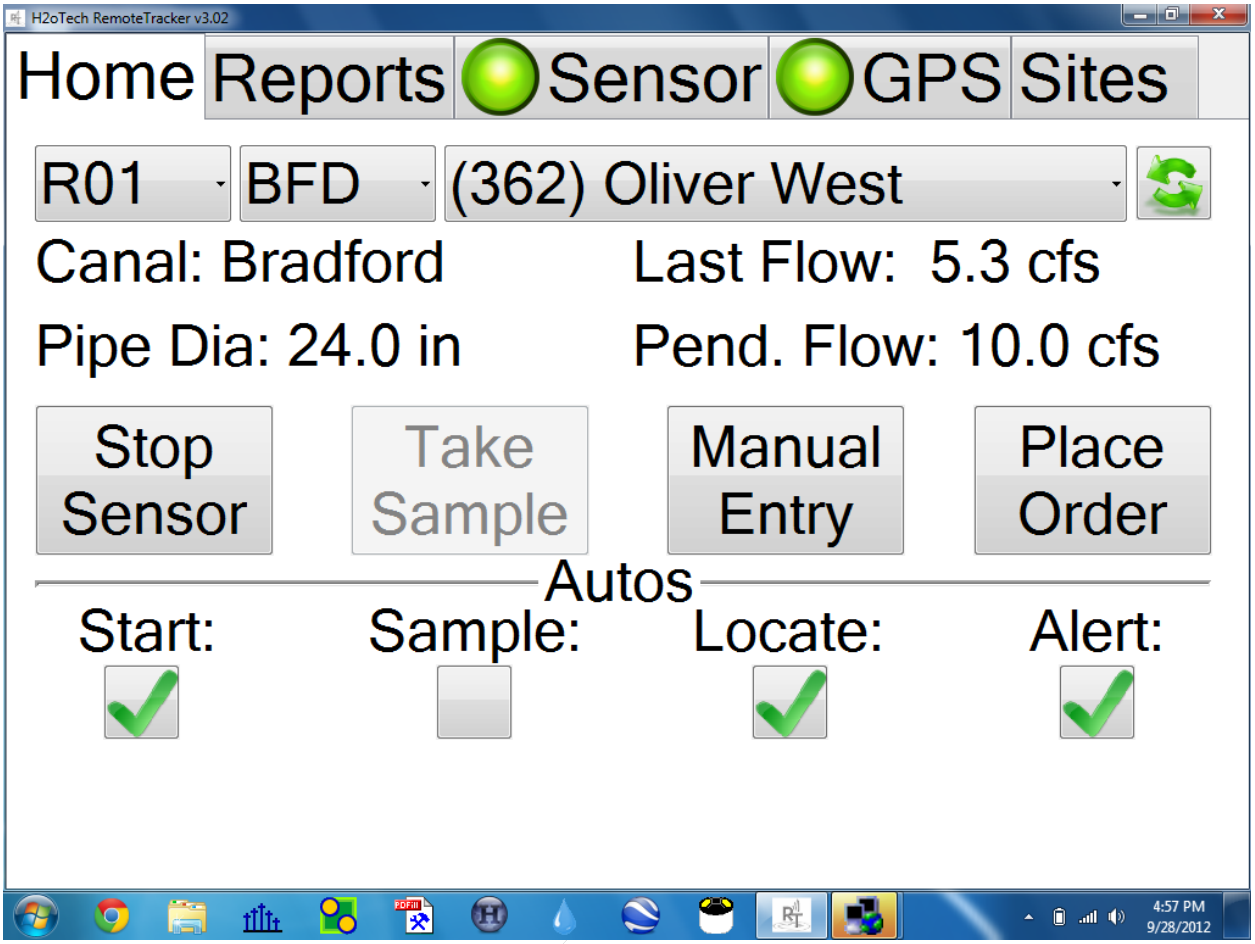


Figure A-1. RemoteTracker User Interface - Home Tab Shown

The basic components of the RemoteTracker system are illustrated in Figure A-2. Water velocity is collected by a portable acoustic Doppler velocimeter deployed during measurement by hanging it on brackets permanently installed at each turnout. The brackets are precisely positioned such that the sample volume is at the center of the pipe. Data is transmitted via a class 1 Bluetooth radio to a ruggedized tablet PC where it is processed, displayed and stored. Data is then transferred via a WWAN to a file server at the District headquarters. Data from each operator is aggregated with an automated database procedure and then returned to each operator via WWAN, thereby ensuring that delivery and order data is shared and accessible throughout the entire District.

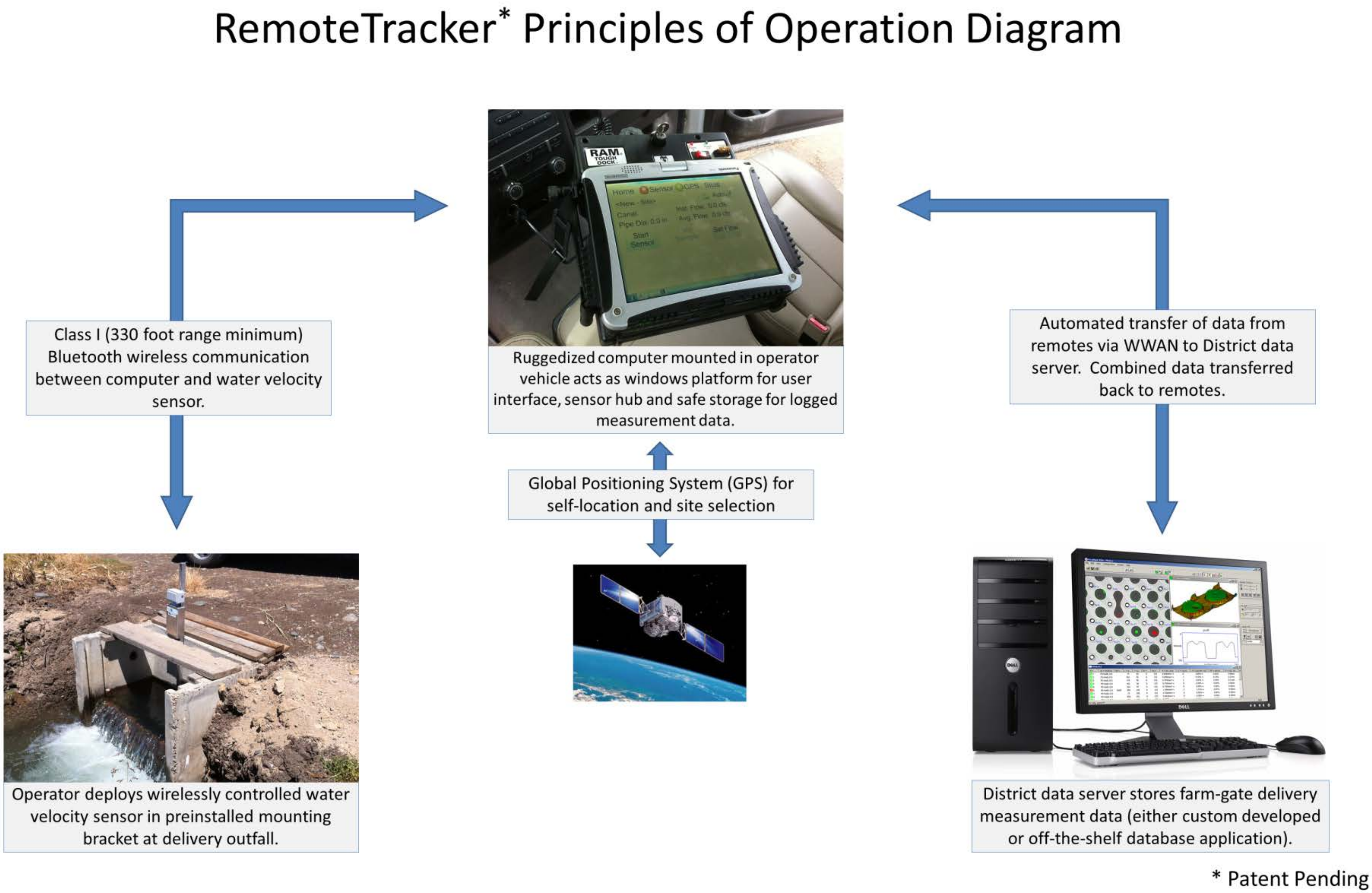


Figure A-2. RemoteTracker Principles of Operation Overview

The key to pipe flow measurement using the RemoteTracker is the consistent relationship between a single velocity measurement at the center of the pipe and the average pipe flow velocity shown in Figure A-3 derived from 146 measurements of center and mean pipe velocity. Based on this relationship, with the pipe diameter and cross sectional area known, the single point velocity can be accurately and reliably correlated with mean pipe velocity (flow rate).

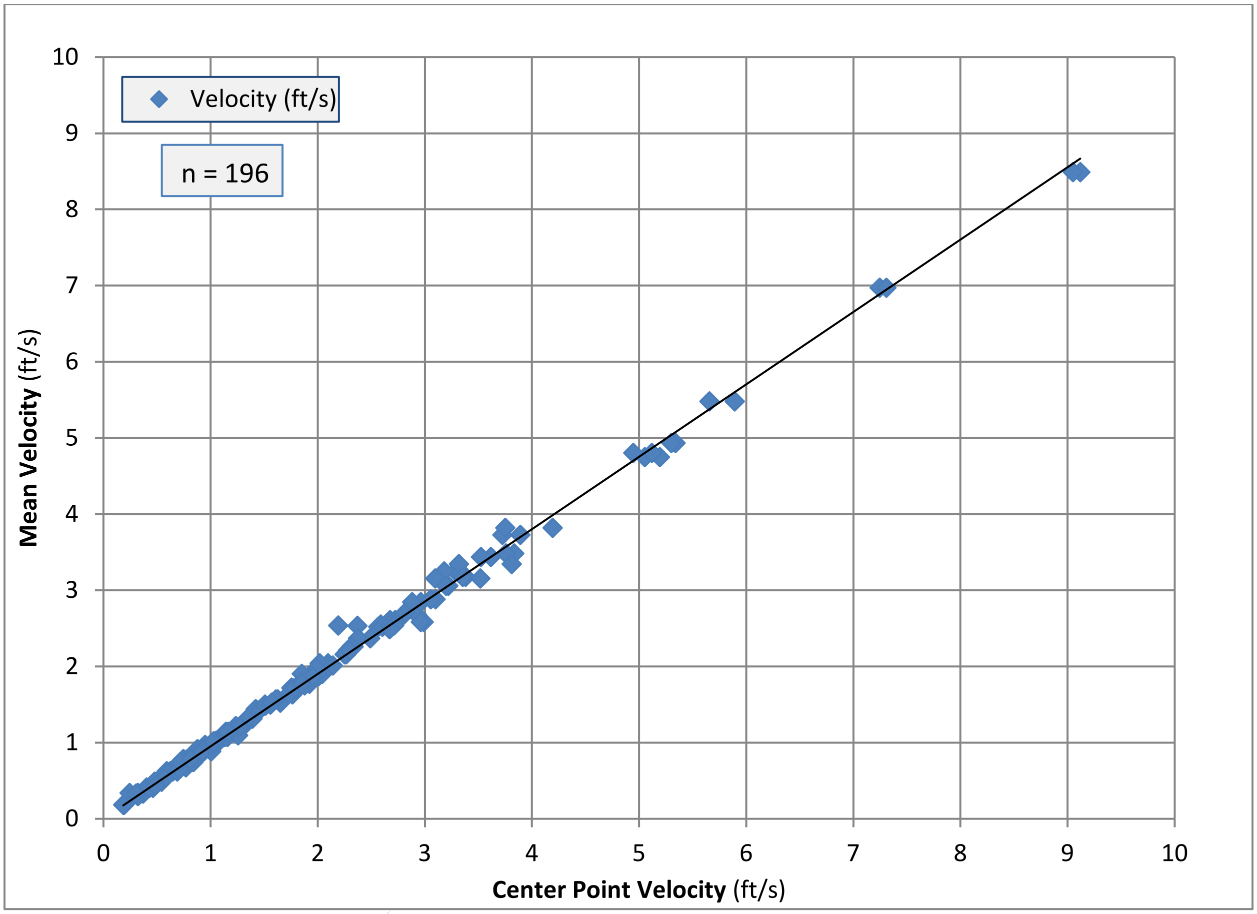


Figure A-3. Relationship between Average and Center Point Pipe Flow Velocity

As with weir and orifice gate measurement, full pipe flow is required for the RemoteTracker to measure correctly. Therefore, a weir box is needed at each turnout to ensure full pipe flow as well as to accommodate the mounting bracket to hold the wireless water velocity sensor so that the sample volume is at the center of the pipe.

The RemoteTracker system can also be integrated with existing or new data management systems at the District office for report generation, accounting and billing. This capability can be added later to provide additional efficiencies in water billing and accounting procedures.

A-3.0 Initial Testing Results

A-3.1 Laboratory Testing

Additional testing was performed at the California State University Chico Agricultural Teaching and Research Center (CSUC ATRC) in July of 2012. Flow data obtained from the RemoteTracker was compared to measurements taken with a 10-inch diameter magnetic flow meter manufactured by Water Specialties. Figure A-4 shows the Water Specialties Magnetic meter with an Endress & Hauser Transit-Time Meter installed just upstream as an additional check. The 3 foot wide by 3 foot deep concrete flume was modified to simulate a typical delivery configuration by forcing all the flow through a 20 foot length of 18 inch HDPE smooth interior wall pipe submerged in the concrete flume. The RemoteTracker wireless water velocity sensor was installed at the pipe outfall using a temporarily constructed headwall with a mounting bracket as shown in Figure A-5.

Figure A-4. Water Specialties Magnetic Flow Meter at CSUC ATRC

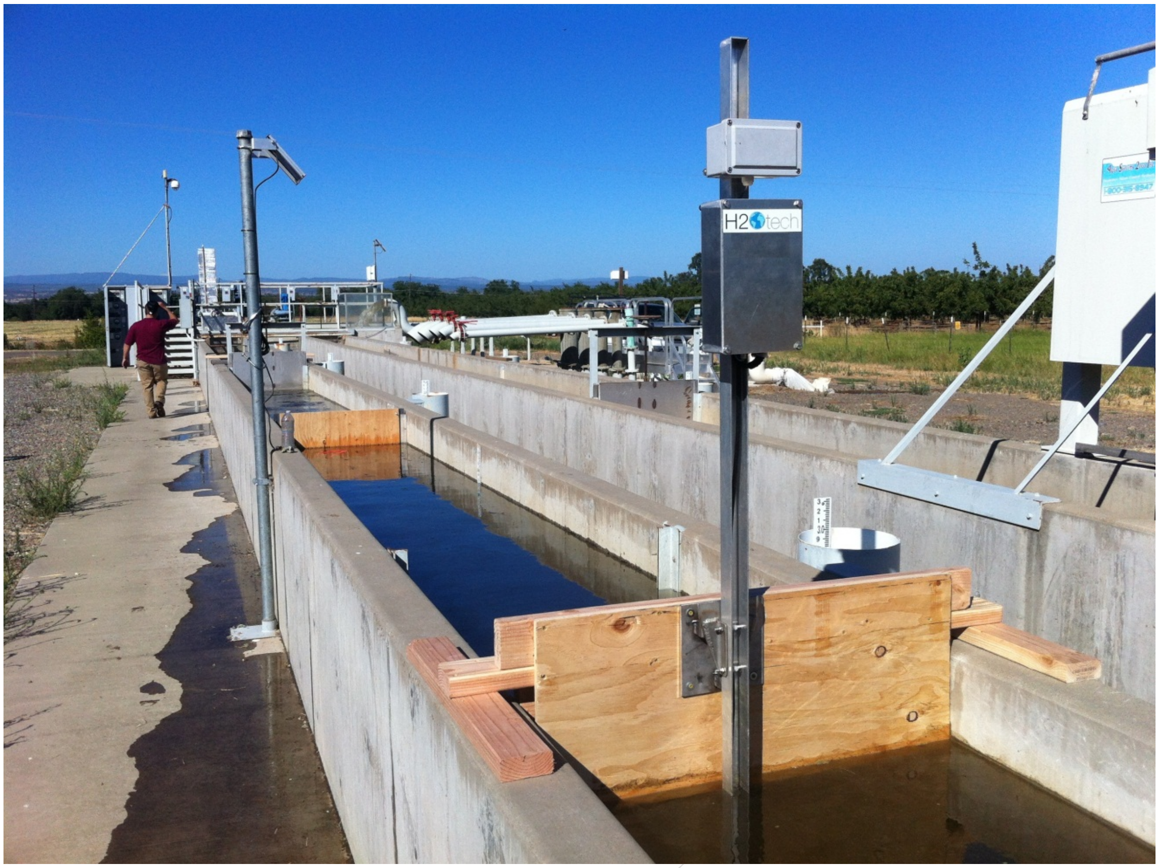


Figure A-5. RemoteTracker Wireless Water Velocity Sensor Installed at CSUC ATRC

Seven comparison measurements were made between the RemoteTracker and magnetic meter ranging from 0.5 cfs to just over 3.0 cfs (the maximum pump capacity). The percent difference between the two measurements averaged roughly -2.6 percent with a range of -10.2 to 2.8 percent indicating that the RemoteTracker measurement methodology compares very well with the magnetic meter. Note that the -10.2 percent difference occurred at the lowest flow rate of approximately 0.5 cfs and represents an absolute flow rate difference of just 0.05 cfs between the two measurement methods. The results of the comparison measurements are presented in Figure A-6 where the blue bars represent flow rates obtained with a magnetic meter, the red bars represent flow rates obtained with the RemoteTracker and the green triangles represent the percent difference between the two (secondary vertical axis).

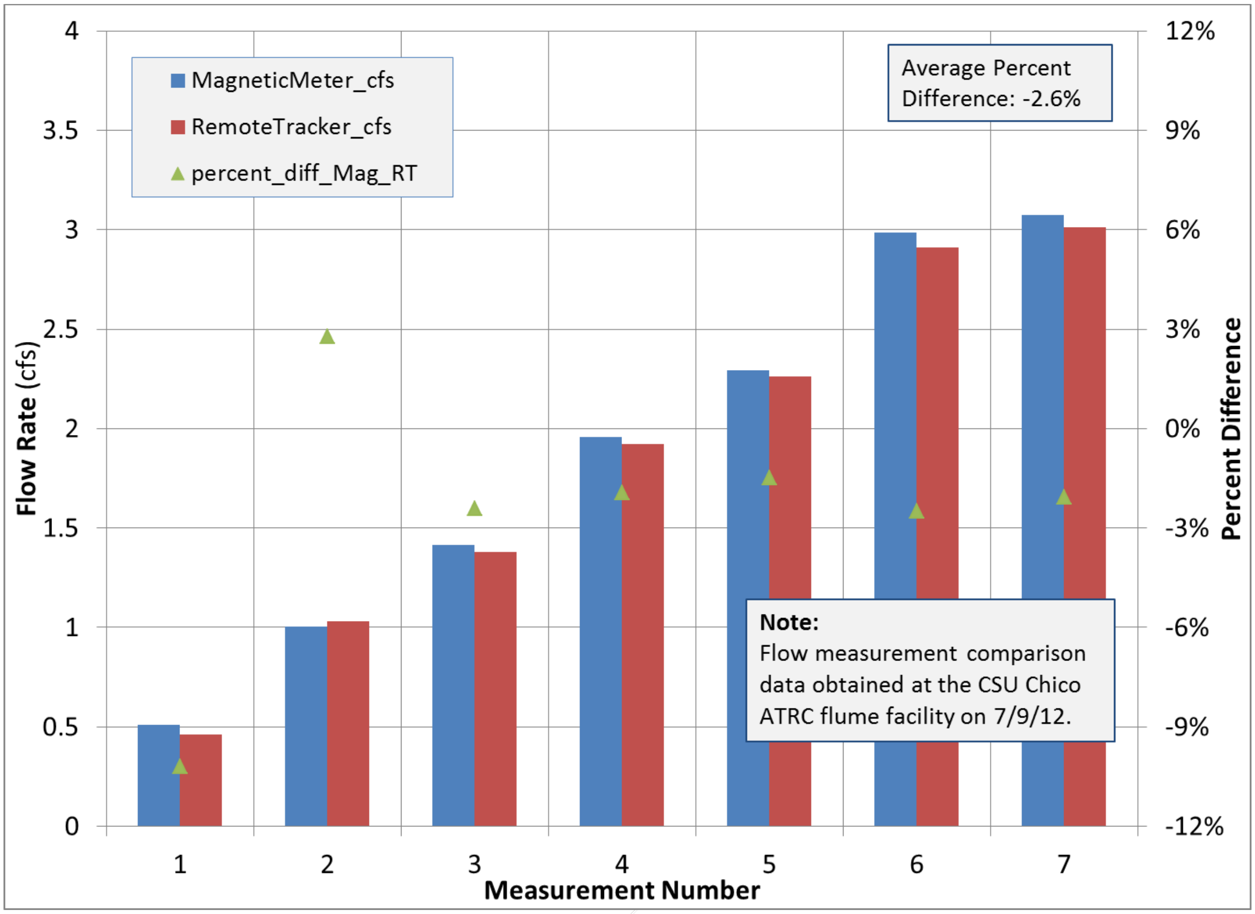


Figure A-6. RemoteTracker and CSUC ATRC Magmeter Comparisons

A-3.2 Field Testing

Five comparison measurements between the RemoteTracker and USGS mid-section method measurements with a SonTek ADV were performed at two turnouts in two irrigation districts (one turnout in each District) in Northern California during the 2011 irrigation season. The turnouts were selected because the delivery spilled into a field ditch (or head ditch) rather than a field, so both a RemoteTracker and a USGS mid-section method measurement (Rantz 1982) could be taken and compared. Figure A-7 shows the cross section report for one of the measurements in a typical earthen head ditch, in this case with a maximum depth of 2.5 feet, top width of 14 feet and bottom width of 5 feet. Typically, velocity measurements were performed at 0.5 foot intervals with velocities averaged over a 40 second period.

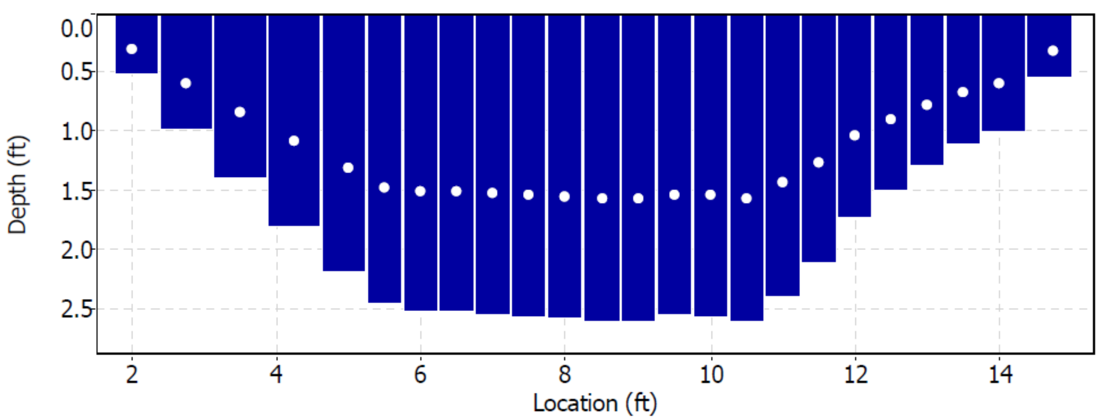


Figure A-7. SonTek ADV Cross Section for Canal Verification Measurement

The percent difference between the RemoteTracker and the USGS mid-section method averaged roughly 0.9 percent with a range of -0.8 to 3.4 percent, indicating that the RemoteTracker measurement methodology compares very well with the standard mid-section open channel methodology. The results of the comparison measurements are presented below in Figure A-8 where the blue bars represent flow rates obtained with a SonTek ADV in an open channel downstream of the turnout, the red bars represent flow rates obtained with the RemoteTracker and the green triangles represent the percent difference between the two (secondary vertical axis).

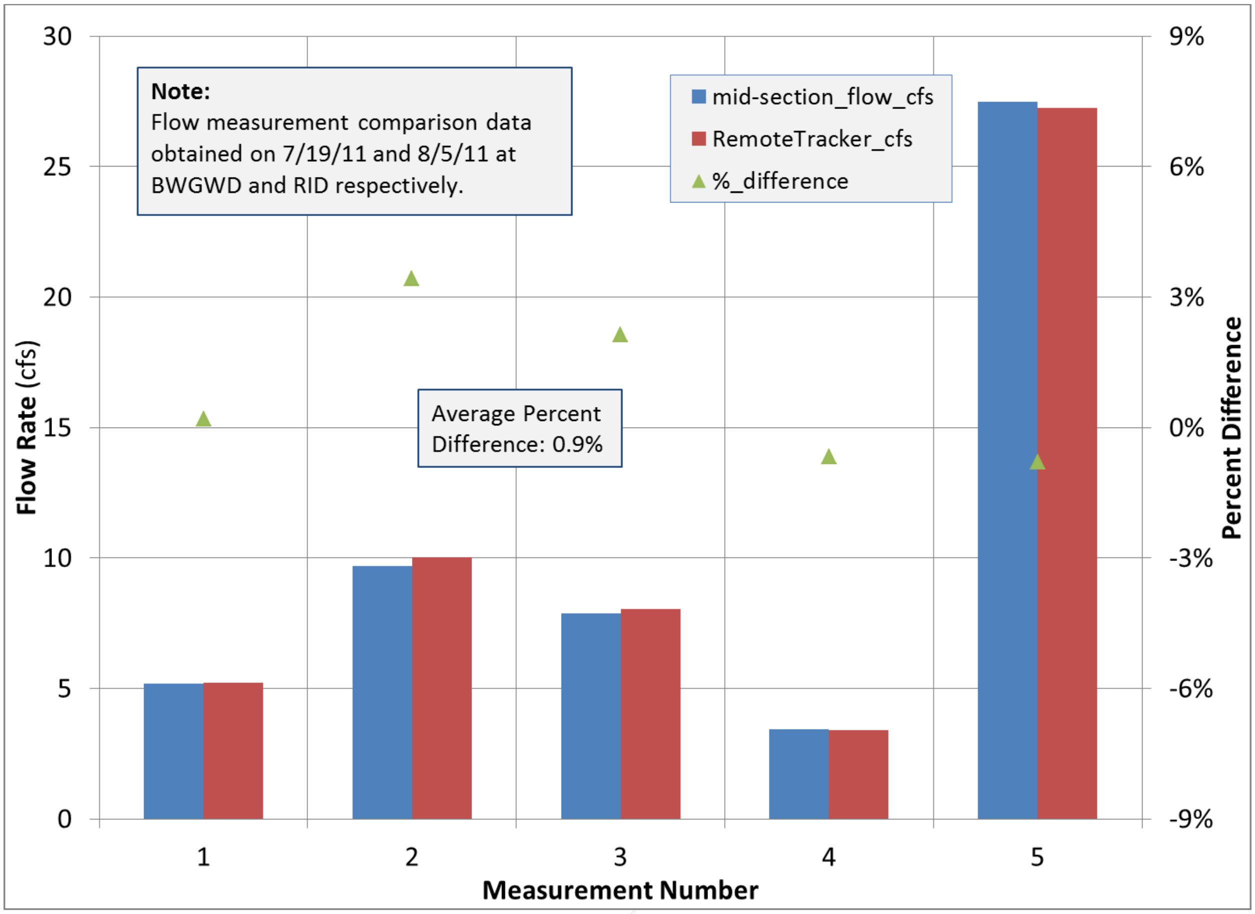


Figure A-8. RemoteTracker and Mid-Section method Comparisons

A-4.0 Volumetric Conversion (CCR 23 §597.4 (e) (3))

Accuracy requirements established by CCR 23 §597 apply to delivery volume and not instantaneous flow rate or velocity. CCR 23 §597.4(e)(3)(B) states, "For devices that measure velocity only, the documentation shall describe protocols associated with the measurement of the cross-sectional area of flow and duration of water delivery…". This document provides descriptions of the protocols associated with the measurement of (1) average velocity, (2) cross-sectional area of flow and (3) duration of delivery, in addition to the corresponding accuracies associated with each measurement.

Because the RemoteTracker WWVS measures water velocity only, Equation A-1 suggested in CCR 23 597.4(e)(3)(B) is used to calculate volume.

$$\forall = V * A * \Delta t$$ **(Equation A-1)**

Where the variables are defined as:

- $\forall$: Volume
- V: Average Velocity
- A: Cross-Section Flow Area
- Δt: Duration of Delivery

This relative accuracy analysis assumes:

- 3 cubic foot per second (cfs) maintenance delivery
- A 24 inch inner diameter delivery pipe
- Normal distribution of measurement errors

A 3 cfs delivery was selected because it represents the lower range of agricultural water delivery rates and accuracy is harder to achieve at low flows. A 24 inch pipe is the average turnout pipe size within most agricultural districts. These assumptions lead to the listed variables having the values presented below.

- V_{RT} = RemoteTracker Velocity Measurement = 1.00 ft/s
- $V_{Avg}*$ = Average Velocity of the pipe at the time of the RemoteTracker spot measurement = 0.95 ft/s (determined by correlation with measured velocity; see Figure A-3)
- D = Pipe Diameter = 2.00 ft
- A = Cross-Section Flow Area = 3.14 ft^2

Based on the following analysis, the expected accuracy in volumetric measurements performed with the RemoteTracker system is ±4.6 percent.

A-4.1 Volumetric Accuracy Analysis Overview

Volumetric accuracy of water deliveries consists of the accuracies in each of the following three components:

- Average Velocity (V_{Avg})
- Cross-Section Flow Area (A)
- Duration of Delivery (Δt)

The total absolute accuracy is found using the following equation;

$$\sigma_{\forall} = \pm\sqrt{\left(\frac{\partial\forall}{\partial V_{Avg}}\sigma_{V_{Avg}}\right)^2 + \left(\frac{\partial\forall}{\partial A}\sigma_A\right)^2 + \left(\frac{\partial\forall}{\partial \Delta t}\sigma_{\Delta t}\right)^2}$$ **(Equation A-2)**

Where the variables are defined as:

- $\forall$: Volume
- V_{Avg}: Average Velocity
- Δt: Duration of Delivery
- σ: Absolute Accuracy (expressed in the units of the term in question)
- U: Relative Accuracy (expressed as a percentage)

The total relative accuracy is:

$$U_{\forall} = \frac{\sigma_{\forall}}{\forall} = \pm\frac{1}{\forall}\sqrt{\left(\frac{\partial\forall}{\partial V_{Avg}}\sigma_{V_{Avg}}\right)^2 + \left(\frac{\partial\forall}{\partial A}\sigma_A\right)^2 + \left(\frac{\partial\forall}{\partial \Delta t}\sigma_{\Delta t}\right)^2}$$ **(Equation A-3)**

$$U_{\forall} = \pm\sqrt{\frac{1}{\forall^2}\left(\left(\frac{\partial\forall}{\partial V_{Avg}}\sigma_{V_{Avg}}\right)^2 + \left(\frac{\partial\forall}{\partial A}\sigma_A\right)^2 + \left(\frac{\partial\forall}{\partial \Delta t}\sigma_{\Delta t}\right)^2\right)}$$

Where the partial derivatives are:

$$\frac{\partial\forall}{\partial V_{Avg}} = A\Delta t \ , \ \frac{\partial\forall}{\partial A} = V_{Avg}\Delta t \ , \ \frac{\partial\forall}{\Delta t} = V_{Avg}A$$

Substituting in the solutions to the partial derivatives:

$$U_{\forall} = \pm\sqrt{\frac{1}{\forall^2}\left(\left(A\Delta t\sigma_{V_{Avg}}\right)^2 + \left(V_{Avg}\Delta t\sigma_A\right)^2 + \left(V_{Avg}A\sigma_{\Delta t}\right)^2\right)}$$

$$U_{\forall} = \pm\sqrt{\left(\frac{A\Delta t\sigma_{V_{Avg}}}{\forall}\right)^2 + \left(\frac{V_{Avg}\Delta t\sigma_A}{\forall}\right)^2 + \left(\frac{V_{Avg}A\sigma_{\Delta t}}{\forall}\right)^2}$$

$$U_{\forall} = \pm\sqrt{\left(\frac{\sigma_{V_{Avg}}}{V_{Avg}}\right)^2 + \left(\frac{\sigma_A}{A}\right)^2 + \left(\frac{\sigma_{\Delta t}}{\Delta t}\right)^2}$$

This becomes:

$$U_{\forall} = \pm\sqrt{\left(U_{V_{Avg}}\right)^2 + (U_A)^2 + (U_{\Delta t})^2}$$ **(Equation A-4)**

Based on Equation A-4, the relative accuracies of Average Velocity, Cross-Section Flow Area, and Duration of Delivery are required. The following sections detail their determination.

A-4.2 Relative Accuracy in Velocity

The following bullet points provide protocols for the collection of water velocity data.

- The RemoteTracker WWVS will be deployed in the delivery pipe outfall so that the sample volume is located in the center of the delivery pipe
- Water velocities will be collected with the RemoteTracker WWVS at:
  - The start of all delivery events
  - After any changes in delivery events
- Shutoffs will be recorded on the RemoteTracker user interface with the “Record Shutoff” button at the time the gate is closed

The accuracies in average velocity consist of three parts:

1. $\sigma_{V_{RT}}$: Accuracy of RemoteTracker velocity measurements
2. $\sigma_{V_{Avg*}}$: Accuracy due to the process of correlating RemoteTracker velocity measured at the pipe center and the average velocity of the pipe at the time of the RemoteTracker spot measurement[2]
3. $\sigma_{\Delta V_T}$: Accuracy due to the difference between the average velocity at the time of the RemoteTracker spot measurement and the actual average velocity for the duration of the delivery (i.e. change in velocity over time)

The average velocity relative accuracy is:

[2] Average velocity at the time of the RemoteTracker spot measurement represents a snapshot of the average water velocity in a delivery pipe at the time of the RemoteTracker measurement.

$$U_{V_{Avg}} = \pm \frac{\sigma_{V_{Avg}}}{V_{Avg}}$$ **(Equation A-5)**

Where the variables are defined as:

- V_{Avg}: Average Velocity
- $U_{V_{Avg}}$: Relative Velocity Accuracy
- $\sigma_{V_{Avg}}$: Absolute Velocity Accuracy

The average velocity of the entire irrigation event is the summation of the average velocity at the time of observation and the average change in velocity throughout the remainder of the event due to water level fluctuations.

$$V_{Avg} = V_{Avg} * + \Delta V_T$$ **(Equation A-6)**

Where the variables are defined as:

- V_{Avg}: Average Velocity
- V_{Avg} $*$: Average Velocity at the time of the RemoteTracker spot measurement
- ΔV_T: Average Change in Velocity over time

Therefore:

$$\sigma_{V_{Avg}} = \pm \sqrt{\left(\frac{\partial V_{Avg}}{\partial V_{AvgO}} \sigma_{V_{AvgO}}\right)^2 + \left(\frac{\partial V_{Avg}}{\partial \Delta V_T} \sigma_{\Delta V_T}\right)^2}$$ **(Equation A-7)**

Where the partial derivatives are:

$$\frac{\partial V_{Avg}}{\partial V_{Avg^*}} = 1, \; \frac{\partial V_{Avg}}{\partial \Delta V_T} = 1$$

Substituting in the solutions to the partial derivatives:

$$\sigma_{V_{Avg}} = \pm \sqrt{\left(\sigma_{V_{Avg^*}}\right)^2 + \left(\sigma_{\Delta V_T}\right)^2}$$ **(Equation A-8)**

The following subsections present (1) the accuracy of the RemoteTracker velocity measurements, (2) the accuracy of the average velocity at the time of the RemoteTracker spot measurements ($\sigma_{V_{Avg}*}$) and (3) the accuracy in the change in average velocity over time ($\sigma_{\Delta V_T}$).

A-4.2.1 Accuracy of RemoteTracker Velocity Measurement

The RemoteTracker system uses a SonTek ADV for water velocity measurements. The SonTek ADV technical specifications sheet lists a velocity measurement error of 0.01 or 1.0% (SonTek 2006). Therefore, $\sigma_{V_{RT}}$ is equal to 0.010 ft/s, or 1.0% of 1.00 ft/s (V_D).

A-4.2.2 Accuracy of the Average Velocity at the Time of the RemoteTracker Spot Measurement

The average velocity is computed as the product of the velocity measured by the RemoteTracker and the coefficient correlating the RemoteTracker velocity measurement to the average velocity at the time of the RemoteTracker spot measurement.

$$V_{Avg} *= CV_{RT}$$ **(Equation A-9)**

Where the variables are defined as:

- $V_{Avg} *$: Average velocity at the time of the RemoteTracker spot measurement
- C: Coefficient correlating the RemoteTracker velocity measurement to the average velocity at the time of the RemoteTracker spot measurement, which is equal to 0.95 (see Figure A-3)
- V_{RT}: RemoteTracker velocity measurement

Therefore:

$$\sigma_{V_{Avg^*}} = \pm\sqrt{\left(\frac{\partial V_{Avg^*}}{\partial C}\sigma_C\right)^2 + \left(\frac{\partial V_{Avg^*}}{\partial V_{RT}}\sigma_{V_{RT}}\right)^2}$$ **(Equation A-10)**

Where the partial derivatives are:

$$\frac{\partial V_{Avg} *}{\partial C} = V_{RT}, \frac{\partial V_{Avg} *}{\partial V_{RT}} = C$$

Substituting in the solutions to the partial derivatives:

$$\sigma_{V_{Avg^*}} = \pm\sqrt{(V_{RT}\sigma_C)^2 + \left(C\sigma_{V_{RT}}\right)^2}$$ **(Equation A-11)**

Based on water velocity data collected, the average error introduced by converting the RemoteTracker velocity measurement to the average velocity at the time of the RemoteTracker spot measurement (σ_C) is 0.014 or 1.4%.

Inserting the determined values into Equation A-11:

$$\sigma_{V_{Avg*}} = \pm\sqrt{(1.0 * 0.014)^2 + (0.95 * 0.010)^2} = \pm\, 0.017\ ft/s$$

A-4.2.3 Accuracy of the Change in Velocity over Time

A Microsoft Access database was developed to assess the accuracy in the change in velocity over time. Based on the orifice equation, the change in velocity through an orifice is solely a function of changes in head (or difference between upstream and downstream water level). Only water level data from the typical irrigation season (i.e. May through August) was used. It was assumed that measurements of velocity were performed every three days.

The difference between the head observed every three days and the actual average of the 15 minute data during the three day period was computed for each 15 minute record and then averaged over the observation period. Equation A-14 was then used to calculate the change in velocity over time (ΔV_T) for each three day period. The initial head (h_i) was assumed to be 0.5 feet to simulate a low head delivery. A low head was chosen because water level fluctuations impact the velocity of low head deliveries more significantly than high head deliveries.

Rearranging Equation A-6:

$$\Delta V_T = V_{Avg} - V_{Avg}\,*$$

From the orifice equation:

$$V = C(2gh)^{0.5}$$ **(Equation A-12)**

Where the variables are defined as:

- V: Velocity
- C: Discharge Coefficient
- g: gravitational constant
- h: Head

Orifice gates in most agricultural water districts operate under submerged conditions (i.e. not free flow conditions). As upstream canal water levels fluctuate, the flow through the orifice would theoretically vary as a function of the changes in canal water level to the one-half power. However, since the orifice gates are submerged, the hydraulically connected downstream water level also varies together with the upstream canal water level. This provides a damping effect on the overall change in velocity due to upstream water level fluctuations. The California Polytechnic State University at San Luis Obispo Irrigation

Training and Research Center (ITRC) suggest using a power of 0.38 in the orifice equation to simulate the damping effect of submergence for a range of downstream channel conditions (Burt and Geer 2012).

$$V = C(2gh)^{0.38} \qquad \textbf{(Equation A-13)}$$

Substituting values:

$$\Delta V_T = C(2gh_{avg})^{0.38} - C(2gh_O)^{0.38}$$

Where the variables are defined as:

- h_{avg}: Average Head
- h_O: Observed Head

Factoring:

$$\Delta V_T = C(2g)^{0.38}\left((h_{avg})^{0.38} - (h_O)^{0.38}\right)$$

Substituting values:

$$\Delta V_T = C(2g)^{0.38}\left((h_i + \Delta h_{avg})^{0.38} - (h_i)^{0.38}\right) \qquad \textbf{(Equation A-14)}$$

Where the variables are defined as:

- h_i= Initial head at time of observation
- Δh_{avg}= average change in head

Since the volumetric reporting requirements apply to a monthly or bi-monthly basis (California Water Code §531.10(a)), the change in velocity over time was then averaged on a monthly time step. The average of the absolute values of each of the average monthly changes in velocity over time was taken across all nine sites. Largely due to the fact that water level fluctuations are normally distributed, the results of the hydraulic database model suggest that the average change in velocity over time due to water level fluctuation is:

$$\sigma_{\Delta V_T} = \pm\, 0.033\; ft/s$$

Based on the evaluation of continuous upstream and downstream water level data from 14 irrigation events in RD 108 with an average duration of five days, the average change in velocity over time was determined to be ±1.0 percent. In the context of this analysis, the accuracy in the change in velocity over time would be:

$$\sigma_{\Delta V_T} = \pm 1.0\% \; or \pm 0.010 \; ft/s$$

Therefore, utilizing the value of ±0.033 ft/s for the volumetric accuracy analysis is a conservative assumption.

Inserting the calculated values into Equation A-8, the average velocity accuracy is:

$$\sigma_{V_{Avg}} = \pm\sqrt{(0.017)^2 + (0.033)^2} = 0.037 \; ft/s$$

The relative accuracy of the average velocity is:

$$U_{V_{Avg}} = \pm \frac{\sigma_{V_{Avg}}}{V_{Avg}} = \pm \frac{0.037 \; ft/s}{0.95 \; ft/s} = \pm \; 0.039 \; or \; 3.9\%$$

A-4.3 Relative Accuracy in Cross-Section Flow Area

The following bullet points provide protocols for the collection of cross-section flow area data.

- The cross-section flow area will be calculated by measuring the inner diameter of the delivery pipe at the location of the water velocity measurement and using Equation A-16 to calculated area from inner diameter
- Inner pipe diameters will be measured with best professional practices when the pipe is dry

The accuracy in the inner pipe diameter measurement is assumed to be 0.02 feet (or 1/4 inch). The relative accuracy due to area is:

$$U_A = \pm \frac{\sigma_A}{A}$$ **(Equation A-15)**

The correlation between diameter and area is:

$$A = \frac{\pi \mathrm{D}^2}{4}$$ **(Equation A-16)**

Where the variables are defined as:

- A: Cross-Section Flow Area
- π: Pi
- D: Inner Diameter

The accuracy is:

$$\sigma_A = \pm\sqrt{\left(\frac{\partial A}{\partial D}\sigma_D\right)^2}$$ **(Equation A-17)**

Where the partial derivative is equal to:

$$\frac{\partial A}{\partial D} = \frac{2\pi D}{4} = \frac{\pi D}{2}$$

The assumed pipe is 2.00 feet (24 inch) in diameter, giving an area of 3.142 ft^2

$$\sigma_A = \pm\sqrt{\left(\frac{\partial A}{\partial D}\sigma_D\right)^2} = \sqrt{\left(\frac{\pi D}{2}0.02\right)^2} = \sqrt{\left(\frac{\pi 2}{2}0.02\right)^2} = \pm\, 0.063\, ft$$

The relative accuracy in the cross-section flow area is:

$$U_A = \pm\frac{\sigma_A}{A} = \pm\frac{0.063\, ft}{3.142\, ft} = \pm\, 0.020\ or\ 2.0\%$$

A-4.4 Relative Accuracy in Duration of Delivery

The following bullet points provide protocols for the collection of duration of delivery data.

- The start time for delivery will be the date and time recorded in the RemoteTracker system when a velocity measurement is taken at the start of a delivery
- The stop time for delivery will be the date and time recorded in the RemoteTracker system when either:
    - "Record Shutoff" is pressed after a gate is closed at the end of a delivery or
    - A new velocity measurement is taken after a change in delivery flow rate is made

A conservative value for the duration of an irrigation event is assumed to be a period of 24 hours. The possible accuracy in duration measurement is considered to be 15 minutes for the startup and 15 minutes for the shutoff (or 0.25 hours for both). Realistically, the actual accuracy in duration is much smaller when using the RemoteTracker system since the operator is recording water velocity data on site when gate position changes are made. The relative accuracy due to duration of delivery is:

$$U_{\Delta t} = \pm\frac{\sigma_{\Delta t}}{\Delta t}$$ **(Equation A-18)**

Where:

$$\Delta t = Et - St$$ **(Equation A-19)**

Where the variables are defined as:

- Δt: Duration of Delivery
- St: Start Time
- Et: End Time

The accuracy of the Duration of Delivery is:

$$\sigma_{\Delta t} = \pm\sqrt{\left(\frac{\partial \Delta t}{\partial St}\sigma_{St}\right)^2 + \left(\frac{\partial \Delta t}{\partial Et}\sigma_{Et}\right)^2} \qquad \textbf{(Equation A-20)}$$

Where the partial derivatives are equal to:

$$\frac{\partial \Delta t}{\partial St} = 1, \ \frac{\partial \Delta t}{\partial Et} = 1$$

$$\sigma_{\Delta t} = \pm\sqrt{(\sigma_{St})^2 + (\sigma_{Et})^2} = \sqrt{(.25)^2 + (0.25)^2} = 0.35\ hrs$$

The relative accuracy in the duration of delivery is:

$$\boxed{U_{\Delta t} = \pm\frac{\sigma_{\Delta t}}{\Delta t} = \pm\frac{0.35}{24} = \pm\, 0.015\ or\ 1.5\%}$$

A-4.5 Relative Accuracy in Volume

As previously stated this relative accuracy assumes a 3 cfs maintenance delivery in a 24" pipe. Inserting the calculated accuracy value for each component, the relative accuracy is as follows:

$$U_{\forall} = \pm\sqrt{\left(U_{V_{Avg}}\right)^2 + (U_A)^2 + (U_{\Delta t})^2} \qquad \textbf{(Equation A-21)}$$

Inserting all calculated accuracy values the relative accuracy in volumetric measurements is:

$$U_{\forall} = \pm\sqrt{(.039)^2 + (.020)^2 + (.015)^2}$$

$$\boxed{U_{\forall} = \pm\, 0.046\ or\ \pm 4.6\%}$$

Based on the foregoing analysis and the resulting ±4.6% accuracy in delivery volume determined for the RemoteTracker, the RemoteTracker complies with the ±5.0% accuracy standard in CCR 23 §597 for laboratory testing.

EXHIBIT 2

REPORT DETAILING THE COST OF SERVICE

RECLAMATION DISTRICT NO. 108

REPORT DETAILING THE COST OF SERVICE

BACKGROUND

Reclamation District No. 108 (RD108) was formed in 1870 under the general Reclamation District Law of 1868 for the purpose of constructing levees to provide flood protection to over 100,000 acres of farmland along the west side of the Sacramento River from north of Colusa to Knights Landing. In the early 1900s, RD108 was consolidated to approximately 58,000 acres to provide irrigation water service, flood control, and drainage for lands within its service area. In 1917, RD108 began construction of major irrigation distribution system facilities for delivery of water from the Sacramento River to approximately 48,000 acres.

RD108 obtains its water supply from the Sacramento River under its riparian water rights and licenses for appropriation of surface waters. This water supply is supplemented when necessary from groundwater, using the District's wells and privately owned wells and by diversion of water from the Colusa Basin Drain under the District's appropriative license. RD108's appropriative water rights for diversion from the Sacramento River have priority dates of 1917 and 1919. RD108's appropriative water right for diversion from the Colusa Basin Drain has a priority date of 1947.

In 1964, RD108 entered into a negotiated settlement agreement with the U.S. Bureau of Reclamation (USBR), quantifying the amount of water RD108 could divert from the Sacramento River. The resulting negotiated agreement recognized RD108's annual entitlement of Base Supply of 199,000 acre-feet per year (ac-ft/yr) of flows from the Sacramento River and also provided for a 54,500 ac-ft/yr allocation of Central Valley Project supply (Project Supply). In 1974, the District reduced its Project Supply allocation to 33,000 ac-ft/yr with the expectation that conservation efforts including canal lining and recirculation of drainage water would reduce diversion requirements. The subsequent contract entitlement was thus for a total of 232,000 ac-ft/yr. The contract stipulated maximum diversions of Base and Project Supply for the months of April through October and remained in effect until March 31, 2006, at which time it was extended for an additional 40 years.

Rice is the predominant crop grown within RD 108's service area. Other key crops include tomatoes, alfalfa, vineseed, wheat, and corn.

ACCOUNTING BASIS

RD108 irrigation services are accounted for within a single irrigation fund. RD108 uses the accrual basis of accounting and, as such, revenues are recognized when earned and expenses are recorded when the liability is incurred, regardless of the timing of cash flows. Capital assets are depreciated over the useful life of the asset.

COST OF WATER SERVICE

For purposes of complying with the mandates of Article XIII D of the California Constitution, it is imperative that the amount of a charge (such as the water rates) not exceed the cost of service. The cost of service is determined by preparing a budget with all revenues and expenses necessary to operate RD108 (including a budget reserve), but without including the revenues generated from annual water rates. Then, using an estimate of the number of acres that will be irrigated, associated water duties, and volumes of water delivered, water rates necessary to balance the budget can be calculated.

As shown on the attached Table 1 the Irrigation Budget for 2016 is projected to result in a net loss. RD108's 2016 Irrigation Budget demonstrates that its water rates will not exceed the cost of service and, in fact, every property in RD108 receiving water will be charged slightly less than the cost of service.

Avoided Cost of Service for Lift Pumps

Some RD108 customers receive water via lift pumps that are operated by the Water User to lift water from the RD108 conveyance channel to the field to be irrigated. As a result, RD108 avoids additional costs that would otherwise be required to construct and operate District pumping facilities to lift the water from the canal for each Water User. In order to account for this avoided cost of service that would otherwise be incurred, RD108 reduces the charge for water delivered by the estimated avoided pumping costs. This cost is estimated to be approximately $0.30 per acre-foot per foot of lift.

PROPORTIONALITY OF WATER RATES TO SERVICE PROVIDED

Charges subject to Article XIII D must also be proportional to the service provided. Historically, RD108 has charged its landowners who receive water for rice irrigation a per-acre water rate. For other crops, a per-acre water rate is charged for the first irrigation, followed by a lesser per-acre water rate for each subsequent irrigation. For non-rice crops, this approach results in higher rates on fields with crops using more irrigation applications, which results in rates reasonably proportional to the amount of water applied. As described previously, Water Users who pump water using lift pumps are charged lesser rates in proportion to the avoided cost to RD108 of pumping the water. For non-rice crops, all charges are calculated based on the number of irrigations provided. Due to the fact that RD108's field turnouts have not historically been metered, this method is reasonable for estimating Water User's water use.

In 2015, RD108 authorized Davids Engineering to evaluate potential rate structures and estimated applied water duties for irrigation by crop[1] with the goal of developing a water rate based in part on the actual volume of water delivered to individual field turnouts, as required under California Senate Bill x7-7 (SBx7-7), also known as the Water Measurement Program, and the Water Conservation Act of 2009. The evaluation included evaluation of a three-part rate structure that includes two fixed (per acre) components of the water rate and a volumetric (per acre-foot) component of the water rate.

PROPOSED WATER RATES

Three-Part Rate Structure

For 2016, it is proposed that the three-part rate structure evaluated be implemented, including two fixed rate components and a volumetric rate component, as described above. The first fixed component of the rate includes an equal charge per acre irrigated applicable to all crops. The second fixed component of the rate includes a per-acre charge that varies based on the estimated applied water duty for each crop.

[1] A table of estimated applied water duties by crop is provided as Exhibit 1.

The volumetric component of the rate includes a charge based on the actual quantity of water delivered, as measured by RD108.

A large part of RD108's annual expenses are related to the fixed costs of operating and maintaining the water system infrastructure and are not directly dependent upon the amount of water actually delivered to irrigated parcels within RD108. As such, it is desirable for RD108 to implement the proposed rate structure, including the volumetric component of the rate, in 2016. The proposed rate structure provides benefits to RD108, as compared to a wholly fixed or wholly volumetric rate structure. A portion of charges based on the number of acres irrigated using RD108 water, promotes revenue stability to RD108 across years and allows RD108 to proceed with delivery measurement at field turnouts and to implement associated volumetric charges as required by SBx7-7 without solely charging based on the amount delivered. Basing a portion of charges based on the actual volume of water delivered to field turnouts encourages conservation of limited water supplies and provides equitability among Water Users growing a particular crop with different amounts of applied water per acre.

For the proposed rate update, RD108 has determined that, on average, one third of the cost of service is to be recovered through each of the three components of the rate, with adjustments based on lift pump costs incurred by RD108 Water Users, applied to the second fixed rate component (per-acre charge based on crop grown and corresponding estimated applied water duty) and the volumetric rate component (per acre-foot charge based on actual measured delivery volume) as appropriate. This division of fixed and volumetric rate components is expected to result in a desirable blend of the benefits described above.

2016 Water Rates

It is proposed that for 2016 and subsequent years, unless otherwise modified by the RD108 Trustees, the three-part rate structure will be applied. All rates represent proposed <u>maximum</u> water rates that could be charged and may be reduced at any time at the discretion of the RD108 Board of Trustees.

Proposed rates have been calculated based on the projected cost of service for 2016, minus any revenues from other sources. Estimated irrigation water rate changes for 2016 by crop are summarized in Exhibit 2. Increased water rates reflect a combination of increased cost of service and changes resulting from transition for RD108's current rate structure to the proposed three-part rate structure, which includes a rate component based on the volume of water delivered. Due to the change in rate structure, the rate of increase for individual crops varies. In general water rates for crops with the least number of irrigations increase by the greatest percentage due to the inclusion of the fixed component applied to all crops based on the acreage irrigated. Conversely, water rates for crops with the greatest number of irrigations tend to decrease.

A sample rate sheet describing water rate components by crop for 2016 is provided in Exhibit 3. Example rate calculations for individual fields are provided in Exhibit 4.

Payment Collection Schedule

Under the three-part rate structure, payment will be due in three installments, with the exception of deliveries for rice straw decomposition, as described below. The acreage-based fixed rate component will be due prior to delivering water to the field at the beginning of the irrigation season. The crop-based estimated applied water fixed rate component will be due by August 1 of the year during which the crop is grown. The volumetric rate component based on the actual volume of water delivered will be due by December 1 of the year during which the crop is grown.

For rice straw decomposition (decomp) and the second crop for double-cropped fields, the acreage-based fixed rate component will be waived, as it will have been paid for the preceding crop. The estimated applied water fixed rate component will be due prior to reflood for decomp or prior to the first irrigation of the second crop for double-cropped fields. The volumetric rate component based on the actual volume of water delivered for decomp and second crops will be due prior to the first irrigation of the field in the following year or by April 1, whichever comes first.

CONCLUSION

The proposed three-part rate structure ensures that RD108's water rates do not exceed the cost of service, are reasonably proportional to the service provided, equitably distributed among Water Users, and compliant with the requirements of the California Water Code established with the adoption of SBx7-7.

Table 1. RD108 2016 Irrigation Budget.

INCOME	
Water Sales/Irrigation	$ 3,000,000.00
Water Sales/Fair Ranch	$ 29,800.00
Water Sales/Rice Straw Decomposition	$ 200,000.00
Water Transfer	$ -
Earned Interest	$ 4,500.00
Outside Drainage Charge	$ 2,779.00
Miscellaneous Operating	$ -
TOTAL INCOME	$ 3,237,079.00
EXPENSES	
USBR Water Charges	$ 922,615.00
Office Supplies	$ 80.00
Power & Energy	$ 850,000.00
System Facilities	$ 1,644,402.00
Water Transfer	$ -
Water Conservation Program	$ -
Miscellaneous Non-Operating	$ -
TOTAL EXPENSES	$ 3,417,097.00
NET INCOME/LOSS	$ (180,018.00)

EXHIBIT 1. ESTIMATED APPLIED WATER DUTIES (DELIVERIES) BY IRRIGATED LAND USE[2].

Crop	Estimated Applied Water Duty (acre-feet per acre)	Comments
Alfalfa	4.50	
Beans	2.50	
Canola	2.20	
Carrots	2.50	
Clover	4.50	
Conservation	2.50	
Cotton	3.30	
Corn	2.50	
Garlic	1.50	
Grain	2.00	Barley, Buckwheat, Milo, Oats, Wheat
Market Veg	2.50	
Melons	1.60	
Onions	1.50	
Orchard, Young	1.60	3 years or younger
Orchard, Mature	3.00	4 years or older
Pasture	3.00	
Pumpkins	1.60	
Rice	5.50	Medium, Short, Sweet
Rice - Wild	5.00	
Safflower	2.20	
Soybeans	2.50	
Sudan Grass	3.00	
Sugar Beets	3.50	
Sunflowers	2.20	
Tomatoes	2.30	
Vetch	2.50	
Vine Seeds	1.60	
Idle Lands	0.00	
Decomp, 1 Flood	1.00	Rice straw decomposition with one-time flood
Decomp, Maint.	2.00	Rice straw decomposition with maintenance flow
Fall Only, 1 Flood	1.00	One-time fall flood (no summer crop)
Fall Only, Maint.	2.00	Fall flood with maintenance (no summer crop)

[2] For double-cropping, duties will be estimated as the sum of duties for individual crops grown.

EXHIBIT 2. ESTIMATED WATER RATE CHANGES FOR 2016 BY CROP.[3,4]

Crop	Budgeted Acres	Estimated Average Irrigations	Estimated Applied Water Duty (ac-ft/ac)	Average Historical Water Rate ($/ac)	Proposed Water Rate ($/ac)	Total Change ($/ac)	Percent Change
Alfalfa	1,850	4.9	4.5	$54.86	$65.86	$11.00	20%
Beans	300	5.6	2.5	$61.58	$46.66	-$14.92	-24%
Corn	500	5.0	2.5	$55.70	$46.66	-$9.04	-16%
Grain	2,400	1.2	2.0	$18.53	$41.86	$23.33	126%
Melons	260	4.4	1.6	$49.93	$38.02	-$11.91	-24%
Orchard, Young	670	3.8	1.6	$44.27	$38.02	-$6.25	-14%
Orchard, Mature	1,700	3.8	3.0	$44.27	$51.46	$7.19	16%
Pasture	160	4.3	3.0	$48.16	$51.46	$3.30	7%
Rice	31,830	NA	5.5	$68.20	$75.46	$7.26	11%
Safflower	840	1.3	2.2	$20.02	$43.78	$23.76	119%
Sudan Grass	40	2.4	3.0	$30.07	$51.46	$21.39	71%
Sunflowers	1,410	1.6	2.2	$22.88	$43.78	$20.90	91%
Tomatoes	3,930	6.7	2.3	$71.44	$44.74	-$26.70	-37%
Vine Seeds	870	4.4	1.6	$49.93	$38.02	-$11.91	-24%
Decomp, 1 Flood	7,000	NA	1.0	$17.57	$9.60	-$7.97	-45%
Decomp, Maint.	4,500	NA	2.0	$23.93	$19.20	-$4.73	-20%
Fall Only, 1 Flood	200	NA	1.0	$17.57	$32.26	$14.69	84%
Fall Only, Maint.	110	NA	2.0	$23.93	$41.86	$17.93	75%

[3] Average historical and proposed water rates by crop are based on gravity deliveries and do not reflect reductions in water rates to be applied based on RD108 avoided costs for pump deliveries. Proposed water rates are based on the estimated applied water duty and will vary somewhat from field to field based on actual usage. Total acres includes 47,070 summer and 12,120 fall irrigated acres. Other totals are calculated as area-weighted averages based on budgeted acreages.

[4] Historically, fields have been billed for water purely on a volumetric basis in some cases. For these fields, the average historical water rate and change in water rate will vary from the values shown depending on the amount of water applied.

EXHIBIT 3. SAMPLE 2016 RATE SHEET.

RECLAMATION DISTRICT NO. 108 - 2016 RATE STRUCTURE

This sheet shows how water rates are distributed between a Crop Specific Fixed Rate Component ($/Acre), which is comprised of an Acreage Rate Component and an Est. AW Rate Component (see Exhibit X), and a Lift Specific Volumetric Rate Component ($/AF) (see Exhibit Y).

Exhibit X - 2016 CROP SPECIFIC FIXED RATE COMPONENT

Installment ->	*First*	*Second*			
Payment Due ->	*Prior to First*	*by August 1st*			
Crop	Acreage Rate Component ($/Acre)	Est AW Duty (AF/Acre)	Est. AW Volumetric Rate Component ($/AF)	Est. AW Rate Component ($/Acre)	Total Fixed Rate Component * ($/Acre)
ALFALFA	$22.66	4.50	$4.80	$21.60	$44.26
BEANS	$22.66	2.50	$4.80	$12.00	$34.66
CANOLA	$22.66	2.20	$4.80	$10.56	$33.22
CARROTS	$22.66	2.50	$4.80	$12.00	$34.66
CLOVER	$22.66	4.50	$4.80	$21.60	$44.26
CONSERVATION	$22.66	2.50	$4.80	$12.00	$34.66
COTTON	$22.66	3.30	$4.80	$15.84	$38.50
CORN	$22.66	2.50	$4.80	$12.00	$34.66
GARLIC	$22.66	1.50	$4.80	$7.20	$29.86
GRAIN	$22.66	2.00	$4.80	$9.60	$32.26
MARKET VEG	$22.66	2.50	$4.80	$12.00	$34.66
MELONS	$22.66	1.60	$4.80	$7.68	$30.34
ONIONS	$22.66	1.50	$4.80	$7.20	$29.86
ORCHARD, YOUNG	$22.66	1.60	$4.80	$7.68	$30.34
ORCHARD, MATURE	$22.66	3.00	$4.80	$14.40	$37.06
PASTURE	$22.66	3.00	$4.80	$14.40	$37.06
PUMPKINS	$22.66	1.60	$4.80	$7.68	$30.34
RICE	$22.66	5.50	$4.80	$26.40	$49.06
RICE - WILD	$22.66	5.00	$4.80	$24.00	$46.66
SAFFLOWER	$22.66	2.20	$4.80	$10.56	$33.22
SOYBEANS	$22.66	2.50	$4.80	$12.00	$34.66
SUDAN GRASS	$22.66	4.90	$4.80	$23.52	$46.18
SUGAR BEETS	$22.66	3.50	$4.80	$16.80	$39.46
SUNFLOWERS	$22.66	2.20	$4.80	$10.56	$33.22
TOMATOES	$22.66	2.30	$4.80	$11.04	$33.70
VETCH	$22.66	2.50	$4.80	$12.00	$34.66
VINE SEEDS	$22.66	1.60	$4.80	$7.68	$30.34
DECOMP, 1 FLOOD	$0.00	1.00	$4.80	$4.80	$4.80
DECOMP, MAINT.	$0.00	2.00	$4.80	$9.60	$9.60
FALL ONLY, 1 FLOOD	$22.66	1.00	$4.80	$4.80	$27.46
FALL ONLY, MAINT.	$22.66	2.00	$4.80	$9.60	$32.26

** Note: Total Fixed Rate Component = Acreage Rate Component + Est. AW Rate Component*

Exhibit Y - 2016 LIFT SPECIFIC NET VOLUMETRIC RATE COMPONENT

Installment ->	*Third*		
Payment Due ->	*by December 1st*		
Amount of Lift (Ft)	Volumetric Rate Component ($/AF)	Lift Credit ($/AF)	Net Volumetric Rate Component ** ($/AF)
0	$4.80	$0.00	$4.80
2	$4.80	$0.60	$4.20
3	$4.80	$0.90	$3.90
4	$4.80	$1.20	$3.60
5	$4.80	$1.50	$3.30
6	$4.80	$1.80	$3.00
7	$4.80	$2.10	$2.70
8	$4.80	$2.40	$2.40
9	$4.80	$2.70	$2.10
10	$4.80	$3.00	$1.80
11	$4.80	$3.30	$1.50
12	$4.80	$3.60	$1.20
13	$4.80	$3.90	$0.90
14	$4.80	$4.20	$0.60
15	$4.80	$4.50	$0.30
16	$4.80	$4.80	$0.00
17	$4.80	$5.10	-$0.30
18	$4.80	$5.40	-$0.60

*** Note: Net Volumetric Rate Component = Volumetric Rate Component - Lift Credit*

Abbreviations: AF: Acre-foot; FT: Foot; Est. AW: Estimated Applied Water

Notes:

1. **Grain** includes Barley, Buckwheat, Milo, Oats, and
2. **Rice** includes Short, Medium, and Sweet.

the following year will be considered on a field-by-field basis.

For summer crops, payments for water charges will be made in three installments:

First Installment (Acreage Charge) = Acreage Rate Component * Acres Planted (due Prior to First Delivery)

Second Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due by August 1st)

Third Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due by December 1st)

For rice straw decomposition and second (double) crops, payments for water charges will be made in two installments:

First Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due Prior to First Delivery)

Second Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due Prior to First Delivery of following year)

EXHIBIT 4. EXAMPLE WATER RATE CALCULATIONS.

RECLAMATION DISTRICT NO. 108 - 2016 RATE STRUCTURE

This sheet shows two sample water rate and water charge calculations.
See Exhibits X and Y for Details on Rates.

For summer crops, payments for water charges will be made in three installments:

First Installment (Acreage Charge) = Acreage Rate Component * Acres Planted (due Prior to First Delivery)
Second Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due by August 1st)
Third Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due by December 1st)

For rice straw decomposition and second (double) crops, payments for water charges will be made in two installments:

First Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due Prior to First Delivery)
Second Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due April 1 of following year)

Example Calculations

Given:

Crop: **Rice**
Acres: **100**
Amount of Lift: (FT) **5**

Installment	Description	Value	Notes
First	Acreage Rate Component ($/AC)	$22.66	Acreage Rate Component for Rice
	Acreage Charge ($)	$2,266.00	Acreage Charge ($): 22.66/Acre * 100 acres = $2266
Second	Est. AW Rate Component($/AC)	$26.40	Est. AW Rate Component for Rice
	Est. AW Charge ($)	$2,640.00	Est. AW Charge ($): 26.4/Acre * 100 acres = $2640
Third	Volume Applied (AF)	620	Volume of water delivered (AF)
	Net Volumetric Rate Component ($/AF)	$3.30	Net Volumetric Rate Component for 5 FT of Lift
	Volumetric Charge ($)	$2,046.00	Volumetric Charge ($): 3.3/AF * 620 AF = $2046
	Total Charge (All Installments) ->	**$6,952.00**	
	Total Charge Per Acre ->	**$69.52**	

Given:

Crop: **Tomatoes**
Acres: **50**
Amount of Lift: (FT) **0**

Installment	Description	Value	Notes
First	Acreage Rate Component ($/AC)	$22.66	Acreage Rate Component for Tomatoes
	Acreage Charge ($)	$1,133.00	Acreage Charge ($): 22.66/Acre * 50 acres = $1133
Second	Est. AW Rate Component ($/AC)	$11.04	Est. AW Rate Component for Tomatoes
	Est. AW Charge ($)	$552.00	Est. AW Charge ($): 11.04/Acre * 50 acres = $552
Third	Volume Applied (AF)	153	Volume of water delivered (AF)
	Net Volumetric Rate Component ($/AF)	$4.80	Net Volumetric Rate Component for 0 FT of Lift
	Volumetric Charge ($)	$734.40	Volumetric Charge ($): 4.8/AF * 153 AF = $734.4
	Total Charge (All Installments) ->	**$2,419.40**	
	Total Charge Per Acre ->	**$48.39**	

RD 1004 Specification Sheet M0300 Strap-on Saddle Flow Meter

DESCRIPTION

All Mc Propeller flow meters are manufactured to comply with applicable provisions of AWWA Standard No. C704-02 for propeller-type flow meters.

FEATURES

Saddle

- The fabricated stainless steel saddle eliminates the fatigue-related breakage common to cast iron and aluminum saddles and provides unsurpassed corrosion protection.
- Fabricated stainless steel construction offers the additional advantage of being flexible enough to conform to out-of-true pipe.

Impellers

- Impellers are manufactured of high-impact plastic, capable of retaining their shape and accuracy over the life of the meter.
- Each impeller is individually calibrated at the factory to accommodate the use of any standard McCrometer register, and since no change gears are used, the M0300 can be field-serviced without the need for factory recalibration.

Bearings

- Factory lubricated, stainless steel bearings are used to support the impeller shaft.
- The shielded bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

Register

- The instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units.
- The register is driven by a flexible steel cable with a magnetically coupled drive, encased within a protective vinyl liner.
- The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

Typical Applications

- Center pivot systems
- Sprinkler irrigation systems
- Drip irrigation systems
- Golf course and park water management
- Gravity turnouts from underground pipelines
- Commercial nurseries
- Water and wastewater management

SPECIFICATIONS

Performance

Accuracy / Repeatability	• ±2% of reading guaranteed throughout full range • ±1% over reduced range • Repeatability 0.25% or better
Range	4" to 16"
Maximum Temperature	(Standard Construction) 160°F constant
Pressure Rating	150 psi. Consult factory for higher rated version.

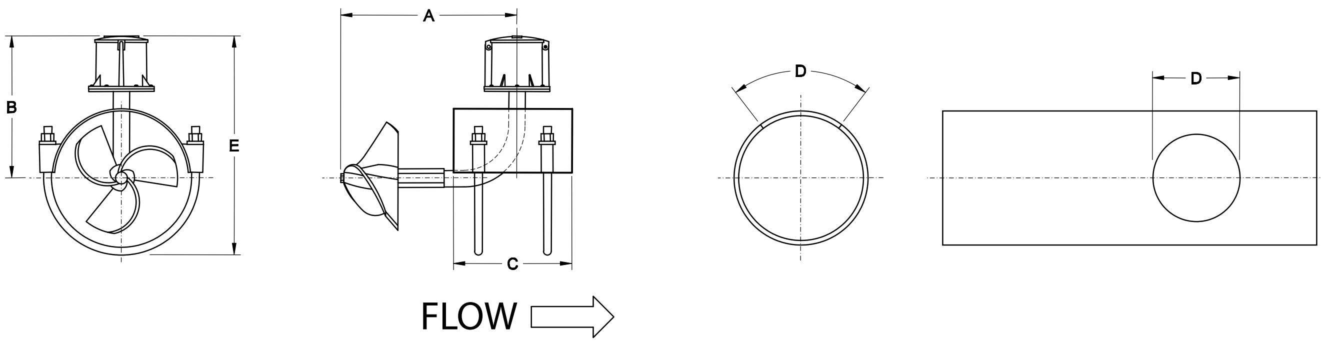
Materials

Saddle	304 stainless steel construction
Bearing Assembly	Impeller shaft is 316 stainless steel. Ball bearings are 440C stainless steel
Magnets	(Permanent type) Alnico
Bearing Housing	304 stainless steel standard, 316 stainless steel optional
Register	An instantaneous flowrate indicator and six-digit straight-reading totalizer are standard. The register is hermetically sealed within a die cast aluminum case. This protective housing includes a domed acrylic lens and hinged lens cover with locking hasp.
Impeller	Impellers are manufactured of high-impact plastic, retaining their shape and accuracy over the life of the meter.

Options

- Extended warranty
- Register extensions
- High temperature construction, 180°F max
- Marathon bearing assembly for higher than normal flowrates 4" and larger
- Digital register available in all sizes of this model
- A complete line of flow recording / control instrumentation
- Canopy boot
- Saddle can be constructed to fit any outside diameter pipe dimensions, including metric sizes.
- Blank repair saddle
- Can be used on a variety of pipe materials such as steel, plastic, cast iron, cement or asbestos cement
- Straightening vanes

DIMENSIONS



M0300	DIMENSIONS							
Meter and Nominal Pipe Size	in.	**4**	**6**	**8**	**10**	**12**	**14**	**16**
	mm	**102**	**152**	**203**	**254**	**305**	**256**	**406**
OD up to	in.	5.5	7.5	9.5	11.5	13.5	15.5	17.5
	mm	140	190	241	292	343	394	444
Minimum Flow	GPM	50	90	100	125	150	250	275
	LPS	3.2	5.7	6.3	7.9	9.5	15.8	17.3
Maximum Flow	GPM	600	1200	1500	1800	2500	3000	4000
	LPS	37.9	75.7	94.6	113.6	157.7	189.3	252.4
Max. Flow w/ Marathon Bearing	GPM	900	1800	2250	2700	3750	4500	6000
Approx. Head Loss in Inches at Max. Flow	in.	23	17	6.75	3.75	2.75	2	1.75
	mm	584	432	171	95	70	51	44
Standard Dial Face *	GPM/ Gal	1000/ 100	1800/ 100	2500/ 100	3K/ 1000	4K/ 1000	6K/ 1000	8K/ 1000
Approx. Shipping Weight-lbs.	lbs	12	17	21	24	28	28	30
	kg	5.4	7.7	9.5	10.9	12.7	12.7	13.6
A	in.	7.625	15	15	15	15	15	15
	mm	194	381	381	381	381	381	381
B	in.	8.25	10.75	10.75	10.75	11.75	13.75	13.75
	mm	210	273	273	273	298	349	349
C	in.	7	8	8	9.5	9.5	9.5	9.5
	mm	178	203	203	241	241	241	241
D	in.	4**	5.125**	6**	7**	7.25	7.25	7.25
	mm	102	130	152	178	184	184	184
E	in.	10.75	14	15	17	19	20.625	21.625
	mm	273	356	381	432	483	524	549

*Indicates the dial face range and multiplier
**Standard pipe only. For other than standard pipe, consult factory for cutout dimensions.

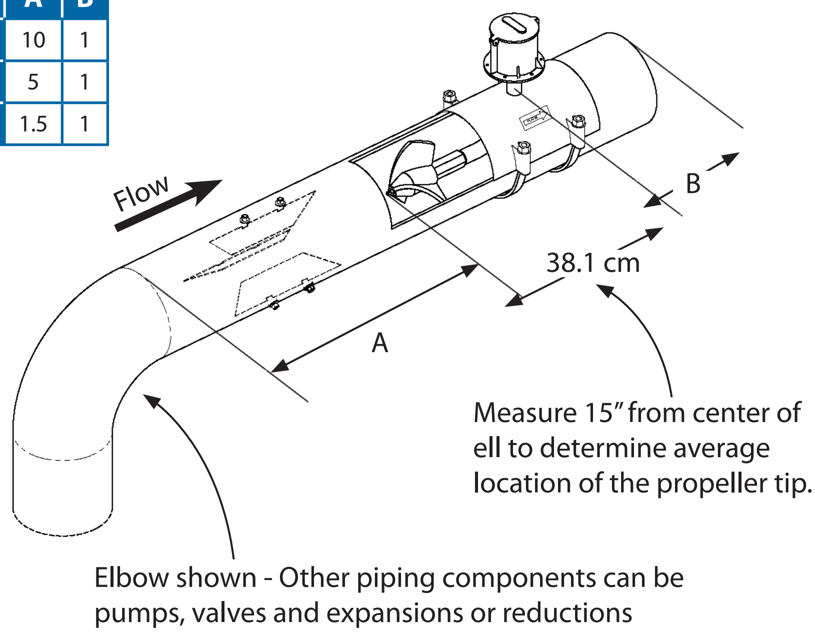
For larger sizes see Model M1400.
McCrometer reserves the right to change design or specification without notice.
Please specify the inside diameter of the pipe when ordering.

INSTALLATION

Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory.

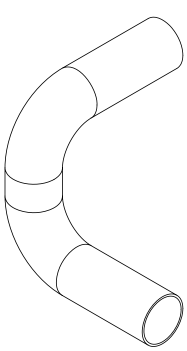
PIPE RUN REQUIREMENTS

Configuration	A	B
Without straightening vanes	10	1
With straightening vanes	5	1
With FS100 Flow Straightener	1.5	1

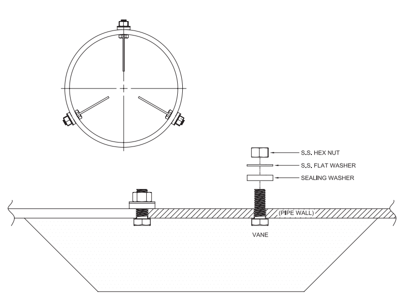


STRAIGHTENING VANES

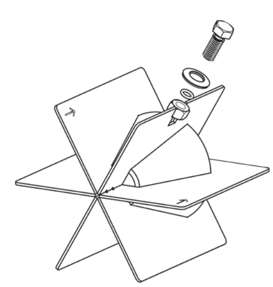
Special attention should be given to systems using two elbows "out of plane" or devices such as a centrifugal sand separator. These cause swirling flow in the line that affect propeller meters. Well developed swirls can travel up to 100 diameters downstream if unobstructed. Since most installations have less than 100 diameters to work with, straightening vanes become necessary to alleviate the problem. Straightening vanes will break up most swirls and ensure more accurate measurement. McCrometer actively encourages installing vanes just ahead of the meter. Straightening vanes are available in weld-in, bolt-in, and the FS100 Flow Straightener.



Elbows out of plane



Bolt-in straightening vanes



FS100 Flow Straightener

TOTALIZERS

Typical face plates

Standard register

Optional 7-wheel totalizer

FlowCom register

Mechanical Totalizer

The instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective vinyl liner. The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

Digital Totalizer

The optional FlowCom register displays a flowmeter's flowrate and volumetric total. Available are optional outputs: scaled pulse and/or industry standard 4-20mA signal. The FlowCom can be fitted to any new or existing McCrometer propeller flowmeter.

Wireless Telemetry

The optional FlowConnect is designed specifically for wireless telemetry via either satellite or cellular data service. Manual meter reading is never required. It uses either the mechanical register or the digital register (both shown above).

You can determine how often readings are made and transmitted to the cloud database, which you can view on a PC or on a cell phone. The viewing utility provides data tools that can analyze flow rate, consumption, and possible anomalies in an irrigation system.

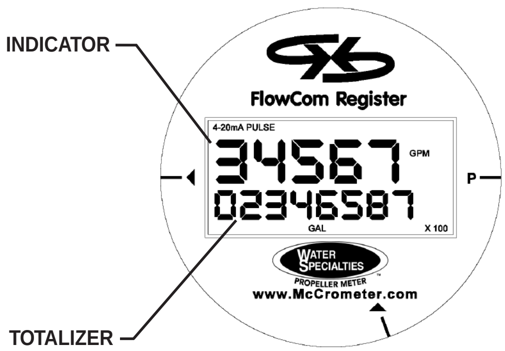
3255 WEST STETSON AVENUE • HEMET, CALIFORNIA 92545 USA
TEL: 951-652-6811 • 800-220-2279 • FAX: 951-652-3078
www.mccrometer.com

RD 1004 Water Specialties Propeller Meter

WATER SPECIALTIES PROPELLER METER™

MODEL OF12-D

OPEN FLOW METER
SOLID STATE ELECTRONIC PROPELLER METER
DIGITAL INDICATOR - TOTALIZER
SIZES 10" thru 72"



TYPICAL
DIGITAL INDICATOR-TOTALIZER

DESCRIPTION

MODEL OF12-D OPEN FLOW METERS are designed for accurate metering of ditch turnouts, reservoir outlets, closed conduits or other similar installations. The rigid, light weight construction and simple installation allow easy removal for winter storage or transfer to other locations. The upper mounting plate is equipped with a padlock hasp. The lower bracket has suitable guides for easy installation. An optional revolving mounting bracket, with padlock hasp, is also available. The revolving mounting bracket allows the meter assembly to be raised approximately 2 inches permitting the column to be rotated 180 degrees and easily withdrawn. The revolving mounting bracket is ideal when high velocity flow conditions exist. An optional remote mounting kit with up to 100 feet of cable is available to locate the indicator-totalizer at remote locations.

INSTALLATION can be made to any wall or vertical structure which will center the propeller in the flow measuring area. The meter location must have a controlled flow measuring area and a full flow of liquid for proper accuracy. Fully opened gate valves, fittings or other obstructions that tend to set up flow disturbances should be a minimum of ten pipe diameters upstream from the meter. Installations with less than ten pipe diameters of straight pipe require straightening vanes. Meters with straightening vanes require at least five pipe diameters upstream.

PROPELLER is magnetically coupled with the electronic sensor through the sealed gearbox. This completely eliminates water entering the meter assembly, and eliminates all moving parts except for the propeller. The propeller is a conical shaped three bladed propeller, injection molded of thermoplastic material resistant to normal water corrosion and deformity due to high flow velocities.

BEARING in propeller is a water lubricated ceramic sleeve and spindle bearing system with a ceramic/stainless steel spindle. Dual ceramic thrust bearings, standard on all meters, handle flows in both forward and reverse directions. The bearing design promotes extended periods of maintenance free propeller operation.

DIGITAL INDICATOR-TOTALIZER has a non-volatile EEPROM memory to store totalizer count (updated hourly while running). Features a large two line display. Five digit top line indicates flow rate, and eight digit bottom line provides volumetric flow data. Indicator is available in 22 different units, including GPM, CFS, MGD. Totalizer is available in 20 different units, including Gallons, AF, CF. Units of measurement are user-selectable. Battery life is 6 -10 years. Housing is NEMA 4X rated.

Available with optional 4-20mA and/or pulse output.

SPECIFICATIONS

ACCURACY Plus or minus 2% of actual flow within the range specified for each meter size.

TEMPERATURE RANGE 140° F Maximum. Consult factory for special construction for higher temperatures.

MINIMUM FLOWS As shown for each meter size and construction are required for accurate registration. See flow chart.

MAXIMUM FLOWS As shown for each meter size and construction are rated for continuous operation. See flow chart.

INTERMITTENT FLOWS As shown for each meter size are rated for 10% to 15% of the total time the meter is operating. Consult factory for High Velocity construction when intermittent flows are higher than shown on flow chart and/or when longer operating periods are required.

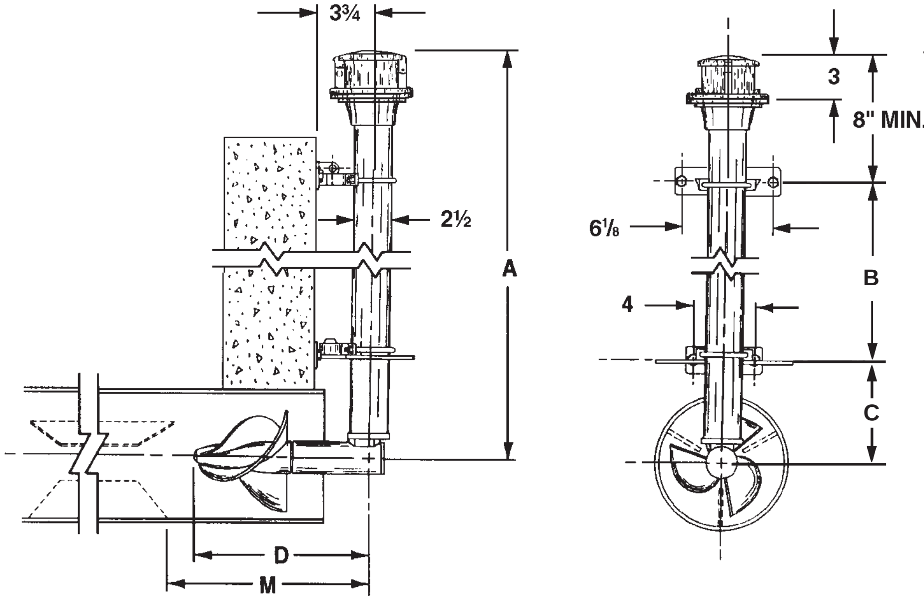
MATERIALS Used in construction are chosen to minimize the corrosive effects of the liquids measured by the meter assembly.
PROPELLER MAGNETS - permanent ceramic type
PROPELLER BEARING - ceramic sleeve type
PROPELLER SPINDLE - ceramic coated stainless steel
PROPELLER - injection molded thermoplastic
GEARBOX - stainless steel
SEPARATOR - stainless steel
BOLTS - stainless steel
DROP PIPE - bronze
METER HEAD - cast bronze
MOUNTING BRACKETS -cast bronze

OPTIONAL EQUIPMENT Includes a remote mounting kit with up to 100 feet of cable, digital transmitter, revolving mounting frame and a wide range of controls and instruments for indicating, totalizing and recording flow data for each meter. Special constructions and materials are available upon request.

ORDERING INFO Must be specified by the customer and includes:
- "A" dimension (see back of data sheet)
- Pipe I.D.
- Minimum & maximum flow ranges
- Temperature of meter environment
- Indicator scale and units
- Totalizer dial units
- Type of materials and construction
- Optional equipment desired

MODEL OF12-D

OPEN FLOW METER
SOLID STATE ELECTRONIC PROPELLER METER
DIGITAL INDICATOR-TOTALIZER
SIZES 10" thru 72"



METER & PIPE SIZE	FLOW RANGES,GPM			DIMENSIONS					SHIPPING WEIGHT POUNDS**
	MIN.	MAX.	INT.	A*	B	C	D	M	
10	300	2000	3000				11½	13½	80
12	400	3000	3500				11½	13½	80
14	500	4000	4500				11½	13½	80
16	600	5000	6000				11½	13½	80
18	800	6000	7500				11½	13½	80
20	900	8000	9000				11½	13½	80
24	1000	10000	13500				11½	13½	80
30	1800	15000	21000				11½	13½	80
36	2000	20000	30000				11½	13½	80
42	3000	30000	40000				11½	13½	80
48	5500	35000	50000				11½	13½	80
54	6500	45000	55000				11½	13½	200
60	7500	60000	80000				11½	13½	200
66	8500	75000	95000				11½	13½	200
72	9500	90000	115000				11½	13½	200

*** NOTE: Model OF12-D meters are equipped with a 6 foot "A" dim. unless otherwise specified.**

**** NOTE: Shipping weights are approximate. Actual weight depends upon "A" dim.**

McCROMETER
www.mccrometer.com

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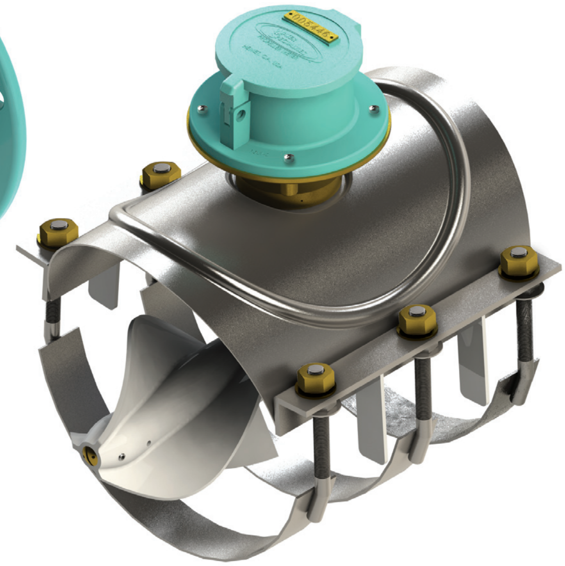
TEL: 951-652-6811 • FAX: 951-652-3078

RD 1004 Water Specialties Propeller Flow Meter

McCROMETER

Water Specialties Propeller Flow Meter™



Built to Last in the Harshest Conditions

WATER SPECIALTIES PROPELLER METER™

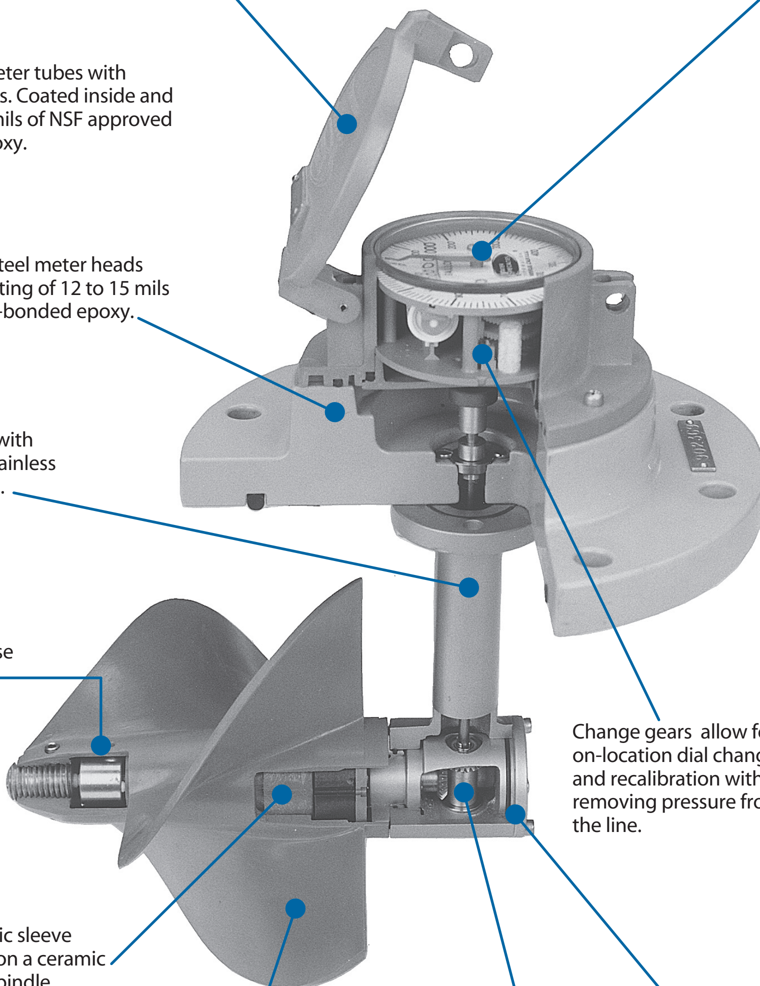
Injection molded thermoplastic bonnets. Hinged lid with padlock hasp to prevent unauthorized entry.

Fabricated steel meter tubes with straightening vanes. Coated inside and out with 12 to 15 mils of NSF approved fusion-bonded epoxy.

Cast iron or fabricated steel meter heads feature a protective coating of 12 to 15 mils of NSF approved fusion-bonded epoxy.

Stainless steel gearbox with removable one-piece stainless steel separator / spindle.

Long life ceramic dual thrust bearings handle both forward and reverse direction flow.



Change gears allow for on-location dial changes and recalibration without removing pressure from the line.

Water-lubricated ceramic sleeve propeller bearing rides on a ceramic sleeved stainless steel spindle.

Injection molded propeller designed to handle temperatures up to 140°F without pitch distortion. Also available for temperatures up to 250°F.

O-ring seals are used at the meter head and all other points where seals are required.

Oil-filled, stainless steel gearbox houses miter gears suspended between stainless steel ball bearings for smooth operation.

Six-Digit Flow Volume Totalizer

Standard**:** Six-digit flow volume totalizer. 3" diameter display with 100 division center sweep dial. Configurable in gallons, cubic feet, acre feet, or any standard liquid measuring units. Magnetic drive assures moisture tight seal. Available with optional 4-20mA and/or pulse output.

FlowCom Digital Indicator-Totalizer

Optional**:** FlowCom digital indicator-totalizer has a non-volatile memory. The five-digit indicator shows flow rate in 22 different units, including GPM, CFS, MGD. The eight-digit totalizer provides volumetric flow data and is available in 20 different units, including Gallons, AF, CF. Units of measurement are user-selectable. Battery life is 6-10 years. Housing is NEMA 4X rated. Available with optional 4-20mA and/or pulse output.

Indicator-Totalizer

Optional**:** Delivers instantaneous flow rate indication and totalization of flow volume. 4-inch diameter display with 250° dial, six-digit totalizer, and test sweep hand. Configurable in GPM, CFS, MGD or any standard liquid measuring units. Choice of standard totalizer measuring units. Available with optional 4-20mA and/or pulse output.

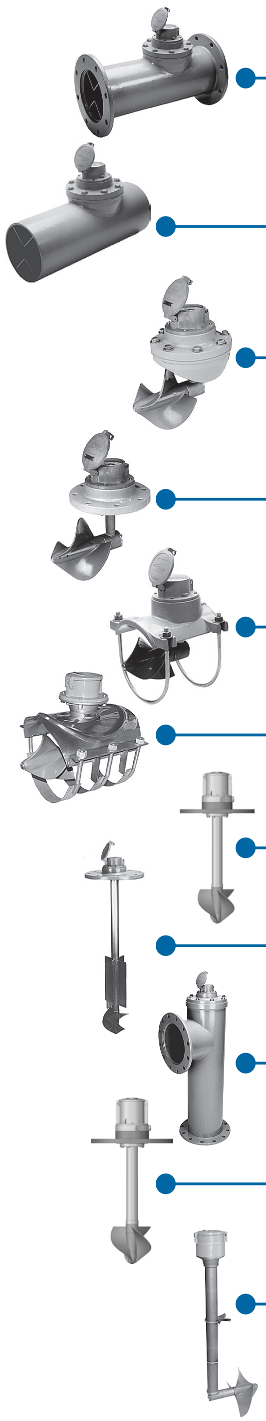
WATER SPECIALTIES PROPELLER METER™

The Water Specialties Propeller Meter is uniquely designed to meet the flow measurement needs of water and wastewater users.

Employed extensively in the water and wastewater industry, it has built a reputation for durability, reliability and high performance.

Our knowledgeable staff can assess your flow measurement application and help you find the best metering technology for your situation.

To find out more about our flow measurement products, or for a free flow evaluation, contact your nearest Water Specialties representative today or visit our website at www.mccrometer.com.



Size	Meter	MODEL NO.	PRESSURE RATING	STANDARD TOTALIZER	INDICATOR/ TOTALIZER	DIGITAL	INSTALLATION NOTES
2" - 48"	STEEL FLANGED-END TUBE METER	ML03	150 PSI	✔			
		ML04	150 PSI		✔		
		ML04D	150 PSI			✔	
		ML08D	300 PSI			✔	
3" - 48"	STEEL PLAIN-END TUBE METER	ML11	150 PSI	✔			●●
		ML12	150 PSI		✔		●●
		ML12D	150 PSI			✔	●●
4" - 72"	STEEL WELDING SADDLE METER	ML19	150 PSI	✔			●●●
		ML20	150 PSI		✔		●●●
		ML20D	150 PSI			✔	●●●
3" - 72"	METER HEAD ASSEMBLY	MLT1	150 PSI	✔			●
		MLI1	150 PSI		✔		●
		MLI1D	150 PSI			✔	●
		MLI2D	300 PSI			✔	●
4"	STRAP-ON SADDLE METER *DUCTILE IRON SADDLE*	LP22D	150 PSI			✔	●●●
6" - 20"	STRAP-ON SADDLE METER *STAINLESS STEEL SADDLE*	LP31	150 PSI	✔			●●●
		LP32	150 PSI		✔		●●●
		LP32D	150 PSI			✔	●●●
4" - 20"	VERTICAL UPFLOW METER	VF28D	150 PSI			✔	○
4" - 20"	VERTICAL DOWNFLOW METER	VF32D	150 PSI			✔	○
4" - 20"	VERTICAL UPFLOW TEE-TUBE METER	VF29	150 PSI	✔			○○
		VF30	150 PSI		✔		○○
		VF30D	150 PSI			✔	○○
10" - 72"	VERTICAL METER HEAD ASSEMBLY	VFT1	150 PSI	✔			
		VFI1	150 PSI		✔		
		VFI1D	150 PSI			✔	
10" - 72"	OPEN FLOW METER	OF12D	150 PSI			✔	○○○

Blue shaded model numbers are standard totalizer options.
Replacement meter heads available for other brands of meters.
Consult factory for special pressure ratings or materials of construction.

Installation notes

● Meters bolt into existing Water Specialties saddles or meter tubes.

●● Installation is made by using one of many types of pipe couplings available or by welding to adjoining pipe.

●●● Installation is made by cutting a hole in the existing pipe and then attaching meter securely to the line.

○ Installation is made to an appropriate cast iron or fabricated tee. Replace an elbow in existing systems, such as on the suction side of a centrifugal pump or laterals in irrigation systems.

○○ Installation is made to any vertical discharge line with the proper size flange connection, or to vertical discharge concrete turnouts with proper anchor bolts.

○○○ Installation is made to any wall or vertical structure which will center the propeller in the measuring area. For use in ditch turnouts, reservoir outlets, closed conduits, or other similar installations that have a controlled flow measuring area and full flow of liquid.

FLOWCOM: YOUR DIGITAL REGISTER SOLUTION

Specially designed LCD display can be read in bright sunlight and will not be damaged by prolonged exposure to sunlight. The indicator-totalizer is encapsulated in a moisture resistant barrier so no moisture can come in contact with the electronic components. This solid state design offers extended life.

Long Life Battery

The battery has a 6 to 10 year lifespan.

Transmitter Optional Outputs

- AMI compatible output
- 4-20mA
- Pulse output
- Contact closure

Memory

The non-volatile memory retains the totalizer quantity and programming.

Easy Installation

The electronic meters can be installed vertically, horizontally, or inclined.

In-field Conversion Kits

Water Specialties mechanical propeller meters can be converted to electronic propeller meters in the field.

McCrometer's Expertise in Flow Physics

A Leader in Flow Metering Solutions

Our application engineers, researchers, and designers apply their expertise in real-world fluid dynamics to continuously improve our innovative flow metering solutions. Instrument, process, facility, and consulting engineers worldwide have confidently chosen McCrometer's flow meters for over 60 years.

Committed to Quality Manufacturing in the USA

McCrometer prides itself on the fact that all Water Specialties flow meters are designed, manufactured, and tested in the USA. Manufacturing takes place in our headquarters in Hemet, California and we own and operate one of the world's largest volumetric test facilities in Porterville, California. Our manufacturing facilities and quality control systems are the foundation for being a trusted supplier. Our USA based, high quality manufacturing is another reason our customers around the world have confidently chosen McCrometer flow meters for their most challenging flow applications since 1955.

McCROMETER

www.mccrometer.com

Corporate Headquarters:
3255 West Stetson Avenue | Hemet | CA 92545 | U.S.A.
Phone: 800-220-2279 | 951-652-6811 | Fax: 951-652-3078

Lit# 30100-02 | Rev 2.7 | 8-11-17

Attachment D
Sample Bills

Anderson-Cottonwood Irrigation District (ACID)

(Not required.)

Glenn-Colusa Irrigation District (GCID)

Glenn-Colusa Irrigation District
Post Office Box 150
Willows, California 95988
530.934.8881

INVOICE

Date: 4/28/2020
Invoice #: 20 17924

Blue Fire Farms
P.O. Box 819
Williams, CA 95987

Remit Payment To:
Glenn-Colusa Irrigation District
P.O. Box 150
Willows, CA 95988

Description	Units	Rate	Amount
Water Purchase	381.70	20.80	$7,939.36
Payment on Inv # 20 17924			($3,175.74)
Payment on Inv # 20 17924			($2,381.81)
Payment on Inv # 20 17924			($2,381.81)

Invoice Total:	$7,939.36
Payments:	$7,939.36
Balance:	$0.00

- < Cut Along Here > -

To ensure your payment is posted properly, Please return this portion with your payment.

Invoice #: 20 17924 **Customer:** Blue Fire Farms **Total:** $0.00
Acct: BLUE 30000

Provident Irrigation District (PID)

Provident Irrigation

258 S. Butte St.
Willows, CA 95988

Invoice

DATE	INVOICE #
11/24/2020	2924

BILL TO
ABC Company PO Box 123 Willows, CA 95988

P.O. NO.	TERMS	PROJECT

DESCRIPTION	QTY	RATE	AMOUNT
Rice Water 2020	20	90.00	1,800.00

Total	$1,800.00
Payments/Credits	$0.00
Balance Due	$1,800.00

Princeton-Codora-Glenn Irrigation District (PCGID)

Princeton-Codora-Glenn Irrigation District

PO Box 98
Princeton, CA 95970

Invoice

Date	Invoice #
11/24/2020	14863

Bill To
ABC Company PO Box 123 Willow, CA 95988

P.O. No.	Terms	Project

Quantity	Description	Rate	Amount
20	Rice Water 2020	120.00	2,400.00
		Total	$2,400.00

Reclamation District No. 108 (RD 108)

Reclamation District Number 108
975 Wilson Bend Rd
P.O. Box 50
Grimes, CA 95950
Ph: 530.437.2221 Fx: 530.437.2248 www.rd108.org

Invoice Number:	2020 - .(Year - InvoiceID)	**Invoice Name:**	2020 Irrigation (Adopted 2020)
Customer:		**Invoice Date:**	10/19/2020
		Volume Period:	3/1/2020 - 9/30/2020
		Volume Finalized:	Yes

Balance Summary * (1201 ac; 7192.9 af)

Item	Amount
Total Charges	$119,903.50
Total Payments	($67,886.50)
Balance	**$52,017.00**

Notes:
* Amounts shown in parentheses represent credits.
** Blank Payment and Adjustment Summaries mean that no Payments and/or Adjustments have been made.

Charge Summary

Charge Component	Amount
Volumetric Charge	$107,893.50

Payment Summary **

PayDate	PayNum	PayAmount	Comments

Adjustment Summary **

Invoice Number: 2020 - (Year - InvoiceID)
Customer:

Invoice Name: 2020 Irrigation (Adopted 2020)
Invoice Date: 10/19/2020
Volume Period: 3/1/2020 - 9/30/2020
Volume Finalized: Yes

Field Details *

FieldID	Crop Name	Acre-age	Percent Farmed	Acreage Rate ($/ac)	Acreage Charge ($)	Crop Rate ($/ac)	Crop Charge ($)	Vol Rate Adj	Vol Rate ($/af)	Volume Deliver-ed (af)	Duty (af/ac)	Volume Charge ($)	Field Charge ($)
	Rice	81	100.0%	$10.00	$810.00	$0.00	$0.00	0	$15.00	590.4	7.29	$8,856.00	$9,666.00
	Rice	75	100.0%	$10.00	$750.00	$0.00	$0.00	0	$15.00	546.6	7.29	$8,199.00	$8,949.00
	Rice	70	100.0%	$10.00	$700.00	$0.00	$0.00	0	$15.00	341.5	4.88	$5,122.50	$5,822.50
	Rice	74	100.0%	$10.00	$740.00	$0.00	$0.00	0	$15.00	361	4.88	$5,415.00	$6,155.00
	Rice	126	100.0%	$10.00	$1,260.00	$0.00	$0.00	0	$15.00	851.4	6.76	$12,771.00	$14,031.00
	Rice	230	100.0%	$10.00	$2,300.00	$0.00	$0.00	0	$15.00	1231.9	5.36	$18,478.50	$20,778.50
	Rice	220	100.0%	$10.00	$2,200.00	$0.00	$0.00	0	$15.00	1178.3	5.36	$17,674.50	$19,874.50
	Rice	325	100.0%	$10.00	$3,250.00	$0.00	$0.00	0	$15.00	2091.8	6.44	$31,377.00	$34,627.00
Total Acres Farmed **--->		**1201**					**Total Volume Delivered (af) -->**			**7192.9**			

Notes:
* In cases where one Turnout serves two or more fields, the Volume Delivered measured at the Turnout is apportioned to individual fields based on irrigated acreage. Consequently, individual field Volume Delivered quantities may be different than actual quantities.
** Acres Farmed only includes primary crop and excludes subsequent crops, non-irrigated crops, and idle lands.

Abbreviations: ac - acre; af - acre-feet; ft - feet

Reclamation District No. 1004 (RD 1004)

11/23/20

Reclamation District No. 1004
134 5th Street
Colusa, CA 95932

Water Use Statement

Barale Ranch LLC
P O Box 935
Alamo, Ca
94507

Meter Reading Date: 11/23/20

Field #	Beginning Meter Reading	Current Meter Reading	Y-T-D Adjustments	Total Acre Feet Used	Water Charges	Water Deposits	Deposit Balance or (Amount Owed)
155	0	176	0	176	$3,432.00	$4,208.10	$776.10
158	0	332	0	332	$6,474.00	$6,002.10	($471.90)
160	0	217	0	217	$4,231.50	$6,430.14	$2,198.64
161	0	0	0	0	$0.00	$783.90	$783.90
162	0	0	0	0	$0.00	$1,220.70	$1,220.70
			Total Balance:	725	$14,137.50	$18,644.94	$4,507.44

Meridian Farms Water Company (MFWC)

Meridian Farms Water Company

PO Box 187
Meridian, CA 95957

INVOICE

DATE	INVOICE #
10/20/2020	9301

BILL TO
A-Z Farming

Phone #	Fax #	E-mail	TERMS	DUE DATE
530-696-2456	530-696-2551	aduffey@succeed.net		10/20/2020

QUANTITY	DESCRIPTION	RATE	SERVICED	AMOUNT
210	Water Demand on 35 Acres of Rice, Field Z, 3rd install	9.33		1,959.30

Due in 30 days, add 1 1/2% (18% annual) to late payments.

Total	$1,959.30
Payments/Credits	$0.00
Balance Due	$1,959.30

Sutter Mutual Water Company (SMWC)

RECLAMATION DISTRICT 1500

CA 95676

Invoice

Date	Invoice #
12/7/2020	39

Bill To
Sutter Mutual Water Company.

P.O. No.	Terms	Project
	Net 30	

Quantity	Description	Rate	Amount
1	Diesel Fuel	100.00	100.00
	SAMPLE BILLING		

Thank you for your business.	**Total**	$100.00

SUTTER MUTUAL WATER COMPANY
PO BOX 128
ROBBINS, CA 95676

Phone 530-738-4423

Invoice

Date 12/7/2020
Invoice # 52

Bill To
Customer

Due Date	Delinquent
12/7/2020	

Description	Qty	Rate	Amount
DIESEL FUEL	1	100.00	100.00
SAMPLE BILLING			

Total	$100.00
Pymnts/Credits	$0.00
Balance Due	$100.00

Thank you for your business.

Natomas Central Mutual Water Company (NCMWC)

Natomas Central Mutual
Water Company

2601 West Elkhorn Blvd.
Rio Linda, CA 95673

(916) 419-5936
(916) 419-8691 FAX

INVOICE

D-200047

DATE

10/22/2020

SHAREHOLDER/OWNER:

Account No.	TERMS: DELINQUENT CHARGES 18% 30 DAYS AFTER DATE OF INVOICE

Field	Crop	Description	Acres	Ac/Ft	Rate	Amount
		SAMPLE BILL				
S005	Tomatoes	Water Delivered to Tomato Crop	12	12	9.06	108.72
S006	Tomatoes	Water Delivered to Tomato Crop	8	8	9.06	72.48
S007	Beans	Water Delivered to Bean Crop	15	11	9.06	99.66
S073	Beans	Water Delivered to Bean Crop	10	7.33	9.06	66.41
S013	Beans	Water Delivered to Bean Crop	15	11	9.06	99.66
S013	Truck F...	Water Delivered to Kale Crop	3	2.2	9.06	19.93
S093	Beans	Water Delivered to Bean Crop	36	26.4	9.06	239.18
S042	Sunflo...	Water Delivered to Sunflower Crop **DRAIN**	43	20.76	9.06	188.09
S046	Beans	Water Delivered to Bean Crop	33	24.2	9.06	219.25
S118	Tomatoes	Water Delivered to Tomato Crop	8	8	9.06	72.48
S070	Tomatoes	Water Delivered to Tomato Crop **DRAIN**	35	35	9.06	317.10
S008	Milo	Water Delivered to Milo Crop	9	7.8	9.06	70.67
S010	Milo	Water Delivered to Milo Crop	52	45.07	9.06	408.33
S046	Truck F...	Water Delivered to Vine Seed	17	37.4	9.06	338.84
S077	Truck F...	Water Delivered to Vine Seed	9	19.8	9.06	179.39

TOTAL $2,500.19

Attachment E
Water Shortage Plans

Anderson-Cottonwood Irrigation District (ACID)

(ACID does not have a water shortage plan.)

Anderson-Cottonwood Irrigation District

Rotation and apportionment:

Rule 9 of Anderson-Cottonwood Irrigation District Rules and Regulations states: Water will be furnished in rotation to each irrigator. Ditchtenders will endeavor to give advance notice, personally or through others, to irrigators of the approximate time their rotation will start. Any irrigator not taking water when his turn arrives may forfeit his right during that rotation. In the event of shortages, the District will endeavor to equitably apportion the available water supply.

Glenn-Colusa Irrigation District (GCID)

Critical Year Excerpt from the Water Management and Conservation Policy Adopted January 23, 2014

V. WATER MANAGEMENT AND CONSERVATION RULES IN WATER SHORTAGE YEARS (25% REDUCTION IN WATER SUPPLY)

In the event of a "Shasta Critical" water supply designation or in years in which the Board concludes that the District's water supply will be inadequate to provide water in a quantity furnished in years of average precipitation, the District will implement the following alternatives and actions to supplement and maximize water supplies available to the landowners and water users of the District in accordance with the District's *Rules and Regulations.*

The following critical water year conservation measures will be strictly adhered to from April 1 to October 31:

1) Rice:

a) Field spillage:
- Field spillage will be allowed through a notched weir board with a board on top from April 1 to July 1.
- No field spillage will be allowed from July 1 to the end of the irrigation season.

b) Field drainage:
- 1 field drainage and re-flood will be allowed between April 1 and July 1.
- Delivery of water must be terminated at least 7 days prior to end of season draining.

c) Upon receiving a verifiable Pest Control Advisor (PCA) recommendation, field drainage and re-flooding will be allowed to alleviate crop stress. If deemed necessary, GCID will conduct water sample tests to confirm sample readings.

d) Water depth in flooded rice fields must not exceed 6 inches at the high point of a field.

e) Water orders:

- Water delivery orders for all changes in field delivery flow must be placed with the water operator by 1 p.m. the day prior to water delivery.
- Water orders for field drainage must be placed with the water operator 24 hours in advance of draining a field.

f) Water must be effectively managed to maintain water elevation, minimize water depth fluctuations, and prevent waste of water.

2) <u>Other Crops and Water Uses</u>:

a) Provided that all crop water needs have been satisfied and there is remaining supply, some water may be available for non-crop water uses including rice straw decomposition and duck ponds prior to October 31, but there is no guarantee. Water users wishing to guarantee a supply of water for fall non-crop use, should purchase a sufficient quantity of apportioned water for those uses prior to the primary apportionment deadline.

b) Water must be effectively managed to prevent excessive field runoff and waste of water. This includes flood irrigated orchards, alfalfa, pastures and row crops.

c) The number of irrigations to alfalfa and irrigated pastures will be limited during the months of April through October. The District will establish the number of irrigations available based upon the water supply allocation the District receives pursuant to its contract with Reclamation.

VI. WATER MANAGEMENT AND CONSERVATION RULES IN EXTREME WATER SHORTAGE YEARS (GREATER THAN 25% REDUCTION IN WATER SUPPLY)

In the event of a "Shasta Critical" water supply designation that results in an allocation of less than 75%, the District will implement the following alternatives and actions to supplement and maximize water supplies available to the landowners and water users of the District in accordance with the District's *Rules and Regulations.*

The following extreme critical water year conservation measures will be strictly adhered to from April 1 to October 31:

EXHIBIT C

1) Rice:

a) Field spillage:
- No field spillage will be allowed from the date the rice is flooded until the end of the irrigation season. Tail boxes are required to be sealed with either plastic or a soil berm.

b) Field drainage:
- Delivery of water must be terminated at least 7 to 14 days prior to end of season draining.

c) Additional drainage:
- Upon receiving a verifiable Pest Control Advisor (PCA) recommendation, field drainage and re-flooding will only be allowed in order to alleviate crop stress due to poor water quality. If deemed necessary, GCID will conduct water sample tests to confirm sample readings.

d) Water depth in flooded rice fields must not exceed 6 inches at the high point of a field for the entire season.

e) Water orders:
- Water delivery orders for all changes in field delivery flow must be placed with the water operator by 1 p.m. the day prior to water delivery.
- Water orders for field drainage under VI. 1) b) above must be placed with the water operator 24 hours in advance of draining a field.

f) Water must be effectively managed to maintain water elevation, minimize water depth fluctuations, and prevent waste of water.

2) Other Crops and Water Uses:

a) Provided that all crop water needs have been satisfied and there is remaining supply, some water may be available for non-crop water uses including rice straw decomposition and duck ponds prior to October 31, but there is no guarantee. Water users wishing to guarantee a supply of water for fall non-crop use, should purchase a sufficient quantity of apportioned water for those uses prior to the primary apportionment deadline.

b) Water must be effectively managed to prevent excessive field runoff and waste of water. This includes flood irrigated orchards, alfalfa, pastures and row crops.

c) The number of irrigations to alfalfa and irrigated pastures will be limited during the months of April through October. The District will establish the number of irrigations available based upon the water supply allocation the District receives pursuant to its contract with Reclamation.

Provident Irrigation District (PID)

(PID does not have a water shortage plan.)

Provident Irrigation District

Shortage of water:

Rule 13 of Provident Irrigation District Rules and Regulations states: When, through lack of water, lack of ditch capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof the full supply of water required by the water users, such supply as can be delivered will be equitably pro-rated until such time as delivery of a full supply can be given. A pro-rata delivery means a simultaneous flow available at a point nearest the District system for the use of each and every landowner or water user in as nearly an exact proportion as can be determined of the total amount available or that can be delivered, based on the individual's right to receive water as fixed by acreage, crop to be irrigated, ditch capacity, or otherwise. The method may be applied to all, or a part of the system.

Princeton-Codora-Glenn Irrigation District (PCGID)

(PCGID does not have a water shortage plan.)

Princeton-Codora-Glenn Irrigation District

Shortage of water:

Rule 13 of Princeton-Codora-Glenn Irrigation District Rules and Regulations states:

When, through lack of water, lack of ditch capacity, or for any other reason, it is not possible to deliver throughout the District or any portion thereof the full supply of water required by the water users, such supply as can be delivered will be equitably pro-rated until such time as delivery of a full supply can be given. A pro-rata delivery means a simultaneous flow available at a point nearest the District system for the use of each and every landowner or water user in as nearly an exact proportion as can be determined of the total amount available or that can be delivered, based on the individual's right to receive water as fixed by acreage, crop to be irrigated, ditch capacity, or otherwise. The method may be applied to all, or a part of the system.

Reclamation District No. 108 (RD 108)

(RD 108 does not have a water shortage plan.)

Reclamation District 108

Shortage of water:

Rule 7 of Reclamation District 108 Rules and Regulations states: Whenever a general shortage of water appears imminent, the Board of Trustees shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary, local or similar shortages, the Manager is authorized to place in effect such variations in service as in his judgement the occasions requires.

Reclamation District No. 1004 (RD 1004)

Reclamation District 1004

Shortage of water:

Reclamation District 1004 Rules and Regulations state: Whenever a general shortage of water appears imminent, the Board of Trustees shall so find by resolution duly passed and recorded in its minutes. The resolution shall incorporate special rules and regulations to cover the distribution of the available water supply during the period of the shortage. In the event of temporary, local or similar shortages, the Manager is authorized to place in effect such variations in service as in his judgment the occasions requires

Meridian Farms Water Company (MFWC)

WATER ALLOCATION POLICY
FOR WATER YEAR 2020

Meridian Farms Water Company (MFWC) Sacramento River Settlement Contract (SRSC) with the United States Bureau of Reclamation (Reclamation) allows for the annual diversion of up to 35,000 acre-feet of Base Supply and Project Water as defined under the SRSC. Under the terms of MFWC SRSC, in Shasta Critical years (generally defined as years in which the annual unimpaired inflow into Shasta Lake is less than 3.2 million acre-feet), MFWC's supply is reduced by 25% to 26,250 acre-feet. Although there is no precedent for reducing the SRSC supply below 75%; Reclamation has announced an initial allocation for the 2020 water year of 40%. If the final SRSC remains at 40%, a procedure is required to reduce MFWC demand to align with the decreased supply.

MFWC adopted the following Water Allocation Policy for Water Year 2020 in order to maximize the use of available water in a fair and reasonable method to its water users. Based upon the foregoing, MFWCs policy for the allocation of water during the 2020 water year is as follows:

A. <u>Establishment of Annual Water Requirements for Crops</u>
Applied water unit duties are established for the water use of each crop type grown in MFWC and are attached in Exhibit A.

B. <u>Primary Allocation of Available Supply</u>
MFWC will estimate the total water supply available for the irrigation season by taking the SRSC contract supply less any shortages, adding available District groundwater pumping, and then deducting a 20% buffer quantity. This calculated volume of water will be the amount the District will apportion on a pro rata basis to irrigable District lands. Irrigable District land acreages are defined for each field on the attached Exhibit B.

C. <u>Primary Allocations</u>
MFWC landowners or their authorized agent may contract for any of their primary allocations using the attached Contract/Assignment Form (Exhibit C). Any water contracted by a landowner or their authorized agent which is not used will be charged.

D. <u>Assignment of Right</u>
Allocations to landowners may be assigned to others, in whole or in part, for use within the District using the Contract/Assignment Form (Exhibit C). Any water assigned to a water user or their authorized agent which is not used will be charged at MFWC price per acre rate for the unused allocation.

E. Secondary Allocation

A secondary allocation will be made for any water that is not contracted or assigned by the deadline for primary allocations. The remaining water will be apportioned on a pro-rata basis to all landowners that (1) fully contracted their primary allocation and (2) indicated on their Water Contract/Allocation Form (Exhibit C) a desire to receive a secondary allocation should it be available.

F. Water Application Process

Water users or their authorized agent possessing contracted or assigned allocation supplies will file a Water Budget Form, attached as Exhibit D. The Water Budget Form shall indicate the total available supply contracted or assigned to the water user and summarize the total demand, including: field number(s), acreage(s), and applied water unit duty(ies). To be able to maximize the acreage irrigated in the District, fields may be split into smaller sizes than listed in Exhibit B. Split fields acreages shall be verified by District staff before delivery of water. The remaining portion of a split field may irrigated from non-MFWC water (ex. Groundwater), or fallowed. Crop unit duties are established by the District in Exhibit A.

G. District Groundwater Wells

MFWC owns a number of groundwater wells that can be used to supplement the MFWC water supply. The District will take any necessary steps in order for the wells to be used within the District for water year 2020.

H. Commingling of Groundwater - Private Wells

In order to facilitate the ability of MFWC water users with access to private wells to use their well water to irrigate additional MFWC lands during the 2020 Water Year, MFWC will facilitate the commingling of private well water with MFWC surface water subject to environmental restrictions and operational considerations. Groundwater wells used to supplement MFWC supplies are required to have properly installed and calibrated flow meters. The amount of supply credited to the water user from the groundwater well will be determined by District staff.

I. Wheeling of Groundwater – Private Wells

Water users with private wells that request to utilize the MFWC's conveyance facilities to move their groundwater from one location within MFWC to another may do so subject to environmental restrictions, operational considerations, and conveyance capacity. Groundwater wells which use MFWC facilities to convey water are required to have properly installed and calibrated flow meters.

Sutter Mutual Water Company (SMWC)

SUTTER MUTUAL WATER COMPANY
P.O. BOX 128
ROBBINS, CALIFORNIA 95676
(530) 738-4423
FAX (530) 738-4327

IMPORTANT NOTICE

To: **Landowners and Water Users**
From: **Brad Mattson, Jon Scott**
Subject: **2021 Supply Curtailment Planning**
Date: **January 12, 2021**

Sutter Mutual Water Company (SMWC) is now planning for a "Shasta Critical Year" designation from the Bureau of Reclamation in February. This will result in our available water supply being reduced by 25%. If weather conditions stay dry, we expect increased legal and regulatory pressure on our diversion timing and quantity. If you have not already done so, I would also encourage each of you to speak to your crop insurance agent about preventive planting insurance.

Sutter Mutual Water Company is requiring you to provide a cropping map that adheres to the **3.85 AF/Acre allocation.** A copy of last years crop worksheet has been provided to assist you in this effort. RRA acres that are on this sheet will be the number that is used for setting your allocation. The associated crop unit duty (see Attached) will be used to determine if you are following the requirements of the drought policy. There will be a turnback pool in which water that is not needed will be turned back to SMWC and re allocated on a per acre basis. Water will not be allowed to be moved between operations. The company has always recognized combined farming operations for the purpose of pooling water supplies. (An operation is governed by a single operating entity. I.e.: Partnership, Corporation, etc.) No water will be delivered until these maps have been approved and signed by the grower/operator and by Sutter Mutual Water Company management.

If you are planning on pre-irrigation, we request you to develop a plan and coordinate with us to ensure that we can accommodate your needs in March. We need to ensure all pre-irrigation is completed before April as we anticipate a very early start to the regular irrigation season.

As a first step in dealing with a short water year in 2021, we want to advise you of the following important items:

1. All users will need to submit cropping maps for company water delivery for the coming cropping and irrigation season.by **February 12th, 2021**.

2. The Company's contemplated water availability and delivery plan for 2021 in a water short year assumes a 25% cut-back in the Company's water contract supply. In this event, water supply will be limited to 3.85 AF/Acre.
   a. All acres used will be RRA acres that are on file with the company and used in the crop worksheets.
   b. Crop unit duty values will be used for determining water use.

3. With the above information and assumptions and for the Company to be able to effectively perform meaningful water and operations planning, the Board of Directors and management **requests that you provide your CROPPING PLANS for 2021**. **Including any prevented planting intentions. It is essential you comply with this request by providing the office a copy of your CROP MAP as soon as possible, but not later than FEBRUARY 12th, 2021. Call the office at (530) 738-4423 with your information. You can also email the information to Heather@sutterbasinwater.com**

The Board and Management thank you for your cooperation and understanding in working with us at this time as, we plan for what is shaping into a challenging year for all concerned.

Lastly, for us to deliver project water to your lands, RRA forms are required to be on file at our office. Please contact the office to schedule your RRA appointment with Denise.

Sincerely,

Brad Mattson
General Manager

SUTTER MUTUAL WATER COMPANY
2021 CROP UNIT DUTY LIST

Crop	Acre Feet Per Acre
Rice and Wild Rice	5.50
Tomatoes	2.65
Alfalfa	3.75
Corn	3.75
Sudan	2.50
Milo	1.85
Pre-irrigation	1.00
Wheat	1.25
Safflower	1.00
Sunflower	1.00
Vine seed	2.44
Melons	1.00
Pumpkins	2.00
Walnuts	2.51
Pasture	2.50
Beans	2.75
Garbanzo Beans	1.00
Onions	2.50
Carrots	2.81
Duck/Rice Decomp	1.50

Natomas Central Mutual Water Company (NCMWC)

NCMWC Water Shortage Plan

The NCMWC Board of Directors annually reviews the Company water supply and other environmental conditions to determine the available water and landowner allocation. After review, the Board may determine that a water shortage condition exists due to drought or other system restrictions. When the Board determines a water shortage will occur, the Board will implement the following Water Shortage Plan. Based on the conditions, the Board may choose to modify the Plan as conditions require.

1. When the Board implements the Water Shortage Plan, water allocations will be determined based on landowner submitted crop planting plans. To determine the allocations the Board will take the following steps:
    a. The NCMWC will request landowners to submit planned crop planting plan.
    b. The Board of Directors will review the cropping plans along with available water supply to determine an AF/Acre allocation.
    c. Landowners will then be required to submit their final crop planting plan along with a water transfer and well usage plan.
    d. Anticipated field crop water needs must be met by water allocation and Transfer/Well Usage Plan for the Board to accept the final crop planting plan.
2. Transfers
    a. Transfers are allowed from one field to another if owned by same shareholder.
    b. Transfers are allowed between fields if they are farmed by the same operation and agreed to by landowners.
3. Wells
    a. Transportation of well water will be allowed in the Natomas Water System. Wells are required to be metered and meters read weekly.
    b. Well owner will pay transport fees to pump water to delivery point.
    c. If system capacity constraints exist, well water will take second priority for delivery.

Attachment F
Groundwater Management Plans

The Sustainable Groundwater Management Act (SGMA) requires appropriate agencies and water interests with groundwater basins designated as high or medium priority across the state to develop and implement a Groundwater Sustainability Plan (GSP) by January 31, 2022, and to achieve sustainability within 20 years (2042).

All participating Sacramento River Settlement Contractors are currently working with local counties, districts, and other stakeholders within their respective areas as part of developing and drafting GSPs and will have completed plans by the required January 31, 2022 date.

Attachment G
Groundwater Banking Plan

(None of the participating SRSCs participate in a groundwater banking plan.)

Attachment H
Placeholder – not used

Attachment I
Notices of District Education Programs Available to Customers

Regional Water User Resources

Sacramento River Settlement Contractors (SRSC) work collaboratively across the watershed to optimize resources and enhance sustainability of the resources for all users while maintaining water rights for their members. Nine SRSC members produce regional water management plans to meet their Federal contracting requirements. As part of this effort, the group maintains this page to provide water users with additional resources to meet their combined agricultural and ecological goals. The nine SRSC members that collaborate on this resource page include

Glenn-Colusa Irrigation District
Reclamation District No. 108
Sutter Mutual Water Company
Natomas Mutual Water Company
Provident Irrigation District
Princeton-Codora Glenn Irrigation District
Anderson-Cottonwood Irrigation District
Reclamation District No. 1004
Meridian Farms Water Company

On farm evaluations, irrigation scheduling, crop ET information, efficient water management resources, pump efficiency testing and evaluation

http://www.itrc.org/projects/evals.htm
https://cimis.water.ca.gov/
http://www.wateright.net/
https://norcalwater.org/efficient-water-management/
http://www.pumpefficiency.org/
https://www.fresnostate.edu/jcast/cit/goods/testing.html

Surface, ground, and drainage water quantity and quality data

https://cdec.water.ca.gov/
https://www.svwqc.org/
https://waterdata.usgs.gov/nwis
https://www.casgem.water.ca.gov/OSS/(S(1jbz0iua5nkk3ikdcpbkeqms))/Default.aspx?ReturnUrl=/oss
https://wdl.water.ca.gov/
https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels
https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
https://data.cnra.ca.gov/

Education and training programs

https://www.watereducation.org/programs
http://www.itrc.org/projects/education.htm
http://www.itrc.org/classes.htm
https://www.csuchico.edu/ag/university-farm/itf/classes.shtml

PO Box 150, Willows, CA 95988

SACRAMENTO RIVER SETTLEMENT CONTRACTORS

Contractor website updates

Funding opportunities and financial assistance

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/?cid=stelprdb1048817
https://www.usbr.gov/watersmart/weeg/
https://water.ca.gov/Work-With-Us/Grants-And-Loans
https://www.grants.ca.gov/
https://www.usda.gov/topics/organic/financial-resources-farmers-and-ranchers
http://www.pumpefficiency.org/

PO Box 150, Willows, CA 95988

Attachment J
Water Order Form

Anderson-Cottonwood Irrigation District (ACID)

(Not required.)

Glenn-Colusa Irrigation District (GCID)

2020 WATER APPLICATION INSTRUCTIONS

WATER APPLICATION INSTRUCTIONS

1. Parcel number assigned by the District. This number plus the field number (see #7 below), identifies the exact field location.

2. Please indicate who will be paying the invoice for the water application (landowner or tenant).

3. Landowner's name and address. Please check for accuracy. If the parcel has changed ownership or the address is incorrect, please notify the District office and make any necessary corrections on the form.

4. If there is a tenant, please provide their name and address. The District office will enter the tenant account number when the application is processed.

5. Deeded acres for this parcel.

6. Identifies the District Water Operator who services the field.

7. Growers wishing to assign their own unique field identification should enter it here. You may use up to twenty (20) letters and/or numbers (including spaces) in any combination. The District will add this identification to its database.

8. Field number assigned by the District.

9. Number of irrigable acres for the fields based on District air photos. If there has been a physical change, please notify the District office.

10. Please enter the actual number of acres that you intend to irrigate.

11. Type of crop you are applying for. If you are "splitting" a field, write one above the other in this block. (See field #6 on the sample application.)

12. Corresponding Applied Water Unit Duty of the crop you are applying for (see enclosed "2020 Applied Water Unit Duties for Summer and Winter Crops").

13. The total acre-feet of water the crops will use (multiply Applied Acres by Unit Duty).

GCID
Glenn-Colusa Irrigation District
Post Office Box 150
Willows, California 95988
530.934.8881

2020 WATER APPLICATION

Acct: TSL C 30000

(1) Parcel #: 16 3 02 F

(2) Payor ( )

TSL Company

(3) P.O. Box 150

Willows, CA 95988

(2) Payor (X)

Tenant Acct:

Tabbie S. Lichinsen

(4) 344 East Laurel Street

Willows, CA 95988

(5) Deeded Acres 205.69

6 WO	7 Field Name	8 Field	9 Irrigable Acres	10 Applied Acres	11 Crop	12 Unit Duty	13 Acre Feet
26	TSL	1	68.00	0.00	Pasture	4.9	-
26	Eucalyptus	2	38.10	25.10	Rice	5.5	138.05
26	Trees	3	61.10	61.10	Walnuts	4.4	268.84
26	North 80	4	88.80	68.80	Tomatoes Drip	1.7	116.96
26	Tabbie Two	5	34.90	34.90	Rice	5.5	191.95
26	South 40	6	38.50	20.30	Corn - Silage	4.3	87.29
				18.20	Sunflower	2.2	40.04
		Total Acres:	329.40	228.40	Total Acre Feet Applied:		843.13

WATER APPLICATION WORKSHEET

The Water Application Worksheet should be used to determine the total water demand for all parcels, fields and crops being planted for the 2020 water season, and to make sure that the total water demand does not exceed the total supply from all sources.

1. Customer name.
2. Customer account number.
3. Total acre-feet of water from all sources.
4. Parcel number assigned by the District.
5. Field number assigned by the District.
6. Crop to be irrigated.
7. Actual number of acres to be irrigated.
8. Applied water unit duty (AF/acre) for crop(s) being irrigated.
9. Total water demand (AF) needed to irrigate each crop.
10. Total number of acres to be irrigated.
11. Total water demand for all crops listed to be irrigated. Total water demand must be less than or equal to the total supply from all sources.

Glenn-Colusa Irrigation District
Water Application Worksheet

(1) **TSL COMPANY**
Customer Name

(2) **TSL C 30000**
Account No.

Total Supply From All Allocation Forms **1,316.34** AF
Total Supply From All Assignment Forms **143.75** AF

Total Supply From All Sources **1,460.09** AF (3)

(4) District Parcel Number	(5) Field Number	(6) Crop	(7) (A) Irrigated Area[1] (Acres)	(8) (B) Applied Water Unit Duty[2] (AF/Acre)	(9) (A x B) Water Demand (AF)
16 3 02 F	1	Pasture	68.0	4.9	333.20
16 3 02 F	2	Rice	38.1	5.5	209.55
16 3 02 F	3	Walnuts	61.1	4.4	268.84
16 3 02 F	4	Tomatoes Drip	88.8	1.7	150.96
16 3 02 F	5	Rice	60.8	5.5	334.40
16 3 02 F	6	Corn – Ear	20.3	6.0	121.80
16 3 02 F	6	Sunflowers	18.7	2.2	41.14
	USE ENCLOSED BLUE SHEET				
			(10)		(11)
		Total Irrigated Acres	329.40	Total Water Demand	1459.89

[1] Number of acres to be planted in this field.
[2] Applied water unit duties are defined in *Applied Water Unit Duties for Summer & Winter Crops.*

Total water demand must be less than or equal to the total supply from all sources.

REQUIRED SIGNATURE FORM INSTRUCTIONS

1. Please enter the name of the landowner or tenant responsible for this application and date.

2. Please enter the name and phone number(s) of the "Designated Irrigator" to be contacted in the event of any water delivery problems or violations of the *Water Management and Conservation Policy.*

3. Please enter the name of the person who accepts financial responsibility for any violations of the *Water Management and Conservation Policy* related to irrigation of the fields for which you are applying.

4. Landowner and tenant should read this section thoroughly.

5. Signature and phone number(s) of landowner. A landowner signature is required on all Water Applications.

6. If there is a tenant associated with this application, their signature and phone number(s) are required.

Upon completion, mail or deliver application(s) to the District office. District *Rules and Regulations* provide for three working days to process water applications before water can be delivered, so please plan accordingly.

If you have any questions, please call the District office at (530) 934-8881.

Glenn-Colusa Irrigation District
2020 Water Application
Required Signature Form

1 Applicant: ______________________________ Date: ____________________
(please print)

Applicant designates the following person(s) with responsibility for water management and coordination with the District during the term of this Water Application:

Designated Irrigator: the person responsible for irrigating the land applied for on the water application, placing water orders, and coordinating water use with the District.

2 **Name:** ______________________________ **Mobile #** ____________________
(please print)
Message # ____________________

SAMPLE ONLY

Responsible Party: the person who accepts responsibility for the actions of the "designated irrigator," for all application fees, charges, and for water management and conservation violations and penalties. The "responsible party" could include the landowner, tenant, designated irrigator, or other agent associated with the water applicant. The District considers the "responsible party" to be the designated point-of-contact for all problems associated with water management and water conservation issues.

3 **Name:** ______________________________ **Mobile #** ____________________
(please print)
Message # ____________________

Applicant agrees that the terms and conditions of the *Rules and Regulations* of the District, including the District's *Water Management and Conservation Policy*, as existing now or as amended hereafter, are included within the terms of this application and that by signature hereof, Applicant agrees to such terms and conditions and agrees to indemnify and hold the District, its employees, officers, representatives, and contractors free and harmless from any liability or damages arising directly or indirectly from the performance by the District pursuant to such application.

4 **Applicant understands** that the availability of water from the Bureau of Reclamation to the District is dependent upon lands within Glenn-Colusa Irrigation District being eligible to receive such water. Applicant understands and agrees that, if applicant's lands are not eligible for Bureau water, the District may be required to levy additional charges not set forth in the *Rules and Regulations* at the present time to acquire or make available water to the subject property.

Applicant agrees they are solely responsible for completing the Bureau of Reclamation reporting forms reporting the ownership and leasing upon the subject lands and upon all other lands owned or controlled by owner or owner's tenants. Applicant understands that additional water charges and fines as well as potential claims of perjury may be made by the Bureau of Reclamation for misstatements or omissions.

The landowner is required to sign all water applications, and has ultimate responsibility for all application fees, charges, and water management and conservation violations and penalties.

USE ENCLOSED YELLOW SIGNATURE SHEET

5 **Landowner:** ______________________________ **Phone #** ____________________
(please print)

______________________________ **Mobile #** ____________________
(signature)

6 **Tenant:** ______________________________ **Phone #** ____________________
(please print)

______________________________ **Mobile #** ____________________
(signature)

Glenn-Colusa Irrigation District
Water Application Worksheet

Customer Name ______________________ Account Number ______________________

Total Supply From All Allocation Forms ______________ A/F

Total Supply From All Assignment Forms ______________ A/F

Total Supply From All Sources ______________ A/F

District Parcel Number	Field Number	Crop	(A) Irrigated Area[1] (Acres)	(B) Applied Water Unit Duty[2] (AF/Acre)	(A x B) Water Demand (AF)
		Total Irrigated Acres		Total A/F Demand	

[1] Number of acres to be planted in this field.

[2] Applied water unit duties are defined in *Applied Water Unit Duties for Summer & Winter Crops.*

Total water demand must be less than or equal to the total supply from all sources.

2020 Applied Water Unit Duties for Summer & Winter Crops
75% Water Supply

Summer Crops (1)	AF/Acre	Winter Crops	AF/Acre
Alfalfa	4.5	Barley	2.0
Almonds	4.1	Beet (Seed)	3.5
Almond Drip Year 1	0.8	Broccoli (Seed)	2.8
Almond Drip Year 2	1.6	Cabbage (Seed)	2.8
Almond Drip Year 3	2.3	Carrot (Seed)	4.1
Almond Drip Year 4+	3.1	Celery (Seed)	4.5
Bean (Dry)	2.5	Chard (Seed)	3.4
Clover	4.5	Cover Crop	2.5
Corn (Ear)	6.0	Grain Hay	2.0
Corn (Ear) Drip	4.5	Kale (Seed)	2.8
Corn (Silage)	4.3	Oats & Oat Hay	2.0
Cotton	3.3	Onion & Garlic (Fresh)	1.5
Cover Crop	2.5	Onion (Seed)	3.4
Fallow	0.0	Mustard (Seed)	1.9
Fish Pond	10.5	Radish (Seed)	1.8
Fruit Trees	4.1	Rye	2.0
Grape Vine	2.7	Turnip (Seed)	1.9
Habitat Wetland Summer	6.0	Wheat	2.0
Habitat Wetland Summer 1 Irrigation	1.0		
Habitat Wetland Summer 2 Irrigations	1.8		
Herb	1.0		
Industrial Hemp	2.8	**Winter Water**	
Misc. Deciduous	4.1	October Service Only	1.5
Miscellaneous Field Crops	2.5	November through January 6 Service	2.1
Olive	3.2	October through January 6 Service	2.8
Pasture	4.9	Winter Water Single Irrigation (October 1 - January 6)	1.0
Peas (Dry)	2.5		
Pepper	2.5	Habitat Wetland Winter Available October 1	
Pistachio	4.1	Continuous Flow	3.0
Prune	4.1	1 Irrigation	1.0
Prune - Drip	3.1		
Rice	5.5	Pasture 1 Irrigation (PS1)	1.0
Rice - Wild	4.0	Pasture 2 Irrigations (PS2)	1.8
Safflower	2.2	Pasture 3 Irrigations (PS3)	2.0
Small Vegetable	2.5	Pasture 4 Irrigations (PS4)	2.5
Small Vegetable Drip	1.9	Pasture 5 Irrigations (PS5)	3.0
Sudan Grass	4.9	Pasture 6 Irrigations (PS6)	3.5
Sunflower	2.2	Pasture 7 Irrigations (PS7)	4.0
Sunflower Drip	1.7	Pasture 8 Irrigations (PS8)	4.5
Tomato	2.3		
Tomato Drip	1.7		
Vineseed	1.6		
Vineseed Drip	1.2		
Walnut	4.4		
Walnut Drip Year 1	0.9		
Walnut Drip Year 2	1.7		
Walnut Drip Year 3	2.6		
Walnut Drip Year 4+	3.4		
1 Irrigation	1.0		
2 Irrigations	1.8		

(1) Applied water figures above for summer crops cover water use from April 1 through October 31. Water use on summer crops outside this time period will be subject to an additional one irrigation charge for each irrigation

2020 WATER RATE INFORMATION

2020 Water Rates for water service from April 1, 2020 through October 31, 2020:
Volumetric charge: $20.80 per acre foot for the crop being grown (see enclosed applied unit duty chart)

Any water use before April 1 or after October 31 is subject to additional charges.

Payment schedule: 40% due with application; 30% due June 1, 2020; 30% due August 1, 2020

Returned check charge is $25.00.

The 2020 water application deadline is May 22, 2020, at 5:00 p.m. Late applications are subject to a 5% late penalty except in cases where the application is paid in full at the time of application. Water will not be delivered without an application, required signature form(s) and appropriate payment.

Past due accounts (over 15 days late) will be charged interest at the rate of 1.5% per month (18% per year).

Standby Charge:
The Standby Charge of $6.00 per deeded acre will be due on June 1, 2020, and delinquent if not paid by June 15, 2020.

Drip Irrigation:
Crops irrigated for the entire season using drip or micro sprinklers are eligible for a 25% discount on the volumetric portion of the water rate.

Special Rates for New Orchards:
Newly planted orchard crops irrigated with drip or similar irrigation methods will be charged at the following rates during the tree establishment period (as a percentage of the established full drip irrigation unit duty charge): Year 1 - 25%; Year 2 - 50%; Year 3 - 75%; Year 4 - 100%.

Water Management and Conservation Policy Violations:
The monetary penalty related to violations of the District's *Water Management and Conservation Policy* is $500.00 for the first violation; subsequent violations will be considered by the District's Board of Directors for appropriate penalties.

Construction Water:
Construction water rate is $.50 per 1,000 gallons, with a $500.00 minimum charge

Definitions and Clarifications:
One Irrigation and Second Irrigation are defined as irrigating with enough water flow to rapidly cover to a depth of no more than 12 inches, uniformly irrigate the entire field, then turning the water off.

Islands within the District will be served only after approval by the Board of Directors and will be charged double the normal water rate.

Winter Water for duck ponds or rice straw decomposition will now be defined by the period of delivery. The delivery options are (1) October service only; (2) service from November 1 through January 6; (3) service from October through January 6, or (4) a single irrigation at any time during the winter water period.

Glenn-Colusa Irrigation District
2020 Water Application
Required Signature Form

Applicant: ____ **Date:**______________
(please print)

Applicant designates the following persons with responsibility for water management and coordination with the District during the term of this Water Application:

Designated Irrigator: the person responsible for irrigating the land applied for on the water application, placing water orders, and coordinating water use with the District.

Name: ________________________________ **Mobile #** ____________________
(please print)

Message # ____________________

Responsible Party: the person who accepts responsibility for the actions of the "designated irrigator," for all application fees, charges, and for water management and conservation violations and penalties. The "responsible party" could include the landowner, tenant, designated irrigator, or other agent associated with the water applicant. The District considers the "responsible party" to be the designated point-of-contact for all problems associated with water management and water conservation issues.

Name: ________________________________ **Mobile #** ____________________
(please print)

Message # ____________________

Applicant agrees that the terms and conditions of the *Rules and Regulations* of the District, including the District's *Water Management and Conservation Policy*, as existing now or as amended hereafter, are included within the terms of this application and that by signature hereof, Applicant agrees to such terms and conditions and agrees to indemnify and hold the District, its employees, officers, representatives, and contractors free and harmless from any liability or damages arising directly or indirectly from the performance by the District pursuant to such application.

Applicant understands that the availability of water from the Bureau of Reclamation to the District is dependent upon lands within Glenn-Colusa Irrigation District being eligible to receive such water. Applicant understands and agrees that, if applicant's lands are not eligible for Bureau water, the District may be required to levy additional charges not set forth in the *Rules and Regulations* at the present time to acquire or make available water to the subject property.

Applicant agrees they are solely responsible for completing the Bureau of Reclamation reporting forms reporting the ownership and leasing upon the subject lands and upon all other lands owned or controlled by owner or owner's tenants. Applicant understands that additional water charges and fines as well as potential claims of perjury may be made by the Bureau of Reclamation for misstatements or omissions.

The landowner is required to sign all water applications, and has ultimate responsibility for all application fees, charges, and water management and conservation violations and penalties.

Landowner: ________________________________ **Phone #** ____________________
(please print)

________________________________ **Mobile #** ____________________
(signature)

Tenant: ________________________________ **Phone #** ____________________
(please print)

________________________________ **Mobile #** ____________________
(signature)

Provident Irrigation District (PID)

STANDARD WATER APPLICATION

Provident Irrigation District
258 S. Butte Street, Willows, CA 95988
530-934-4801

The undersigned hereby applies for the irrigation of the below farm crops under and subject to the By-Laws, Rules and Regulations of Tolls and charges adopted (which are by this reference made a part of the application) or to be adopted by the Board of Directors of the District, and hereby grants the right to the Provident Irrigation District to use all ditches and laterals on the below described premises & to install, maintain for distribution, measurement & control of water for irrigation purposes and said District and its officers or employees shall not be liable for damages to persons or property occasioned through such exercise of such right, or for the negligent, wasteful or other use or handling of the water by the user thereof. *It is the sole responsibility of the undersigned to insure that all necessary Reclamation Reform Act documents are on file with the District office prior to delivery of water to the below listed lands.*

Application Due: By 4:00 PM May 1, 2020

Landowner:____

Address: ____

City: ____________________ St. ______________ Zip:______________

Description of Parcels of Lands to be Irrigated

Gate No.	Crop	Acreage	Tenant	Total Amount Due	1st Installment
Totals					

Irrespective of whether landowner or tenant is to pay for water, unpaid charges may, at the District's discretion, be added to the assessment to be levied, or otherwise secured as provided by law.
Water is to be paid by: Landowner _______ Tenant ________ Phone # of Irrigator:____________
This application must be signed by the landowner or his lawful agent, as authorized, in writing, on forms available at the District office. ***Payment for the 1st installment must accompany this application.***

Landowner:______________________________ Date:____________________

Provident Irrigation

258 S. Butte St.
Willows, CA 95988

Invoice

DATE	INVOICE #
11/24/2020	2924

BILL TO
ABC Company PO Box 123 Willows, CA 95988

P.O. NO.	TERMS	PROJECT

DESCRIPTION	QTY	RATE	AMOUNT
Rice Water 2020	20	90.00	1,800.00

Total	$1,800.00
Payments/Credits	$0.00
Balance Due	$1,800.00

Princeton-Codora-Glenn Irrigation District (PCGID)

STANDARD WATER APPLICATION

Princeton-Codora-Glenn Irrigation District
P.O. Box 98, Princeton, CA 95970
530-439-2248

The undersigned hereby applies for the irrigation of the below farm crops under and subject to the By-Laws, Rules and Regulations of Tolls and charges adopted (which are by this reference made a part of the application) or to be adopted by the Board of Directors of the District, and hereby grants the right to the Princeton-Codora-Glenn Irrigation District to use all ditches and laterals on the below described premises & to install, maintain for distribution, measurement & control of water for irrigation purposes and said District and its officers or employees shall not be liable for damages to persons or property occasioned through such exercise of such right, or for the negligent, wasteful or other use or handling of the water by the user thereof. *It is the sole responsibility of the undersigned to insure that all necessary Reclamation Reform Act documents are on file with the District office prior to delivery of water to the below listed lands.*

Application Due: By 4:00 PM May 1, 2020

Landowner:____

Address: ____

City: ________________________ St. _______________ Zip:__________________

Description of Parcels of Lands to be Irrigated

Gate No.	Crop	Acreage	Tenant	Total Amount Due	1st Installment
Totals					

Irrespective of whether landowner or tenant is to pay for water, unpaid charges may, at the District's discretion, be added to the assessment to be levied, or otherwise secured as provided by law.
Water is to be paid by: Landowner _______ Tenant ________ Phone # of Irrigator:_____________
This application must be signed by the landowner or his lawful agent, as authorized, in writing, on forms available at the District office. ***Payment for the 1st installment must accompany this application.***

Landowner:____ Date:________________________

Princeton-Codora-Glenn Irrigation District

PO Box 98
Princeton, CA 95970

Invoice

Date	Invoice #
11/24/2020	14863

Bill To
ABC Company PO Box 123 Willow, CA 95988

P.O. No.	Terms	Project

Quantity	Description	Rate	Amount
20	Rice Water 2020	120.00	2,400.00
		Total	$2,400.00

Reclamation District No. 108 (RD 108)

RECLAMATION DISTRICT NO. 108

APPLICATION FOR DELIVERY OF IRRIGATION WATER DURING 2020

The undersigned Water User hereby applies for delivery of irrigation water during 2020 to the fields listed below, subject to the District's Rules and Regulations. Please note that **NO WATER WILL BE DELIVERED THROUGH A NON-MEASURED/METERED DELIVERY POINT** per State Legislation SBX7-7.

Water Service Charges

Charges for water service are set annually by the Board of Trustees and are listed in the 2020 Water Rate Schedule. **The First installment must be paid in advance of water delivery** in accordance with the following schedule:

IRRIGATION OF CROPS: Due and payable in three installments as follows:

1st Installment - Prior to initial delivery of water – fixed per acre rate
2nd Installment - Not later than August 1 – year-to date volumetric use
3rd Installment - Not later than December 1 – volumetric usage since 2^{nd} installment

Invoices for 2nd and 3rd installments will be mailed to Water Users.

Payment Delinquencies

If any installments are not paid by the date due, the charges are considered to be delinquent and a penalty of five percent (5%) will be added to the balance owing. At the end of each thirty (30) day period following the date of delinquency, interest at the rate of one percent (1%) will accrue on the delinquent charges until the full amount, including penalties and interest is paid. The District may discontinue delivery of water and refuse further delivery of water to the field or fields until all monies owing are paid in full.

Water Users are encouraged to deposit funds with the District for advance payment of irrigation water charges.

(Please Specify Any Organic Fields)

Field #	***Acres***	***Crop***	***Irrig Type***
Total		***Amt Paid:***	

Water User:	
Address:	
Signature:	
Phone #	***Email:***
Field Contact:	
Phone #	

P.O. BOX 50, GRIMES, CA 95950 (530)437-2221 FAX(530)437-2248 rd108@rd108.org

NOTE: Water User Must Report the Beginning Meter Reading Prior to the Start of Water

RECLAMATION DISTRICT NO. 108

Irrigation Ordering Policy

In order for Reclamation District 108 to facilitate reliable irrigation water service to all Landowners and Water Users, please adhere to the water ordering policy outlined below. These practices will ensure the best service and least impact for Water Users and staff.

No Water will be delivered to a non-measured turnout. If you have a question, please call the office.

-Water orders are to be placed with the Waterman according to irrigation system, if you are unsure of what System your Fields are in please contact the Office at (530)437-2221.

Supervisor	**Jordon Navarrot**	**682-4205**
System A	**Edward Rainey**	**870-1100**
System A/D	**Joey Hardin**	**870-1214**
System B	**Isidro Mendez**	**870-1102**
System C	**Ulises Lopez**	**845-1894**
System D	**Crispin Murillo**	**870-1103**

-Water Users must place water orders no later than 4:00 PM prior to the desired irrigation day, and no earlier than 48 hours before the start of water. All other water orders are at the discretion of the District Operations Manager, and may not be granted. Irrigation starts must occur between the hours of 6:00AM and 3:00PM.

-All changes or shut down orders must be placed with the System Waterman 24 hours in advance and confirmed at least 1 hour in advance. Changes and shut downs must occur between the hours of 6:00AM and 3:00PM.

Gary Marler
(530)632-2606

Reclamation District No. 1004 (RD 1004)

The Undersigned Landowner and Tenant hereby apply to **Reclamation District 1004** (the District) for water on lands hereinafter described, subject to, under and pursuant to, the latest rules and regulations adopted by the Trustees of the District. In consideration of the water and other rights provided by the District, the undersigned Tenant agrees to pay the charges so fixed by the Trustees in accordance with the rules and regulations prescribed for the District. In the event the undersigned Tenant fails or is unable to pay to the District the prescribed charges due for whatever reason including the commencement of a case under Title 11 of the United States code, the landowner absolutely and unconditionally guarantees and promises to pay to the District those charges plus all penalties, interest and collection costs (including attorney fees and costs, if any) then owing. The Landowner's liability for payment of the water charges shall be open and continuous for so long as water is provided to the lands described hereinafter. The Landowner's liability for payment shall arise immediately upon the Tenant's failure or inability to pay the charges owing to the District when those charges are due; the Landowner's liability is not contingent upon receiving notice from the District or any other act of the District. Any and all person (s) responsible for causing the District not to have enough Non-Excess, and Eligible Land shall be jointly and severally responsible for the additional costs of the "Full Cost Water" plus any penalties, interest and related costs. The obligation to pay for "Full Cost Water", penalties, interest and related costs shall be that of the landowner, even if caused by a tenant, unless the tenant has satisfied this obligation in full. In the event there are multiple landowner's "properties" with Excess, Non-Eligible Land, the obligation to pay shall be prorated among them on the basis of the number of acre feet of water delivered to the Excess, Non-Eligible Land by the District during the year (s) involved. This obligation shall attach to the property and in inure to the detriment of any subsequent landowner. It is enforceable as a lien against the property.

Field No.	Acres	Crop/Habitat/Transfer	Allocation Total	Unit Duty	Deposit	Amount Due
			0.8	$28.00	$22.40	
			0.8	$28.00	$22.40	
			0.8	$28.00	$22.40	
			0.8	$28.00	$22.40	
			0.8	$28.00	$22.40	
			0.8	$28.00	$22.40	
			0.8	$28.00	$22.40	

The Board of Trustees reserves the right to increase these fees, when necessary.

It is understood that in the event any water charges that shall become payable to the District by reason of the supply of water to the above-described land, as provided in the rules and regulations of the District, are not paid at the time the charges become due, then the District may refuse the delivery of water to the land until the charges are paid in full by either the landowner or the tenant. Delivery of water cannot be made until after this agreement, FSA maps, all RRA forms and the required deposits are returned to **Reclamation District 1004 office at 317 4th Street, Colusa, CA 95932**, and until payment is made for all water previously delivered, including penalties and interest and the District's costs of collection (which shall include attorney's fees and costs). The Tenant and Landowner agree to pay, upon demand, all of the District's costs and expenses, including attorney's fees and legal expenses, incurred in connection with the enforcement of the obligations set forth in this agreement . In the event Federal and/or State law requires the District to shut down its pumping facilities during any part of the irrigation season or amends allocations, the District will be held harmless for any loss to landowner or tenant resulting from adherence to Federal and/or State law as required. **We want to emphasis due to the unprecedented drought conditions RD1004 cannot guarantee delivery of water and we expect the timing of delivery will be unreliable.**

Date: ________________ **RRA:** ________ FSA Map:________________

Water user information:

________________________ ________________________

Address **Signature of Landowner**

________________________ ________________________

City, State ZIP **Signature of Tenant**

____

Telephone Number **PAID:**____________ Check #__________

Water user email: ____

Meridian Farms Water Company (MFWC)

Exhibit C –Water Contract/Assignment Form

Nothing herein contained is intended to guarantee a supply of water to lands within Meridian Farms Water Company (MFWC). The availability of water is subject to: (1) the District's water rights, (2) MFWC water supply contract with the US Bureau of Reclamation, (3) limitations imposed by regulatory agencies, and (4) necessary maintenance and improvement work on the irrigation and drainage systems.

	(A)	(B)	(A x B)
District Field Number	**Area Accepted for Initial Allocation[1] (Acres)**	**Allocation (AF/Acre)**	**Water Supply(AF)**
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		2.98	
		Total Water Supply Contracted/Assigned	

[1]Maximum acreage shown in Exhibit B of the MFWC Water Allocation Policy

The undersigned being the authorized agent for the landowner(s) of said fields in MFWC, and is authorized to manage the water supply for the 2020 water year hereby,

☐ Contract with the MFWC for the use of the water supply as summarized above.

☐ Assign the water supply as summarized above to ____.

☐ If further supply becomes available to the MFWC, I request a Secondary Allocation.

__________________________________ ________________________

Authorized Agent Date

Sutter Mutual Water Company (SMWC)

Sutter Mutual Water Company
15094 Cranmore Road P.O. Box 128 Robbins, CA 95676
Tel: 530.738.4423 Fax: 530.738.4327

Winter Water Application for Water Delivery

Irrigation Season: 2020/21 Date: ________________ LANDOWNER: __________________________

SMWC Field Number: __________________________ FARMER Field No.________________________

Crop(s): Winter Water ______________________ Total RRA Field Acres: ______________

Irrigators Name: ____________________________________ Phone No. ___________________________

No water will be started until the following information is filled out, and all summer water charges are paid in full.

BILLING INFORMATION:

Billing Name: ____

Address:____

City:_________________________________State______________Zip:________________

Phone_______________________________________

Email:____

____ (Submitted by) **________________ (Date)**

____ (Printed Name)

QUESTIONS? PLEASE CALL HEATHER MUNOZ AT (530) 565-5374

Natomas Central Mutual Water Company (NCMWC)

NATOMAS CENTRAL MUTUAL WATER COMPANY

2601 WEST ELKHORN BLVD., RIO LINDA, CA 95673
PHONE: 916-419-5936 ● FAX: 916-419-8691
staff@natomaswater.com
www.natomaswater.com

FORMAL APPLICATION FOR IRRIGATION WATER

Please Submit by March 31

**** The "Acknowledgement of Bylaws" and RRA Forms must be submitted by Shareholder AND Tenant Prior to water delivery ****

All Water Charges for the Following Properties Will Be Billed To:

NAME: ______________________________

ADDRESS: ______________________________

____

TELEPHONE: ______________________________

PLANNED CROPPING PATTERN:

		Acreage				
	Field #	**Gross**	**Planted**	**Crop**	**Account # / Property Owner**	**Drain Rate?**
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Con't on back

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Printed Name ***Signature*** ***Date***

FORMAL APPLICATION FOR IRRIGATION WATER

		Acreage				
	Field #	Gross	Planted	Crop	Account # / Property Owner	Drain Rate?
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
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26						
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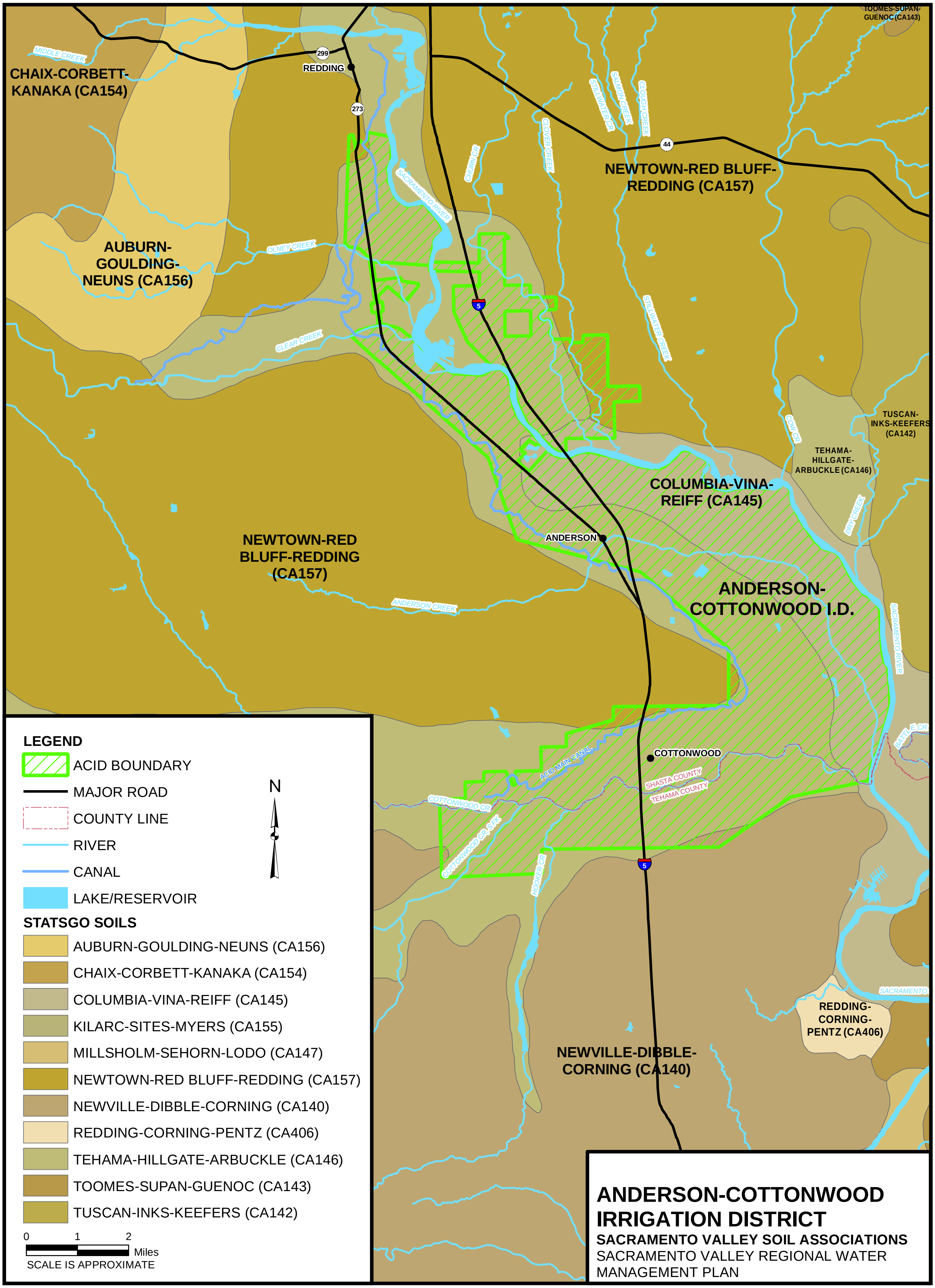
34						
35						

Attachment K
Soil Maps



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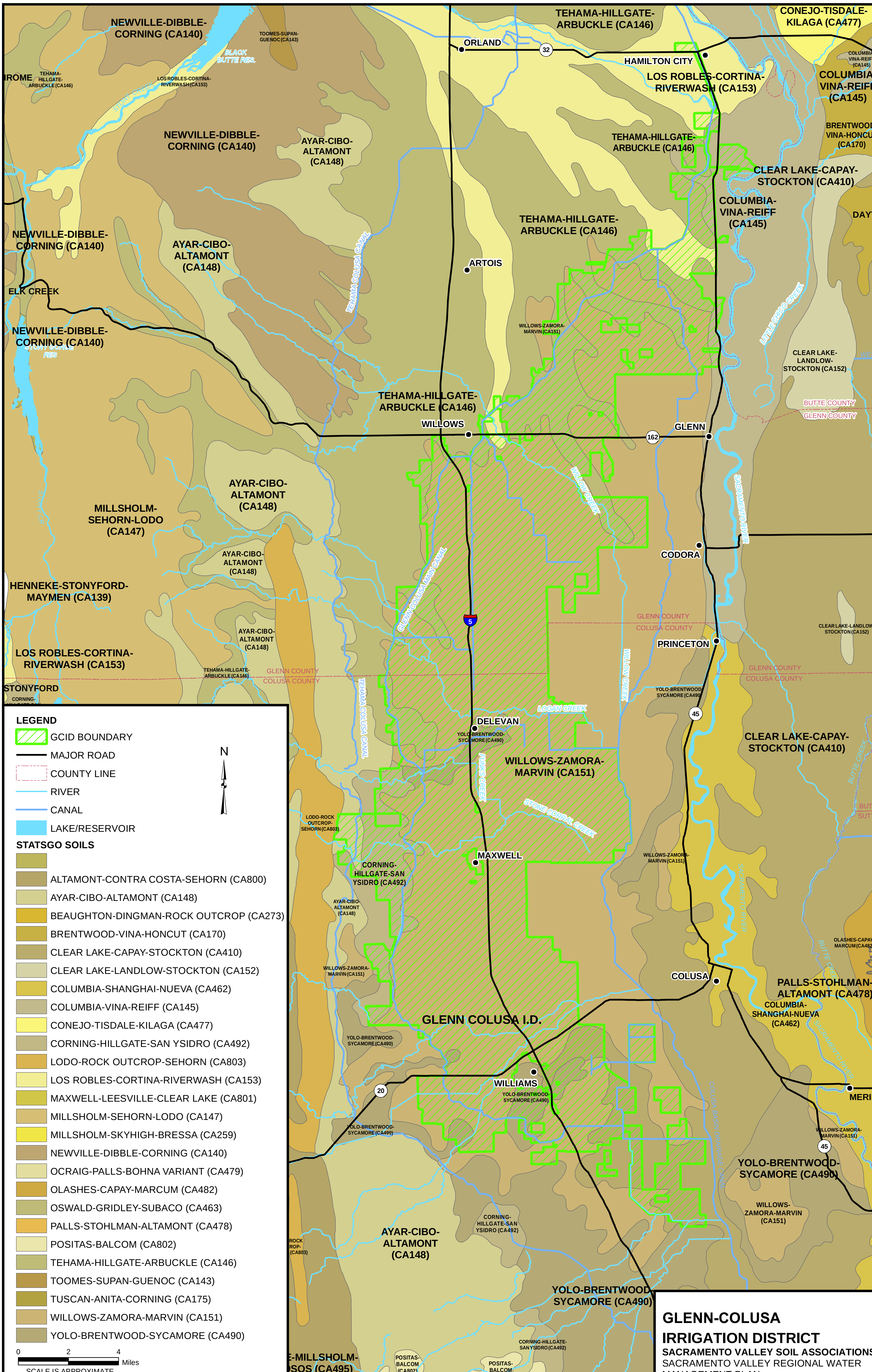

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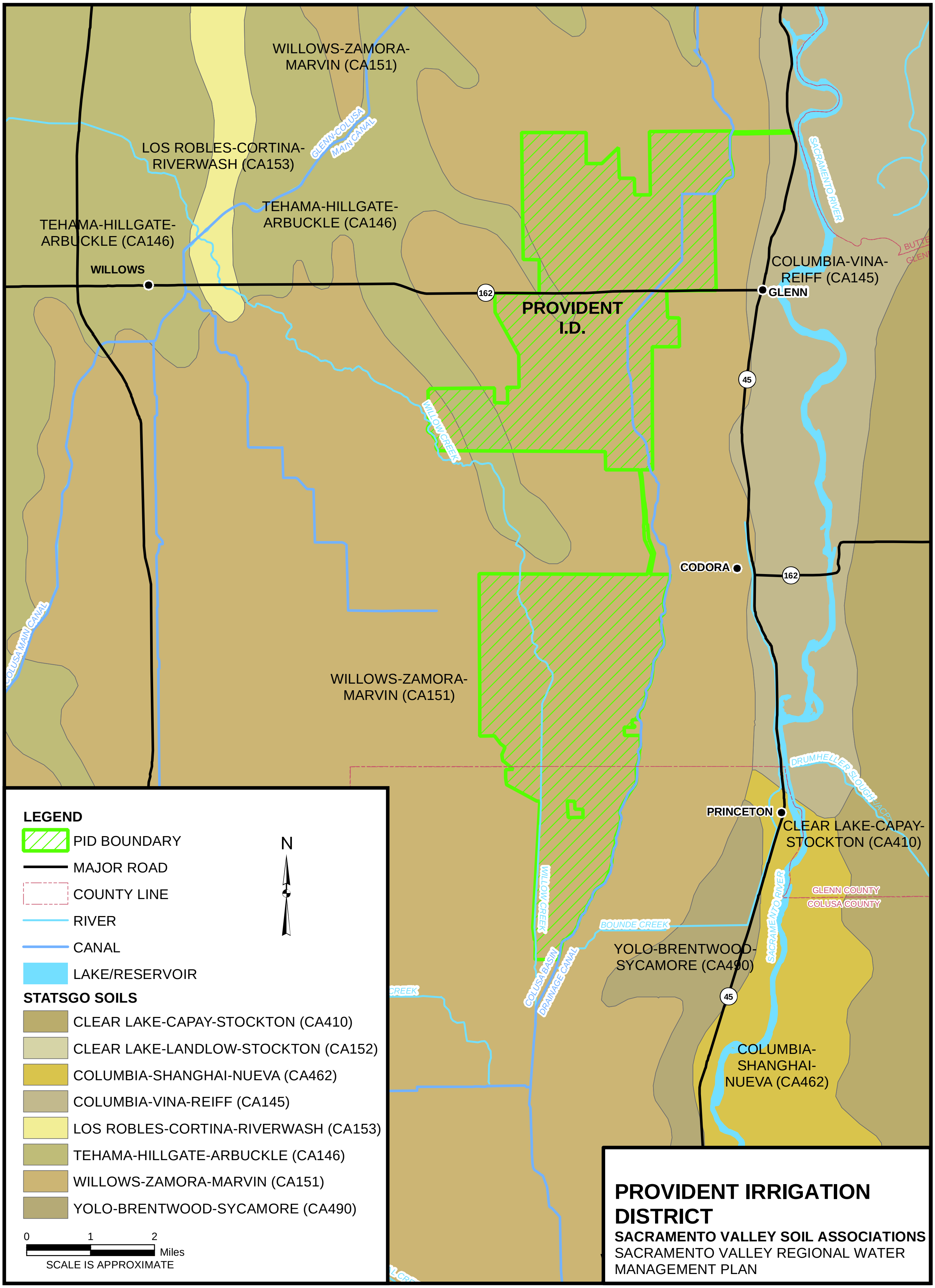
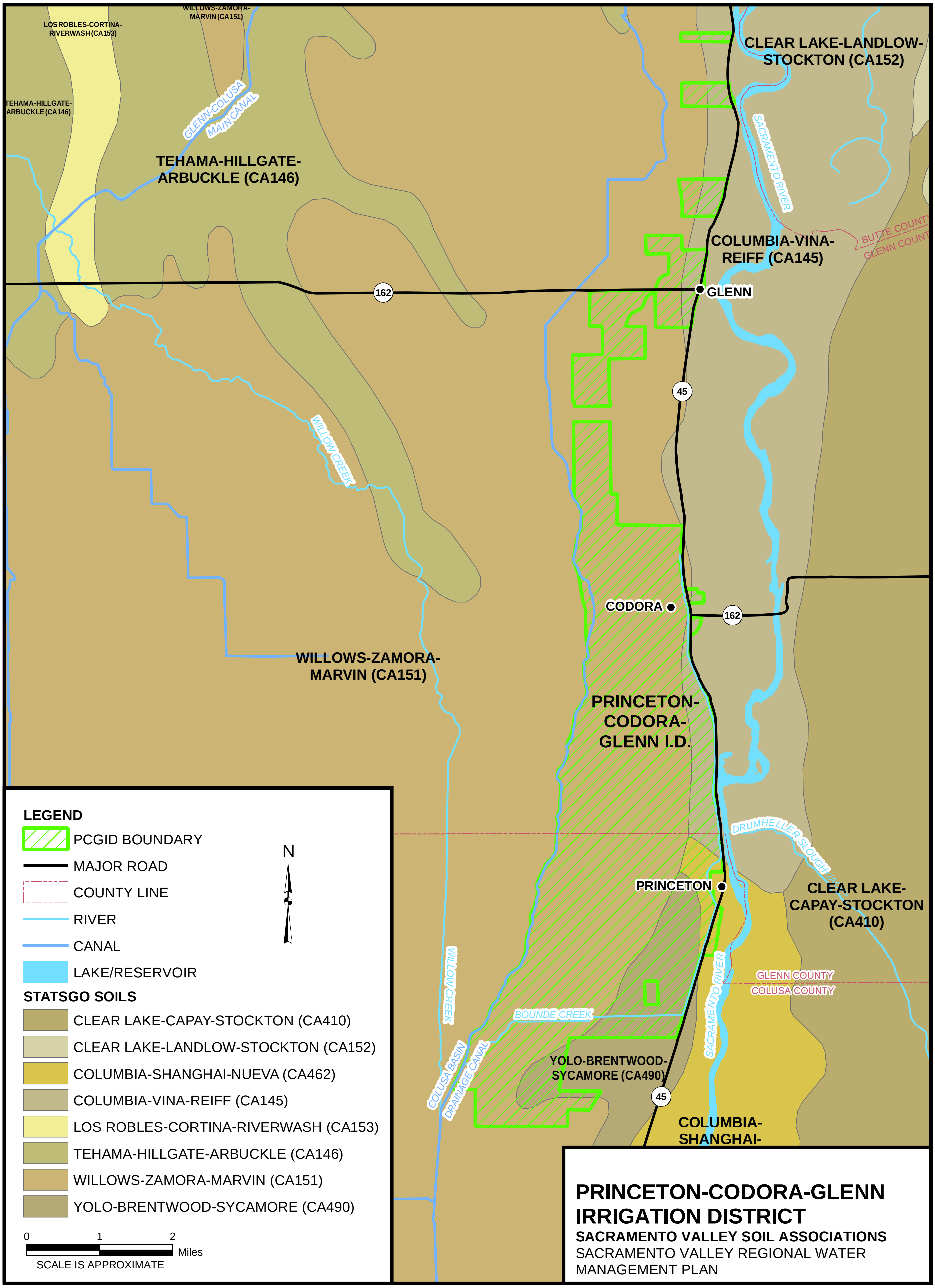


PROVIDENT IRRIGATION DISTRICT

SACRAMENTO VALLEY SOIL ASSOCIATIONS

SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN



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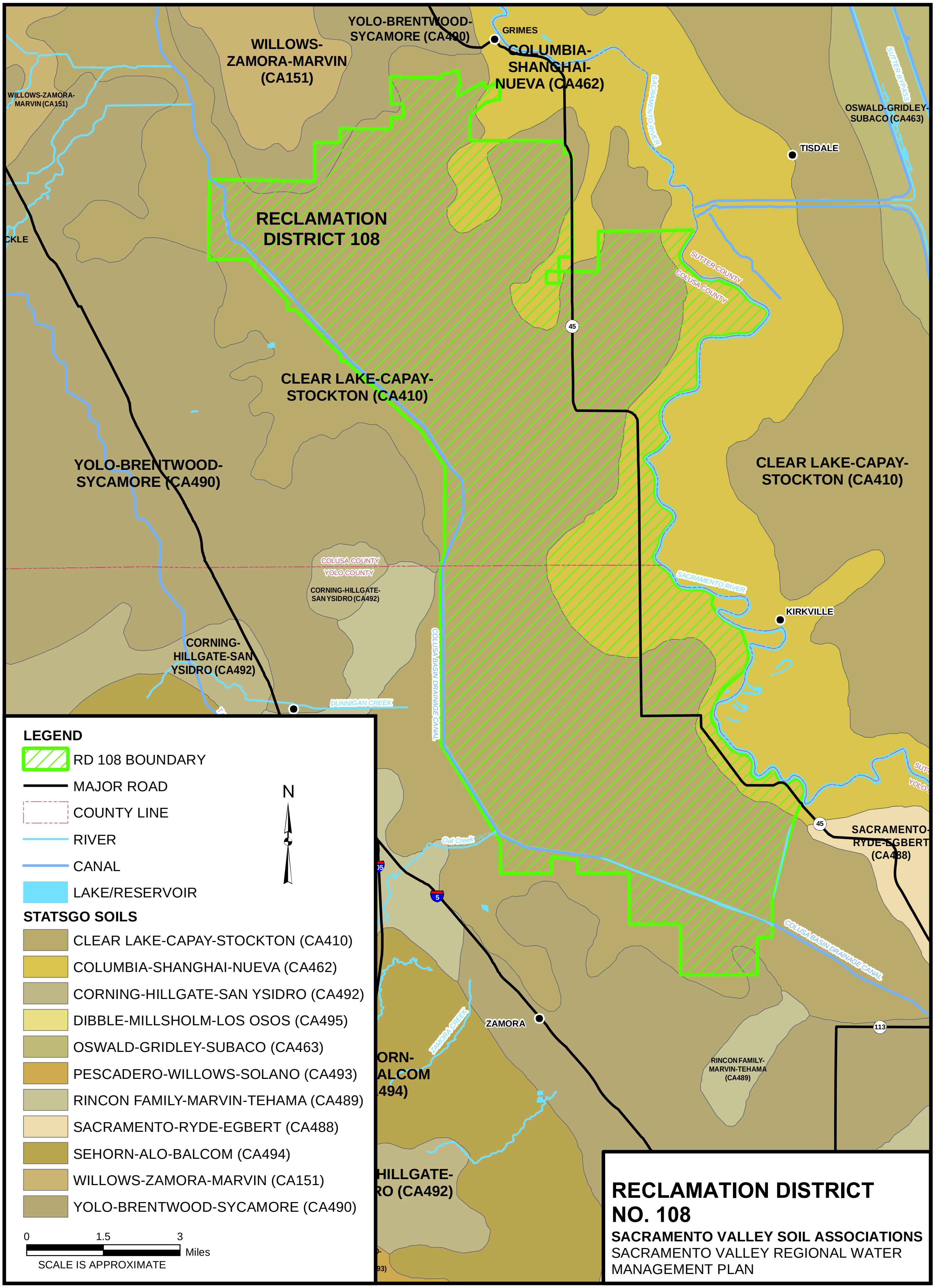
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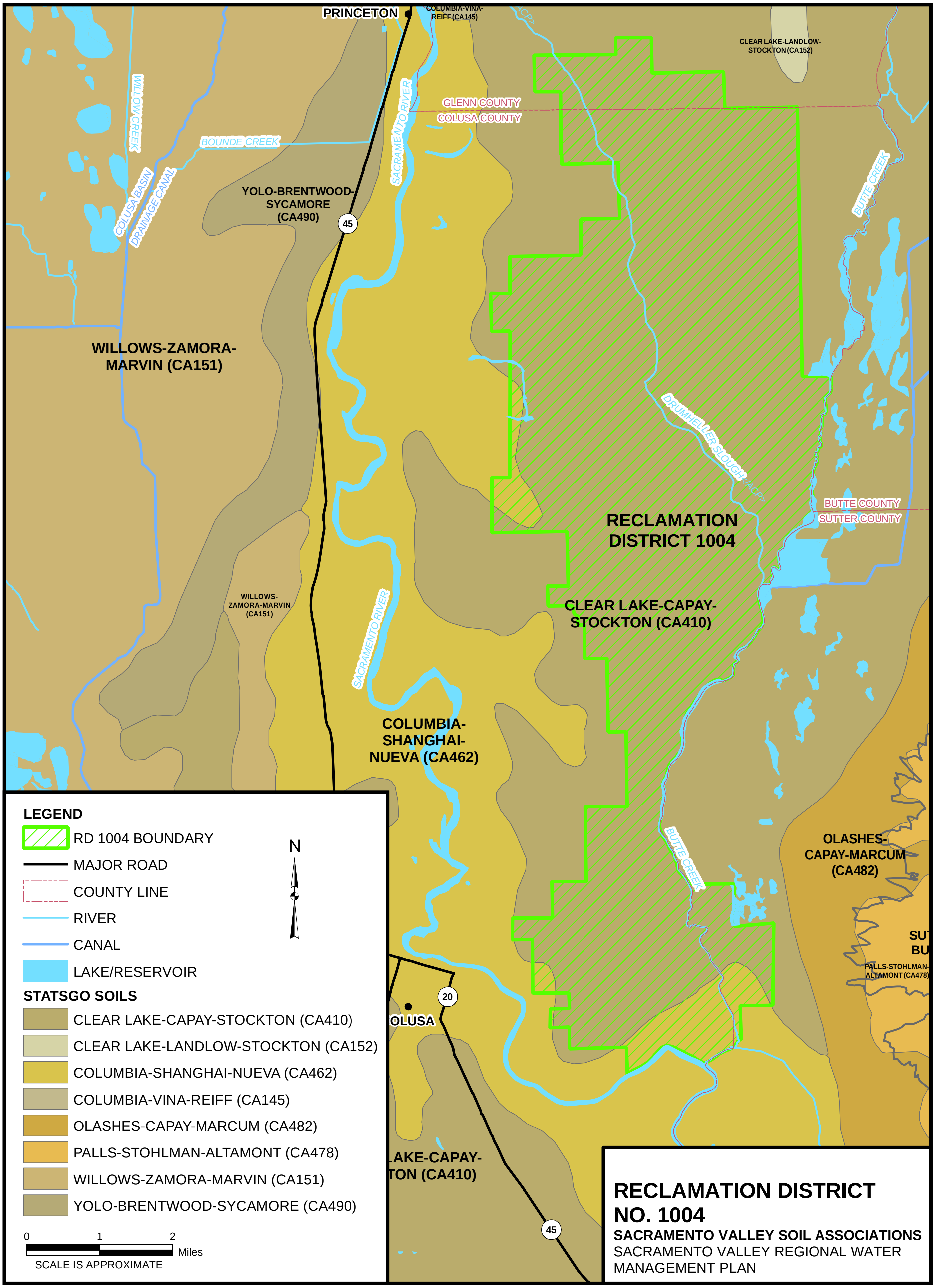
WILLOWS-ZAMORA-MARVIN (CA151)
WILLOWS-ZAMORA-MARVIN (CA151)
GRIMES
COLUMBIA-SHANGHAI-NUEVA (CA462)
SACRAMENTO RIVER
SUTTER BYPASS
OSWALD-GRIDLEY-SUBACO (CA463)
TISDALE
RECLAMATION DISTRICT 108
CKLE
SUTTER COUNTY
COLUSA COUNTY
45
CLEAR LAKE-CAPAY-STOCKTON (CA410)
YOLO-BRENTWOOD-SYCAMORE (CA490)
CLEAR LAKE-CAPAY-STOCKTON (CA410)
COLUSA COUNTY
YOLO COUNTY
CORNING-HILLGATE-SAN YSIDRO (CA492)
SACRAMENTO RIVER
KIRKVILLE
CORNING-HILLGATE-SAN YSIDRO (CA492)
COLUSA BASIN DRAINAGE CANAL
DUNNIGAN CREEK
SACRAMENTO-RYDE-EGBERT (CA488)
Oat Creek
5
COLUSA BASIN DRAINAGE CANAL
ZAMORA CREEK
ZAMORA
113
RINCON FAMILY-MARVIN-TEHAMA (CA489)
ORN-ALCOM 494)
HILLGATE-RO (CA492)
LEGEND
RD 108 BOUNDARY
MAJOR ROAD
COUNTY LINE
RIVER
CANAL
LAKE/RESERVOIR
N
STATSGO SOILS
CLEAR LAKE-CAPAY-STOCKTON (CA410)
COLUMBIA-SHANGHAI-NUEVA (CA462)
CORNING-HILLGATE-SAN YSIDRO (CA492)
DIBBLE-MILLSHOLM-LOS OSOS (CA495)
OSWALD-GRIDLEY-SUBACO (CA463)
PESCADERO-WILLOWS-SOLANO (CA493)
RINCON FAMILY-MARVIN-TEHAMA (CA489)
SACRAMENTO-RYDE-EGBERT (CA488)
SEHORN-ALO-BALCOM (CA494)
WILLOWS-ZAMORA-MARVIN (CA151)
YOLO-BRENTWOOD-SYCAMORE (CA490)
0 1.5 3
Miles
SCALE IS APPROXIMATE
RECLAMATION DISTRICT NO. 108
SACRAMENTO VALLEY SOIL ASSOCIATIONS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN


PRINCETON
COLUMBIA-VINA-REIFF (CA145)
CLEAR LAKE-LANDLOW-STOCKTON (CA152)
GLENN COUNTY
COLUSA COUNTY
WILLOW CREEK
BOUNDE CREEK
SACRAMENTO RIVER
COLUSA BASIN DRAINAGE CANAL
YOLO-BRENTWOOD-SYCAMORE (CA490)
45
BUTTE CREEK
WILLOWS-ZAMORA-MARVIN (CA151)
DRUMHELLER SLOUGH
BUTTE COUNTY
SUTTER COUNTY
RECLAMATION DISTRICT 1004
WILLOWS-ZAMORA-MARVIN (CA151)
CLEAR LAKE-CAPAY-STOCKTON (CA410)
COLUMBIA-SHANGHAI-NUEVA (CA462)
OLASHES-CAPAY-MARCUM (CA482)
PALLS-STOHLMAN-ALTAMONT (CA478)
20
OLUSA
LAKE-CAPAY-TON (CA410)
LEGEND
RD 1004 BOUNDARY
MAJOR ROAD
COUNTY LINE
RIVER
CANAL
LAKE/RESERVOIR
N
STATSGO SOILS
CLEAR LAKE-CAPAY-STOCKTON (CA410)
CLEAR LAKE-LANDLOW-STOCKTON (CA152)
COLUMBIA-SHANGHAI-NUEVA (CA462)
COLUMBIA-VINA-REIFF (CA145)
OLASHES-CAPAY-MARCUM (CA482)
PALLS-STOHLMAN-ALTAMONT (CA478)
WILLOWS-ZAMORA-MARVIN (CA151)
YOLO-BRENTWOOD-SYCAMORE (CA490)
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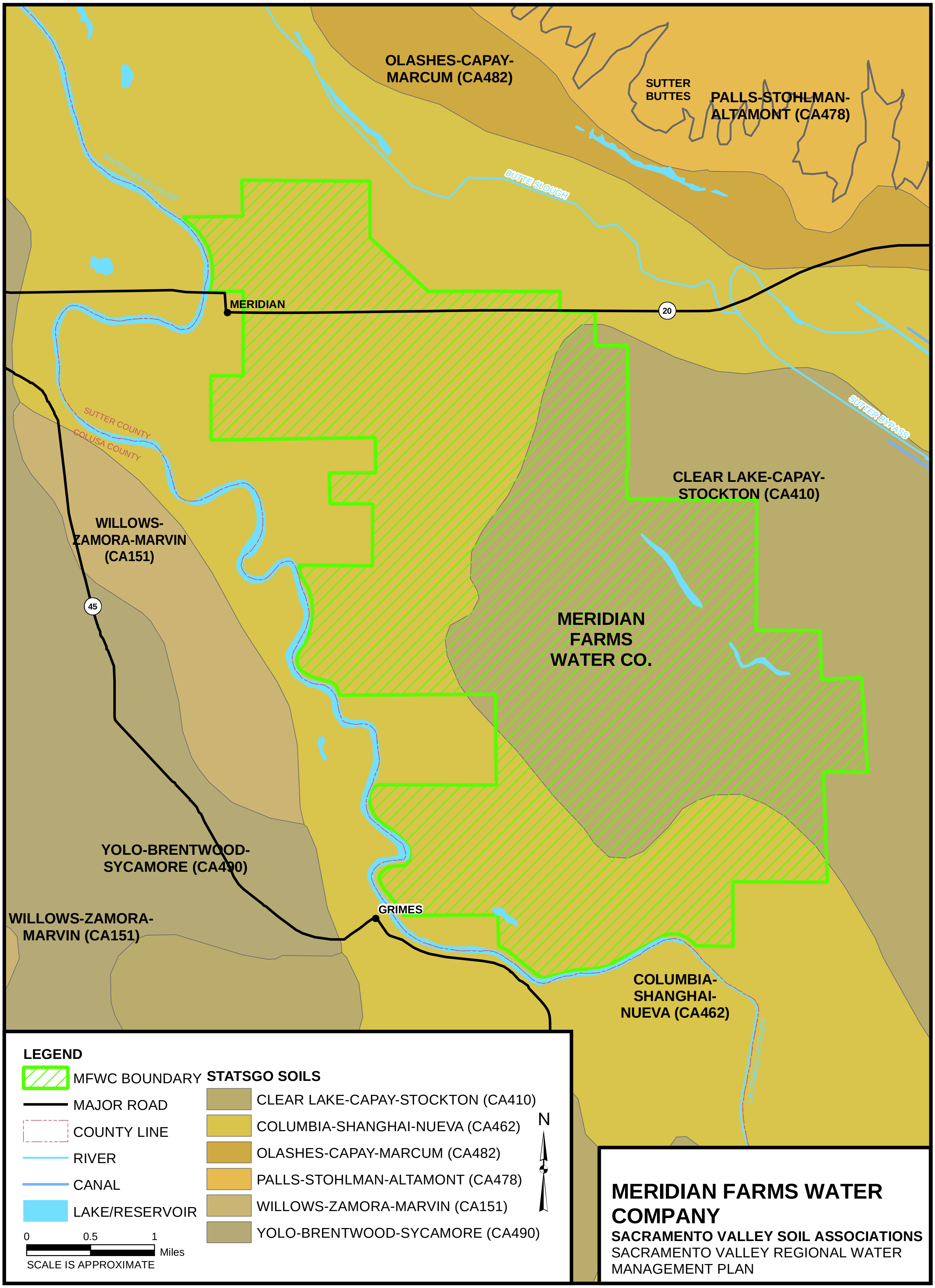
SCALE IS APPROXIMATE
RECLAMATION DISTRICT NO. 1004
SACRAMENTO VALLEY SOIL ASSOCIATIONS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN



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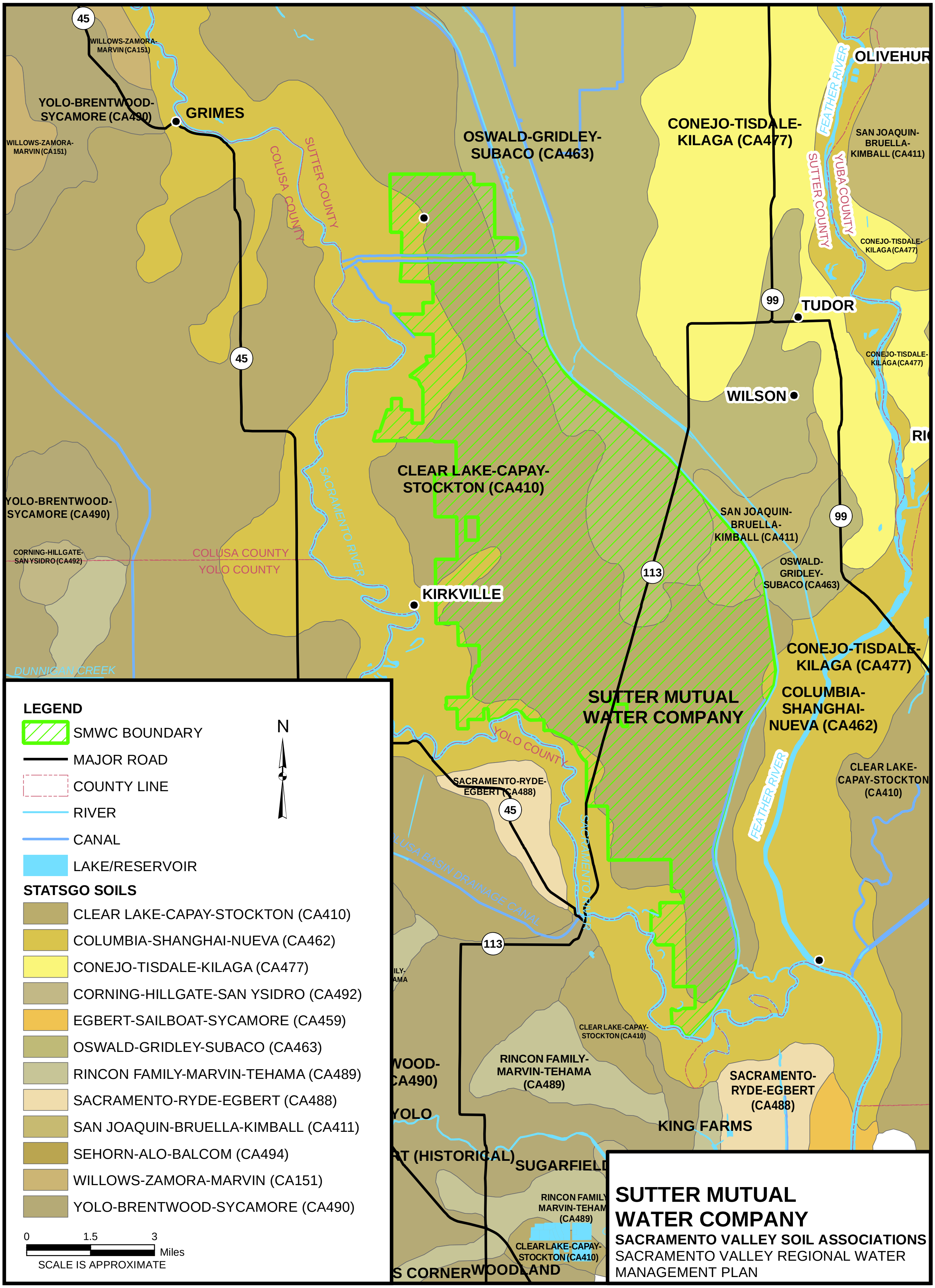
SUTTER MUTUAL WATER COMPANY
SACRAMENTO VALLEY SOIL ASSOCIATIONS
SACRAMENTO VALLEY REGIONAL WATER MANAGEMENT PLAN
LEGEND
SMWC BOUNDARY
MAJOR ROAD
COUNTY LINE
RIVER
CANAL
LAKE/RESERVOIR
STATSGO SOILS
CLEAR LAKE-CAPAY-STOCKTON (CA410)
COLUMBIA-SHANGHAI-NUEVA (CA462)
CONEJO-TISDALE-KILAGA (CA477)
CORNING-HILLGATE-SAN YSIDRO (CA492)
EGBERT-SAILBOAT-SYCAMORE (CA459)
OSWALD-GRIDLEY-SUBACO (CA463)
RINCON FAMILY-MARVIN-TEHAMA (CA489)
SACRAMENTO-RYDE-EGBERT (CA488)
SAN JOAQUIN-BRUELLA-KIMBALL (CA411)
SEHORN-ALO-BALCOM (CA494)
WILLOWS-ZAMORA-MARVIN (CA151)
YOLO-BRENTWOOD-SYCAMORE (CA490)
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1.5
3
Miles
SCALE IS APPROXIMATE
N
SUTTER MUTUAL WATER COMPANY
GRIMES
KIRKVILLE
TUDOR
WILSON
OLIVEHUR
KING FARMS
SUGARFIELD
WOODLAND
45
99
113
SUTTER COUNTY
COLUSA COUNTY
YOLO COUNTY
YUBA COUNTY
SACRAMENTO RIVER
FEATHER RIVER
DUNNIGAN CREEK
WILLOWS-ZAMORA-MARVIN (CA151)
YOLO-BRENTWOOD-SYCAMORE (CA490)
OSWALD-GRIDLEY-SUBACO (CA463)
CONEJO-TISDALE-KILAGA (CA477)
SAN JOAQUIN-BRUELLA-KIMBALL (CA411)
CLEAR LAKE-CAPAY-STOCKTON (CA410)
CORNING-HILLGATE-SAN YSIDRO (CA492)
COLUMBIA-SHANGHAI-NUEVA (CA462)
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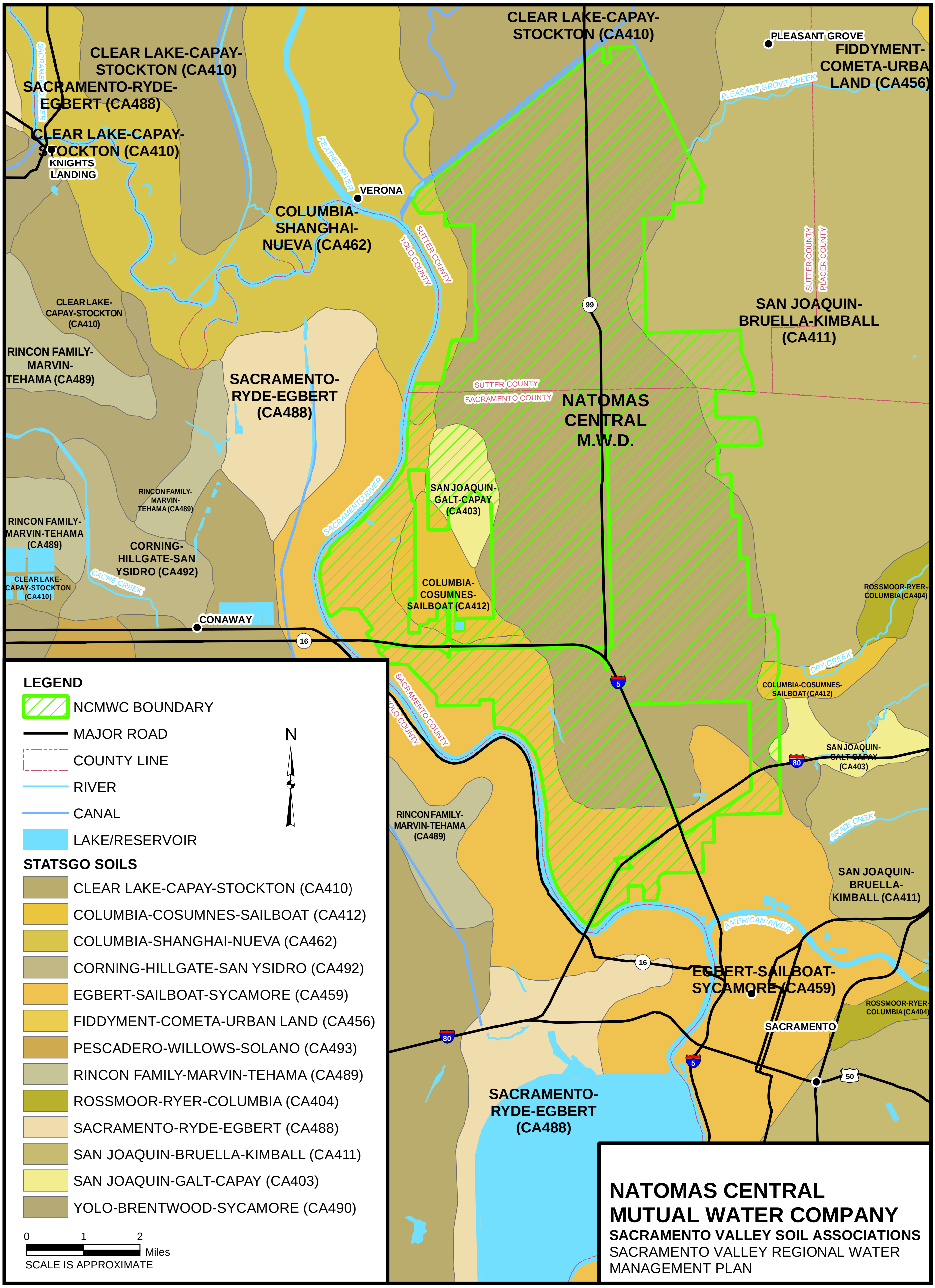
RINCON FAMILY-MARVIN-TEHAMA (CA489)



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Attachment L
Placeholder – not used

Attachment M
Water Balance Summary Tables

Attachment M
Water Balance Summary Tables

Water Balance Summary

Water balance summaries were developed for each participating Sacramento River Settlement Contractor (SRSC) and are included in Appendix A for the 2018–2020 irrigation years. These summaries are based on the Agricultural Water Inventory Tables (Standard Tables) in the *Water Management Planner* (Bureau of Reclamation [Reclamation], 2017) to meet the 2017 Standard Criteria for Agricultural and Urban Water Management Plans. The tables were modified to display and identify information unique to the SRSCs, including rice production. The summaries are limited to the April through October period covered by the SRSC contracts, consistent with prior plans.

The following described the source data used to complete the water balances. These source data are considered the most accurate and current information available at the district level for the 2018–2020 irrigation seasons. Surface water supplies are based on records of the SRSC diversions from Reclamation monthly water accounting and SRSC records. Irrigation district (district) groundwater pumping is based on SRSC records. Private groundwater pumping is estimated by the SRSCs. Precipitation data are based on the average monthly precipitation reported for the Sacramento Valley by the California Irrigation Management Information System (CIMIS) for the Williams, Davis, and Verona stations; for the Redding Sub-basin, precipitation data are based on information from the Gerber South CIMIS station. Crop evapotranspiration (ET) tables were prepared using (1) crop coefficients (Kc values) developed by the Irrigation Training and Research Center at California Polytechnic State University for district water balances for typical year (2018, 2020) and wet year (2019) surface irrigation and (2) monthly 2018-2020

reference ET (ETo) from CIMIS at the previously identified stations. For the SRSCs in the Sacramento Valley, Kc values were developed using the Zone 12 data from the Irrigation Training and Research Center (ITRC) Report (2003) and the average ETo data reported by CIMIS at Williams, Davis, and Verona stations for 2018–2020. The crop ET for the Redding Sub-basin is based on the Zone 14 data from the ITRC Report and 2018-2020 ETo data for the Gerber South CIMIS station. Evaporation for use in estimating distribution system evaporation and seepage is estimated at 1.1 times the monthly ETo. Effective precipitation is estimated at 60 percent of the irrigation season precipitation. Leaching requirements were developed using the methods and equations described by R.S. Ayers and D.W. Westcot in *Water Quality for Agriculture* (Food and Agricultural Association of the United Nations, 1985) (also known as FAO Irrigation and Drain Paper 29, Rev. 1). As identified in the footnotes to Table 5 of the water balances, the crop consumptive use values do not include water required for initial flooding, re-flooding, or flow-through on rice fields.

Table 6 of the water balances summarizes the inflows and outflows from the individual SRSCs, including estimates of available soil moisture, inflow from precipitation, and ET precipitation by crops. The various sources of the district outflows have been estimated by the SRSCs. The subtotal without recirculation was used as a closure term. As such, in addition to percolation to the groundwater basin, the volume shown includes unaccounted for drain water outflow; errors in assumptions used in calculations or estimated uses such as crop water use (ET); and other factors such as effective precipitation, evaporation, and groundwater recharge. A positive value indicates that the assumed percolation to groundwater is greater than groundwater pumping. A negative value may indicate unaccounted for groundwater pumping from privately owned wells. Table 6 of the water balances also shows the quantities of water recaptured and recirculated for reuse within the SRSC service areas.

In addition to the individual water balance tables, a regional-level summary of SRSC diversion and return flows for the 2018–2020 irrigation years was prepared. Figures 1, 2, and 3 are schematics that illustrate the relationships between participating SRSCs and show diversions from the Sacramento River and return flows to the river attributable to the participating SRSCs. Return flows to the river are available for various uses including re-diversion or environmental benefits. The regional-level summaries of SRSC diversion and return flows also identify the average diversion and average consumptive use per cropped acre within the participating SRSC service area for each irrigation year.

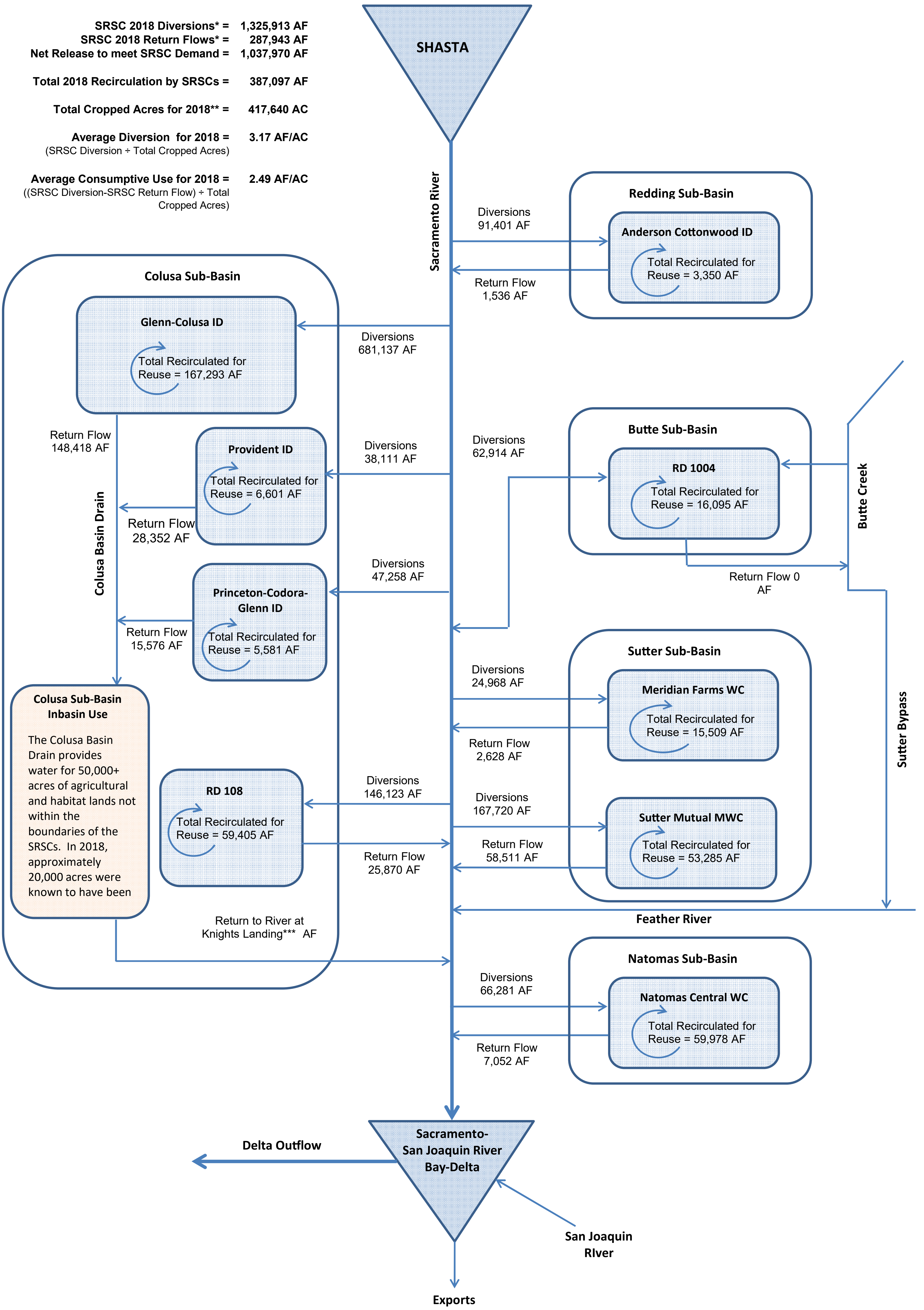
References

Bureau of Reclamation (Reclamation). 2017. *Water Management Planner.* January.

Food and Agriculture Organization of the United Nations. 1985. *Water Quality for Agriculture*. FAO Irrigation and Drain Paper 29, Rev. 1. Prepared by R.S. Ayers and D.W. Westcot. Reprinted 1989 and 1994.

Irrigation Training and Research Center (ITRC). 2003. *California Evapotranspiration Data for Irrigation District Water Balances* (ITRC Report). Available from: http://www.itrc.org/reports/californiacrop.htm

Figures



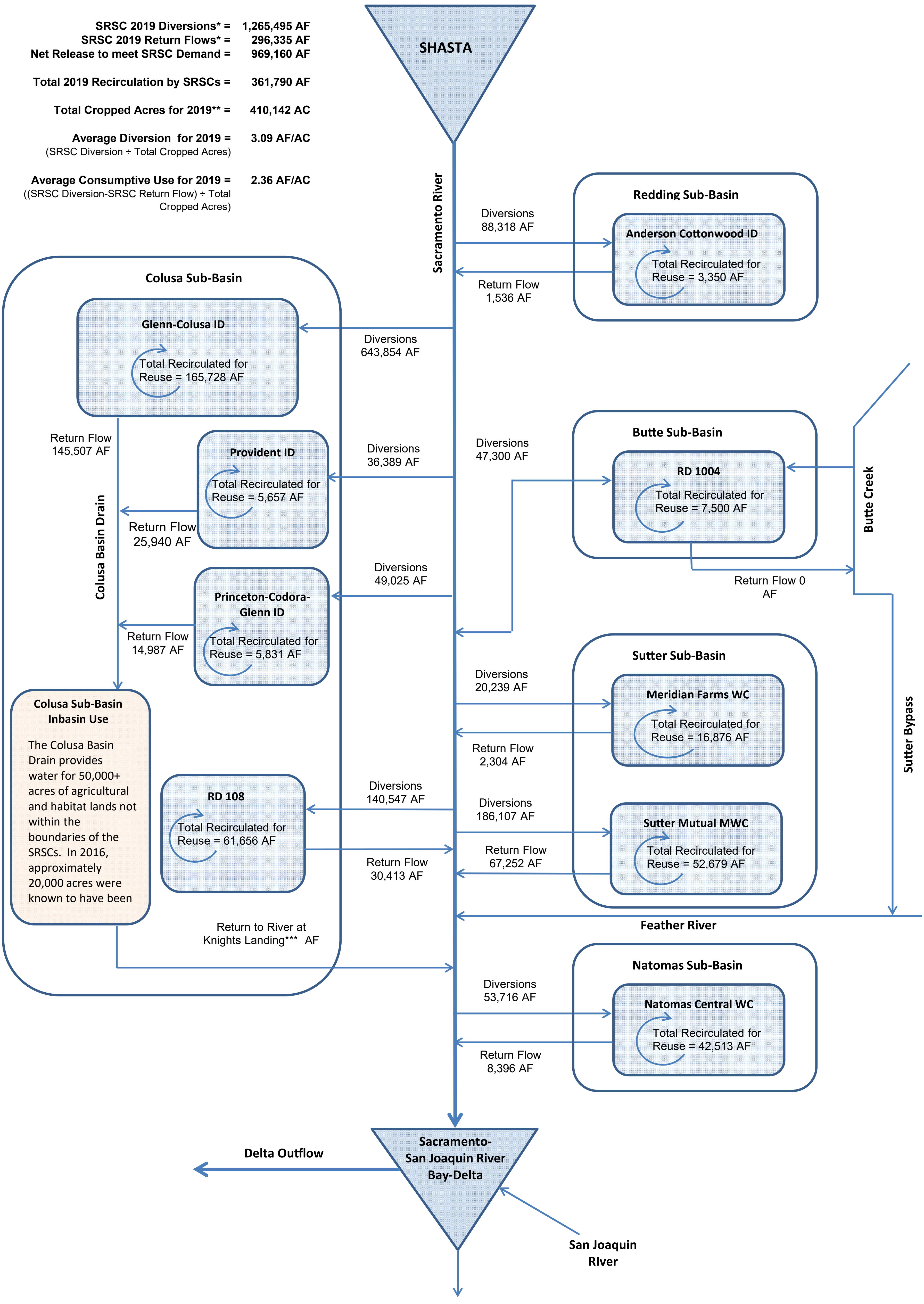
Notes: * Diversions and Return Flows are from 2018 SRSC Water Balance tables.
** Total Cropped Acres for 2018 includes 20,000 acres within the Colusa Sub-basin that rely on return flows from the SRSCs for surface water supplies.
*** Return to River at Knights Landing is currently not publicaly available data, and thus is not available for 2018.

Source: MBK Engineers 2020

Figure 1. Summary of SRSC 2018 Diversion and Return Flows

Jacobs

FES0402211241RDD Att M Figure 2



Notes: * Diversions and Return Flows are from 2019 SRSC Water Balance tables.
** Total Cropped Acres for 2019 includes 20,000 acres within the Colusa Sub-basin that rely on return flows from the SRSCs for surface water supplies.
*** Return to River at Knights Landing is currently not publicaly available data, and thus is not available for 2019.

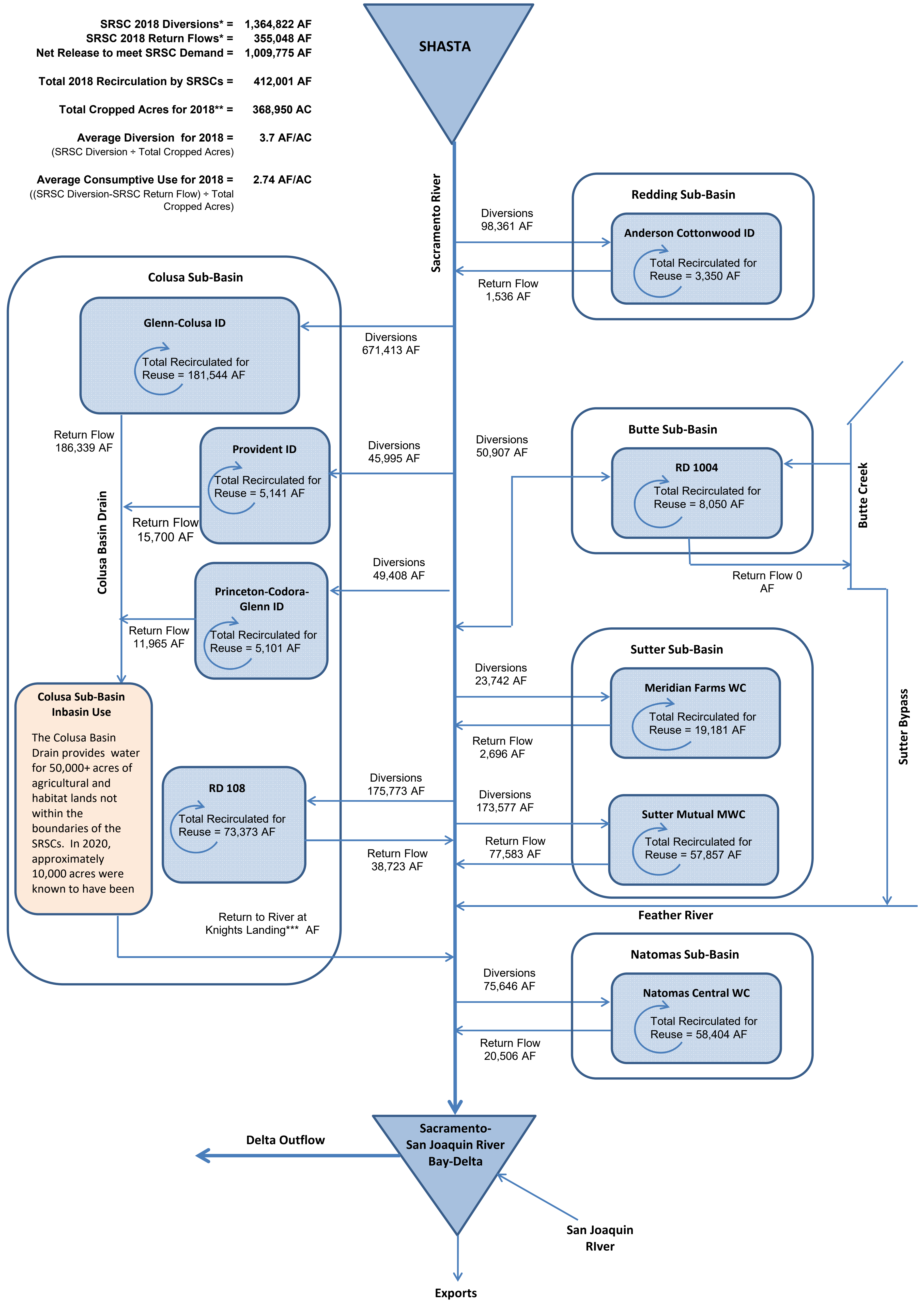
Source: MBK Engineers 2020

Figure 2. Summary of SRSC 2019 Diversion and Return Flows

Jacobs

FES0402211241RDD Att M Figure 3

Summary of SRSC Diversions and Return Flows 2020



Notes: * Diversions and Return Flows are from 2018 SRSC Water Balance tables.
** Total Cropped Acres for 2018 includes 20,000 acres within the Colusa Sub-basin that rely on return flows from the SRSCs for surface water supplies.
*** Return to River at Knights Landing is currently not publicaly available data, and thus is not available for 2018.

Figure 3. Summary of SRSC 2020 Diversion and Return Flows

MBK*ENGINEERS*
11/17/2021

Jacobs

Attachment M1
Water Balance Summaries

2018 Water Balance Summaries

District/Company **_Anderson Cottonwood Irrigation District_**

TABLE 1
Anderson Cottonwood Irrigation District – 2018 Surface Water Supply
(April through October Period Only)
2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	6,380	0	0	0	6,380
May	10,000	0	0	0	10,000
June	17,447	0	0	0	17,447
July	18,028	0	0	0	18,028
August	16,911	0	0	0	16,911
September	16,217	0	0	0	16,217
October	6,418	0	0	0	6,418
TOTAL	91,401	0	0	0	91,401

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2
Anderson Cottonwood Irrigation District – 2018 Groundwater Supply
(April through October Period Only)
2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
TOTAL	0	0

[a]Estimated by District based on observation and historical information.

TABLE 3
Anderson Cottonwood Irrigation District – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)
2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	6,380	0	6,380
May	10,000	0	10,000
June	17,447	0	17,447
July	18,028	0	18,028
August	16,911	0	16,911
September	16,217	0	16,217
October	6,418	0	6,418
TOTAL	91,401	0	91,401

[a]In addition to the water supplies shown in Table 3, 3,350 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Anderson Cottonwood Irrigation District_**

Anderson Cottonwood Irrigation District – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.1	0.26	1.1	0.09
Feb	0.1	0.01	3.4	0.28
Mar	2.4	0.20	3.7	0.31
Apr	2.7	0.23	5.4	0.45
May	1.1	0.09	8.2	0.68
Jun	0.1	0.01	9.9	0.83
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.2	0.60
Sept	0.0	0.00	6.2	0.52
Oct	0.5	0.04	4.6	0.38
Nov	3.4	0.28	2.7	0.22
Dec	2.8	0.23	1.5	0.13
TOTAL-YR	16.2	1.35	63.0	5.25
TOTAL-Apr-Oct	**4.3**	**0.36**	**50.6**	**4.21**

[a]Precipitation is precipitation reported for CIMIS Station at Gerber South (#222).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the reference ET (ETo) reported for the Gerber South CIMIS Station.

TABLE 4

Anderson Cottonwood Irrigation District – 2018 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	177,952	30	123	44	517	24,511	(24,984)
Laterals	871,324	10	200	72	843	11,202	(11,972)
TOTAL			323	117	1,360	35,713	(36,956)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season (April-October).

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Anderson Cottonwood Irrigation District**

TABLE 5

Anderson Cottonwood Irrigation District – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Acres[a]	Crop Et[b]	Effective Precipitation[c]		ETAW	Leaching Requirement	
Crop Name	(crop acres)	(AF/Ac)	(AF/Ac)	(acre-feet)	(acre-feet)	(AF/Ac)	(acre-feet)
Alfalfa	230	2.92	0.14	32	640	0.11	25
Pasture	6,772	3.15	0.14	935	20,424	0.03	203
Walnuts	1,700	3.10	0.14	235	5,043	0.16	272
Crop Acres	8,702			1,201	26,107		500
Total Irrig. Acres	8,702	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Station at Gerber South (#222) x Kc based on ITRC Typical Year ETc for Zone 14 surface irrigation for water balances. Water Needs do not include water required for cultural practices.

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season.

District/Company **Anderson Cottonwood Irrigation District**

TABLE 6

Anderson Cottonwood Irrigation District – 2018 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	91,401
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	0
Available Soil Moisture[c]	Estimated	1,136
	Total Water Supplies =	**92,537**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	35,713
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,243
Riparian ET[d] (Canals/Laterals)	Estimated	1,420
Conveyance System Filling[e] (Canals/Laterals)	Estimated	914
	Total Distribution System =	**39,290**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	26,107
Evapotranspiration of Precip - ET_{pr}	Table 5	1,201
Cultural Practices *(includes Leaching Requirement)*	Table 5	500
	Total Crop Water Needs =	**27,808**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Upslope Drainwater Flow Through[h]	Estimated	0
Remainder Drainwater Outflow[i]	District Records	1,536
	Total District Outflow *(from District Records)* **=**	**1,536**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**3,350**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**23,903**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs. Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on crop acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for cultural practices.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Anderson Cottonwood Irrigation District_**

TABLE 7

Anderson Cottonwood Irrigation District – 2018 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2009	106,922	-	-	-	106,922	3,368	4,138
2010	100,009	-	-	-	100,009	3,151	15,000
2011	89,814	0	0	0	89,814	3,150	15,000
2012	101,229	0	0	0	101,229	3,239	15,000
2013	108,600	0	0	0	108,600	3,340	2,755
2014	86,702	0	0	0	86,702	3,215	1,240
2015	87,315	0	0	0	87,315	3,350	1,150
2016	103,104	0	0	0	103,104	3,350	1,536
2017	91,478	0	0	0	91,478	3,350	1,536
2018	91,401	0	0	0	91,401	3,350	1,536
Total	966,574	0	0	0	966,574	32,863	58,891
Average	96,657	0	0	0	96,657	3,286	5,889

[a]Federal Ag Water Supply from Reclamation Water Account Records. Data prior to 2011 are not available.
[b]Non-Federal Ag Water Supply from District Records. Data prior to 2011 are not available.
[c]Estimated by District based on observation and historical information. Data prior to 2011 are not available.
[d]Estimated by District based on observation and historical information.

District/Company **Glenn-Colusa Irrigation District**

TABLE 1

Glenn-Colusa Irrigation District – 2018 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	33,131	8	0	53	33,192
May	159,252	1	0	447	159,700
June	154,285	4	0	448	154,737
July	130,000	29,666	0	480	160,146
August	90,000	21,619	0	158	111,777
September	23,737	10	0	47	23,794
October	39,413	11	0	0	39,424
TOTAL	629,818	51,319	0	1,633	682,770

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Glenn-Colusa Irrigation District – 2018 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	1,239
May	0	1,858
June	0	1,858
July	0	2,478
August	0	2,478
September	0	1,239
October	0	1,239
TOTAL	0	12,389

[a]Estimated by District based on observation and historical information.

TABLE 3

Glenn-Colusa Irrigation District – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	33,192	0	33,192
May	159,700	0	159,700
June	154,737	0	154,737
July	160,146	0	160,146
August	111,777	0	111,777
September	23,794	0	23,794
October	39,424	0	39,424
TOTAL	682,770	0	682,770

[a]In addition to the water supplies shown in Table 3, 167,293 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Glenn-Colusa Irrigation District**

Glenn-Colusa Irrigation District – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Glenn-Colusa Irrigation District – 2018 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	341,200	70	548	85	2,192	10,966	(13,072)
Pipeline	26,400	2	0	0	0	0	0
Laterals	3,495,360	12	963	150	3,849	4,815	(8,514)
Watershed Drains	2,919,840	15	1,005	157	4,019	5,027	(8,890)
TOTAL			2,517	392	10,060	20,808	(30,475)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 5

Glenn-Colusa Irrigation District – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a]	Crop ET[b]	Effective Precipitation[c]		ETAW	Leaching Requirement	
	(crop acres)	(AF/Ac)	(AF/Ac)	(acre-feet)	(acre-feet)	(AF/Ac)	(acre-feet)
Alfalfa	1,163	2.95	0.04	49	3,376	0.11	128
Almonds	11,703	2.66	0.00	0	31,084	0.18	2,107
Beans	94	0.70	0.04	4	62	0.47	44
Corn	798	1.84	0.04	34	1,432	0.14	112
Cotton	88	2.28	0.04	4	197	0.02	2
Oats	825	0.70	0.04	35	542	0.02	17
Habitat	364	2.43	0.04	15	870	0.03	11
Misc. Deciduous	12	2.71	0.04	1	32	0.16	2
Olives	245	2.71	0.04	10	653	0.09	22
Onions	22	0.83	0.04	1	17	0.28	6
Pasture	3,401	3.21	0.04	143	10,778	0.03	102
Prunes	232	2.81	0.04	10	642	0.18	42
Rice	100,757	2.82	0.04	4,249	279,543	0.06	6,045
Rice Straw Decomp	34,952	0.50	0.04	1,474	16,002	0.00	0
Sudan	363	3.21	0.04	15	1,150	0.07	25
Sunflowers	1,257	1.62	0.04	53	1,979	0.06	75
Tomatoes	927	1.56	0.04	39	1,406	0.08	74
Vegetables	39	0.80	0.04	2	30	0.18	7
Vineseed	1,588	0.94	0.04	67	1,433	0.18	286
Walnuts	5,654	3.07	0.04	238	17,133	0.16	905
Crop Acres	164,484			6,442	368,363		10,012
Total Irrig. Acres	129,532	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 127,000 to 153,000 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Glenn-Colusa Irrigation District**

TABLE 6

Glenn-Colusa Irrigation District – 2018 District Water Balance

(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	682,770
Private Groundwater	Table 2	12,389
Inflow From Precip[b]	Estimated	14,202
Available Soil Moisture[c]	Estimated	5,221
	Total Water Supplies =	**714,582**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	20,808
Evaporation - Precipitation (Canals/Laterals)	Table 4	9,668
Riparian ET[d] (Canals/Laterals)	Estimated	6,500
Conveyance System Filling[e] (Canals/Laterals)	Estimated	8,000
	Total Distribution System =	**44,975**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	368,363
Evapotranspiration of Precip - ET_{pr}	Table 5	6,442
Cultural Practices *(includes Leaching Requirement)*	Table 5	10,012
	Total Crop Water Needs =	**384,817**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	34,605
Irrigation Season Rainfall Runoff[g]	Estimated	15,701
Rice Cultural and Ecosystem Requirement[h]	Estimated	50,000
Upslope Drainwater Flow Through[i]	Estimated	474
Remainder Drainwater Outflow[j]	Calculated	47,638
	Total District Outflow *(from District Records)* =	148,418
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**167,293**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**136,371**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Glenn-Colusa Irrigation District**

TABLE 7

Glenn-Colusa Irrigation District – 2018 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow (acre-feet)
2009	636,777	49,911	0	22,500	709,188	190,980	171,743
2010	572,352	91,017	0	22,500	685,869	194,677	229,665
2011	571,617	86,014	0	40,500	698,131	190,994	255,999
2012	605,963	90,277	0	40,500	736,740	206,542	197,899
2013	698,625	72,274	0	1,650	772,549	217,694	207,154
2014	496,915	52,171	0	1,700	550,786	131,520	102,168
2015	452,681	60,381	0	1,360	514,422	115,694	79,238
2016	623,198	66,038	0	1,600	690,836	167,918	148,275
2017	601,963	66,394	0	1,850	670,207	166,397	136,716
2018	629,818	51,319	0	1,633	682,770	167,293	148,418
Total	5,889,909	685,796	0	135,793	6,711,498	1,749,709	1,677,275
Average	588,991	68,580	0	13,579	671,150	174,971	167,728

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013.

District/Company **_Provident Irrigation District_**

TABLE 1

Provident Irrigation District – 2018 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	2,132	0	313	77	2,522
May	10,427	0	3,545	2,988	16,960
June	11,422	0	4,122	3,014	18,558
July	6,300	2,529	6,036	4,742	19,607
August	2,500	169	5,538	5,118	13,325
September	62	0	314	2,136	2,512
October	2,570	0	575	400	3,545
TOTAL	35,413	2,698	20,443	18,475	77,029

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Provident Irrigation District – 2018 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	97	0
May	621	0
June	99	0
July	156	0
August	0	0
September	16	0
October	0	0
TOTAL	989	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Provident Irrigation District – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	2,522	97	2,619
May	16,960	621	17,581
June	18,558	99	18,657
July	19,607	156	19,763
August	13,325	0	13,325
September	2,512	16	2,528
October	3,545	0	3,545
TOTAL	77,029	989	78,018

[a]In addition to the water supplies shown in Table 3, 6,601 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Provident Irrigation District**

Provident Irrigation District – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at Davis (#6),Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Provident Irrigation District – 2018 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	65,472	35	53	8	210	1,315	(1,517)
Laterals	206,448	12	57	9	227	569	(787)
Water Shed Drains	175,276	15	60	9	241	302	(534)
TOTAL			170	26	679	2,186	(2,838)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season (April-October).

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Provident Irrigation District**

TABLE 5

Provident Irrigation District – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Acres[a]	Crop ET[b]	Effective Precipitation[c]		ETAW	Leaching Requirement	
Crop Name	(crop acres)	(AF/Ac)	(AF/Ac)	(acre-feet)	(acre-feet)	(AF/Ac)	(acre-feet)
Rice	14,206	2.82	0.04	599	39,414	0.06	852
Rice Straw Decomp	9,421	0.50	0.04	397	4,313	0.00	0
Crop Acres	23,627			996	43,727		852
Total Irrig. Acres	14,206	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 19,000 to 23,000 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Provident Irrigation District**

TABLE 6

Provident Irrigation District – 2018 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	78,018
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	2,105
Available Soil Moisture[c]	Estimated	0
	Total Water Supplies =	**80,122**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	2,186
Evaporation - Precipitation (Canals/Laterals)	Table 4	652
Riparian ET[d] (Canals/Laterals)	Estimated	100
Conveyance System Filling[e] (Canals/Laterals)	Estimated	770
	Total Distribution System =	**3,708**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	43,727
Evapotranspiration of Precip - ET_{pr}	Table 5	996
Cultural Practices *(includes Leaching Requirement)*	Table 5	852
	Total Crop Water Needs =	**45,575**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	2,180
Irrigation Season Rainfall Runoff[g]	Estimated	2,214
Rice Cultural and Ecosystem Requirement[h]	Estimated	14,206
Upslope Drainwater Flow Through	Estimated	3,040
Remainder Drainwater Outflow[i]	Calculated	6,713
	Total District Outflow *(from District Records)* **=**	**28,352**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**6,601**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**2,487**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Provident Irrigation District_**

TABLE 7

Provident Irrigation District – 2018 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b,c] (acre-feet)	Upslope Drainwater[c,d] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[d] (acre-feet)
2009	35,471	4,500	11,883	-	51,854	-	-
2010	31,879	4,500	6,727	70,534	113,640	10,233	49,935
2011	26,671	3,346	6,619	73,953	110,589	9,983	53,382
2012	31,466	3,278	27,068	23,651	85,463	9,210	25,268
2013	34,154	2,429	22,195	47,283	106,061	6,022	30,493
2014	27,847	40	2,798	30,338	61,023	2,617	20,618
2015	32,830	0	273	29,494	62,597	6,619	22,479
2016	35,413	2,698	20,443	18,475	77,029	6,836	18,893
2017	33,240	3,723	19,342	19,901	76,206	6,644	30,254
2018	35,413	2,698	20,443	18,475	77,029	6,601	28,352
Total	324,384	27,212	137,791	332,104	821,491	64,765	279,674
Average	32,438	2,721	13,779	36,900	82,149	7,196	31,075

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records; quantities prior to 2008 are estimated.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013.

[d]Data prior to 2010 are not available.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 1

Princeton-Codora-Glenn Irrigation District – 2018 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	2,814	0	72	0	2,886
May	12,369	0	2,208	0	14,577
June	12,724	0	2,847	0	15,571
July	6,740	3,506	3,678	0	13,924
August	2,780	3,921	2,360	0	9,061
September	1,004	0	101	0	1,105
October	1,400	0	430	0	1,830
TOTAL	39,831	7,427	11,696	0	58,954

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

TABLE 2

Princeton-Codora-Glenn Irrigation District – 2018 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	83	0
May	210	1,339
June	36	1,339
July	1,467	1,339
August	1,530	1,339
September	0	1,339
October	0	0
TOTAL	3,326	6,695

[a]Estimated by District based on observation and historical information.

TABLE 3

Princeton-Codora-Glenn Irrigation District – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	2,886	83	2,969
May	14,577	210	14,787
June	15,571	36	15,607
July	13,924	1,467	15,391
August	9,061	1,530	10,591
September	1,105	0	1,105
October	1,830	0	1,830
TOTAL	58,954	3,326	62,280

[a]In addition to the water supplies shown in Table 3, 5,581 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

Princeton-Codora-Glenn Irrigation District – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Princeton-Codora-Glenn Irrigation District – 2018 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	68,640	30	47	7	189	11,818	(12,000)
Laterals	219,384	15	76	12	302	5,666	(5,956)
Water Shed Drains	113,520	15	39	6	156	1,955	(2,105)
TOTAL			162	25	647	19,439	(20,061)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Princeton-Codora-Glenn Irrigation District**

TABLE 5

Princeton-Codora-Glenn Irrigation District – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Acres[a]	Crop ET[b]	Effective Precipitation[c]		ETAW	Leaching Requirement	
Crop Name	(crop acres)	(AF/Ac)	(AF/Ac)	(acre-feet)	(acre-feet)	(AF/Ac)	(acre-feet)
Almonds	80	2.66	0.00	0	212	0.18	14
Pasture	23	3.21	0.04	1	73	0.03	1
Rice	7,518	2.82	0.04	317	20,858	0.06	451
Rice Straw Decomp	1,404	0.50	0.04	59	643	0.00	0
Vineseed	19	0.94	0.04	1	17	0.18	3
Walnuts	1,339	3.07	0.04	56	4,058	0.16	214
Watermelon	1	1.09	0.00	0	1	0.04	0
Crop Acres	10,384			434	25,862		683
Total Irrig. Acres	8,980	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 9,000 to 11,000 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 6

Princeton-Codora-Glenn Irrigation District – 2018 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	62,280
Private Groundwater	Table 2	6,695
Inflow From Precip[b]	Estimated	1,032
Available Soil Moisture[c]	Estimated	269
	Total Water Supplies =	**70,276**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	19,439
Evaporation - Precipitation (Canals/Laterals)	Table 4	622
Riparian ET[d] (Canals/Laterals)	Estimated	100
Conveyance System Filling[e] (Canals/Laterals)	Estimated	590
	Total Distribution System =	**20,751**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	25,862
Evapotranspiration of Precip - ET_{pr}	Table 5	434
Cultural Practices *(includes Leaching Requirement)*	Table 5	683
	Total Crop Water Needs =	**26,980**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	1,172
Rice Cultural and Ecosystem Requirement[h]	Estimated	7,518
Upslope Drainwater Flow Through	Estimated	0
Remainder Drainwater Outflow[i]	Calculated	6,886
	Total District Outflow *(from District Records)* **=**	**15,576**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**5,581**
	Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**6,970**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 7

Princeton-Codora-Glenn Irrigation District – 2018 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[c] (acre-feet)
2009	50,800	13,847	0	-	64,647	6,078	-
2010	44,869	14,428	0	23,736	83,033	5,531	27,428
2011	38,257	12,485	0	26,189	76,931	7,664	26,460
2012	43,303	12,950	17,908	12,856	87,017	8,702	26,388
2013	47,890	10,231	11,453	16,828	86,402	7,383	26,388
2014	38,389	2,789	1,084	15,095	51,822	3,138	17,747
2015	38,888	6,457	99	12,524	57,968	2,627	13,598
2016	43,899	8,269	6,498	0	58,666	3,514	16,408
2017	38,780	10,792	11,375	0	60,947	4,316	15,564
2018	39,831	7,427	11,696	0	58,954	5,581	15,576
Total	424,906	99,675	60,113	107,228	686,387	54,534	185,556
Average	42,491	9,968	6,011	11,914	68,639	5,453	20,617

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records; quantities prior to 2008 are estimated.

[c]Estimated by District based on observation and historical information. Data prior to 2010 are not available.

[d] Estimated by District based on observation and historical information.

District/Company **Reclamation District 108**

TABLE 1

Reclamation District 108 – 2018 Surface Water Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	1,577	0	0	26	1,603
May	33,847	0	0	31	33,878
June	36,154	0	0	117	36,271
July	31,500	8,023	0	255	39,778
August	16,500	8,109	0	196	24,805
September	3,668	0	0	44	3,712
October	6,745	0	0	63	6,808
TOTAL	129,991	16,132	0	732	146,855

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

TABLE 2

Reclamation District 108 – 2018 Groundwater Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
TOTAL	0	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Reclamation District 108 – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	1,603	0	1,603
May	33,878	0	33,878
June	36,271	0	36,271
July	39,778	0	39,778
August	24,805	0	24,805
September	3,712	0	3,712
October	6,808	0	6,808
TOTAL	146,855	0	146,855

[a]In addition to the water supplies shown in Table 3, 59,405acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Reclamation District 108**

Reclamation District 108 – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Reclamation District 108 – 2018 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	528,000	24	291	45	1,163	2,909	(4,027)
Laterals	158,400	24	87	14	349	873	(1,208)
Water Shed Drains	0	0	0	0	0	0	0
TOTAL			378	59	1,512	3,782	(5,235)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Reclamation District 108**

TABLE 5

Reclamation District 108 – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	1,462	2.95	0.04	62	4,244	0.11	161
Beans	125	0.70	0.04	5	82	0.47	59
Corn	257	1.84	0.04	11	461	0.14	36
Cotton	55	2.28	0.04	2	123	0.02	1
Melons	27	1.09	0.00	0	29	0.04	1
Pasture	163	3.21	0.04	7	517	0.03	5
Persimmons	2	2.81	0.04	0	6	0.18	0
Rice	30,393	2.82	0.04	1,282	84,323	0.06	1,824
Rice Straw Decomp	18,640	0.50	0.04	786	8,534	0.00	0
Safflowers	70	1.62	0.04	3	110	0.06	4
Sunflowers	3,372	1.62	0.04	142	5,309	0.06	202
Tomatoes	4,039	1.56	0.04	170	6,127	0.08	323
Vineseed	1,002	0.94	0.04	42	904	0.18	180
Walnuts	3,041	3.07	0.04	128	9,215	0.16	487
Wheat	1,258	0.70	0.04	53	827	0.03	38
Crop Acres	63,906			2,694	120,811		3,321

Total Irrig. Acres 45,266 (If this number is larger than your known total, it may be due to double cropping.)

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 37,700 to 45,250 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Reclamation District 108_**

TABLE 6

Reclamation District 108 – 2018 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	146,855
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	4,469
Available Soil Moisture[c]	Estimated	2,733
	Total Water Supplies =	**154,056**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	3,782
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,453
Riparian ET[d] (Canals/Laterals)	Estimated	3,770
Conveyance System Filling[e] (Canals/Laterals)	Estimated	1,469
	Total Distribution System =	10,474
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	120,811
Evapotranspiration of Precip - ET_{pr}	Table 5	2,694
Cultural Practices *(includes Leaching Requirement)*	Table 5	3,321
	Total Crop Water Needs =	**126,826**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	6,140
Irrigation Season Rainfall Runoff[g]	Estimated	0
Rice Cultural and Ecosystem Requirement[h]	Estimated	30,393
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**25,870**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**59,405**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**(9,113)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Reclamation District 108_**

TABLE 7

Reclamation District 108 – 2018 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[c] (acre-feet)
2009	153,995	0	0	2,433	156,428	50,212	35,458
2010	124,132	20,245	0	2,984	147,361	84,430	22,080
2011	143,793	14,913	0	1,415	160,121	51,819	50,434
2012	141,324	17,967	0	1,160	160,451	53,739	39,975
2013	161,668	25,604	0	1,877	189,149	28,616	78,495
2014	122,334	0	0	780	123,114	51,216	41,217
2015	115,098	1,210	1,396	821	118,525	45,510	33,121
2016	137,703	16,237	0	629	154,569	43,537	33,146
2017	115,384	18,562	0	945	134,891	41,533	34,776
2018	129,991	16,132	0	732	146,855	59,405	25,870
Total	1,345,422	130,870	1,396	13,777	1,491,465	510,017	394,572
Average	134,542	13,087	140	1,378	149,146	51,002	39,457

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

District/Company **Reclamation District 1004**

TABLE 1

Reclamation District 1004 – 2018 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	835	0	9	0	844
May	12,892	0	2,445	0	15,337
June	13,390	0	3,528	0	16,918
July	8,423	6,000	3,578	0	18,001
August	3,600	2,660	4,365	0	10,625
September	4,836	0	1,194	0	6,030
October	10,278	0	235	0	10,513
TOTAL	54,254	8,660	15,354	0	78,268

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Reclamation District 1004 – 2018 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	230	0
June	89	0
July	1,272	0
August	61	0
September	0	0
October	296	0
TOTAL	1,947	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Reclamation District 1004 – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	844	0	844
May	15,337	230	15,567
June	16,918	89	17,007
July	18,001	1,272	19,273
August	10,625	61	10,686
September	6,030	0	6,030
October	10,513	296	10,808
TOTAL	78,268	1,947	80,215

[a]In addition to the water supplies shown in Table 3, 16,095 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Reclamation District 1004_**

Reclamation District 1004 – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Reclamation District 1004 – 2018 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canals	25,872	135	80	12	320	2,000	(2,307)
Canals	28,512	51	34	5	134	838	(967)
Canals	23,232	41	22	3	86	540	(623)
Laterals	42,768	32	31	5	124	773	(892)
Laterals	63,096	22	32	5	127	797	(919)
Laterals	47,256	15	16	3	65	410	(472)
Drains	29,568	44	30	5	119	742	(856)
Drains	29,568	28	19	3	77	480	(554)
Drains	85,536	15	29	5	118	736	(850)
Drains	12,144	12	3	1	13	84	(96)
TOTAL			296	46	1,183	7,399	(8,536)

[a]From District statistics.
[b]Average width of the conveyance facilities.
[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.
[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.
[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Reclamation District 1004**

TABLE 5

Reclamation District 1004 – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Beans	217	0.70	0.04	9	143	0.47	102
Corn	150	1.84	0.04	6	269	0.14	21
Habitat	7,129	2.43	0.04	301	17,033	0.03	214
Rice	13,792	2.82	0.04	582	38,265	0.06	828
Sunflowers	443	1.62	0.04	19	697	0.06	27
Tomatoes	134	1.56	0.04	6	203	0.08	11
Walnuts	181	3.07	0.04	8	549	0.16	29
Watermelon	148	1.09	0.00	0	162	0.04	6
Crop Acres	22,194			930	57,321		1,238
Total Irrig. Acres	22,194	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface water irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 17,000 to 20,000 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Reclamation District 1004**

TABLE 6

Reclamation District 1004 – 2018 District Water Balance

(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	80,215
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	1,997
Available Soil Moisture[c]	Estimated	234
	Total Water Supplies =	**82,447**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	7,399
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,137
Riparian ET[d] (Canals/Laterals)	Estimated	550
Conveyance System Filling[e] (Canals/Laterals)	Estimated	783
	Total Distribution System =	**9,869**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	57,321
Evapotranspiration of Precip - ET_{pr}	Table 5	930
Cultural Practices *(includes Leaching Requirement)*	Table 5	1,238
	Total Crop Water Needs =	**59,488**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Rice Cultural and Ecosystem Requirement[h]	Estimated	13,792
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**0**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**16,095**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**13,089**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Habitat Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Reclamation District 1004**

TABLE 7

Reclamation District 1004 – 2018 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[e] (acre-feet)
2009	38,151	12,170	20,255	0	70,576	10,600	0
2010	48,218	11,250	23,473	0	82,941	12,500	0
2011	35,874	10,639	23,395	0	69,908	7,436	0
2012	43,022	10,048	23,395	0	76,465	16,095	0
2013	41,573	10,802	25,677	0	78,052	16,095	0
2014	40,066	0	26,865	0	66,931	12,070	0
2015	30,276	5,044	8,944	0	44,264	8,050	0
2016	37,414	9,638	28,013	0	75,065	16,095	0
2017	33,980	9,293	18,947	0	62,220	7,500	0
2018	54,254	8,660	15,354	0	78,268	16,095	0
Total	402,828	87,544	214,318	0	704,690	122,536	0
Average	40,283	8,754	21,432	0	70,469	12,254	0

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records; quantities prior to 2008 are estimated.

[c]Estimated by District based on observation and historical information.

[d]Estimated by District based on observation and historical information.

[e]District operates a closed system with little or no outflow; drainwater from rice fields is recaptured and delivered for rice straw decomposition and habitat lands.

District/Company **Meridian Farms Water Company**

Meridian Farms Water Company – 2018 Surface Water Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	844	0			844
May	5,585	0		100	5,685
June	6,180	0		200	6,380
July	2,000	3,884		400	6,284
August	1,100	3,592		400	5,092
September	1,654	0		200	1,854
October	129	0		400	529
TOTAL	17,492	7,476	0	1,700	26,668

100

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2
Meridian Farms Water Company – 2018 Groundwater Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	855	380
June	882	547
July	973	616
August	722	553
September	199	0
October	0	0
TOTAL	3,631	2,096

[a]Estimated by District based on observation and historical information.

TABLE 3
Meridian Farms Water Company – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	844	0	844
May	5685	855	6540
June	6380	882	7262
July	6284	973	7257
August	5092	722	5814
September	1854	199	2053
October	529	0	529
TOTAL	26668	3631	30299

[a]In addition to the water supplies shown in Table 3, 15,509 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Meridian Farms Water Company**

Meridian Farms Water Company – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sep	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Meridian Farms Water Company – 2018 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	84,480	12	23	4	93	698	(788)
Pipeline	0	0	0	0	0	0	0
Laterals	100,320	12	28	4	110	829	(935)
Water Shed Drains	0	0	0	0	0	0	0
Reservoir	0	0	0	0	0	0	0
TOTAL			51	8	203	1,527	(1,723)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Meridian Farms Water Company**

TABLE 5

Meridian Farms Water Company – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	431	2.95	0.04	18	1,251	0.11	47
Beans	473	0.70	0.04	20	311	0.47	222
Corn	189	1.84	0.04	8	339	0.14	26
Cotton	20	2.28	0.04	1	45	0.02	0
Milo	20	1.84	0.04	1	36	0.02	0
Pecans	18	2.86	0.04	1	51	0.18	3
Persimmons	26	2.81	0.04	1	72	0.18	5
Prunes	63	2.81	0.04	3	174	0.18	11
Rice	3,457	2.82	0.04	146	9,591	0.06	207
Safflowers	48	1.62	0.04	2	76	0.06	3
Sunflowers	1,107	1.62	0.04	47	1,743	0.06	66
Tomatoes	1,053	1.56	0.04	44	1,597	0.08	84
Vetch	104	3.21	0.04	4	330	0.06	6
Vineseed	199	0.94	0.04	8	180	0.18	36
Walnuts	999	3.07	0.04	42	3,027	0.16	160
Wheat	780	0.70	0.04	33	512	0.03	23
Crop Acres	8,987			379	19,335		899
Total Irrig. Acres	8,987	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 4,200 to 5,200 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Meridian Farms Water Company_**

TABLE 6

Meridian Farms Water Company – 2018 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	30,299
Private Groundwater	Table 2	2,096
Inflow From Precip[b]	Estimated	460
Available Soil Moisture[c]	Estimated	1,016
	Total Water Supplies =	**33,871**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	1,527
Evaporation - Precipitation (Canals/Laterals)	Table 4	196
Riparian ET[d] (Canals/Laterals)	Estimated	1,706
Conveyance System Filling[e] (Canals/Laterals)	Estimated	267
	Total Distribution System =	**3,696**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	19,335
Evapotranspiration of Precip - ET_{pr}	Table 5	379
Cultural Practices *(includes Leaching Requirement)*	Table 5	899
	Total Crop Water Needs =	**20,613**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	539
Rice Cultural and Ecosystem Requirement[h]	Estimated	3,457
Uplslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**2,628**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**15,509**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**6,935**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Meridian Farms Water Company_**

TABLE 7

Meridian Farms Water Company – 2018 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2009	17,090	8,611	-	7,420	33,121	7,420	3,165
2010	17,530	9,512	0	8,695	35,737	8,695	5,499
2011	16,792	10,565	0	10,915	38,272	10,915	6,750
2012	19,349	11,208	0	11,625	42,182	11,625	5,825
2013	20,899	9,281	0	800	30,980	20,618	3,871
2014	16,630	4,043	0	900	21,573	10,663	2,574
2015	16,353	2,229	0	750	19,332	11,000	2,426
2016	18,170	8,563	0	900	27,633	19,503	3,052
2017	11,214	7,313	0	1,700	20,227	12,734	2,750
2018	17,492	7,476	0	1,700	26,668	15,509	2,628
Total	171,519	78,801	0	45,405	295,725	128,682	38,540
Average	17,152	7,880	0	4,541	29,573	12,868	3,854

[a]Federal Ag Water Supply from Reclamation Water Account Records. Data prior to 2010 are not available.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013
[d]Estimated by District based on observation and historical information.

District/Company **Sutter Mutual Water Company**

Sutter Mutual Water Company – 2018 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	4,413	0	0	0	4,413
May	41,859	0	0	0	41,859
June	38,712	0	0	0	38,712
July	28,500	10,733	0	0	39,233
August	20,000	11,335	0	0	31,335
September	5,000	1,668	0	0	6,668
October	5,500	0	0	0	5,500
TOTAL	143,984	23,736	0	0	167,720

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2
Sutter Mutual Water Company – 2018 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
November	0	0
December	0	0
TOTAL	0	0

[a]Estimated by District based on observation and historical information.

TABLE 3
Sutter Mutual Water Company – 2018 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	4,413	0	4,413
May	41,859	0	41,859
June	38,712	0	38,712
July	39,233	0	39,233
August	31,335	0	31,335
September	6,668	0	6,668
October	5,500	0	5,500
TOTAL	167,720	0	167,720

[a]In addition to the water supplies shown in Table 3, 53,285 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Sutter Mutual Water Company_**

Sutter Mutual Water Company – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Sutter Mutual Water Company – 2018 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Main Canal	39,690	90	82	13	328	2,460	(2,775)
West Canal	52,530	90	109	17	434	3,256	(3,673)
Central Canal	50,640	75	87	14	349	2,180	(2,515)
East Canal	71,970	75	124	19	495	3,098	(3,574)
Laterals	533,390	12	147	23	587	3,673	(4,238)
Sub-Laterals	146,060	8	27	4	107	268	(371)
TOTAL			575	90	2,300	14,935	(17,146)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Sutter Mutual Water Company_**

TABLE 5

Sutter Mutual Water Company – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres (crop acres)	Crop ET[a] (AF/Ac)	Effective Precipitation[b] (AF/Ac)	Effective Precipitation[b] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	644	2.95	0.04	27	1,870	0.11	71
Beans	804	0.70	0.04	34	528	0.47	378
Corn	2,391	1.84	0.04	101	4,291	0.14	335
Milo	100	1.84	0.04	4	179	0.02	2
Melons	386	1.09	0.00	0	421	0.04	15
Rice	29,175	2.82	0.04	1,230	80,944	0.06	1,751
Rice Straw Decomp	16,129	0.50	0.04	680	7,384	0.00	0
Safflowers	279	1.62	0.04	12	439	0.06	17
Sunflowers	5,788	1.62	0.04	244	9,112	0.06	347
Tomatoes	3,324	1.56	0.04	140	5,042	0.08	266
Vineseed	1,169	0.94	0.04	49	1,055	0.18	210
Walnuts	44	3.07	0.04	2	133	0.16	7
Wheat	1,269						
Crop Acres	61,502			2,524	111,401		3,399
Total Irrig. Acres	45,373	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 37,000 to 44,350 acre-feet in 2018).

[b]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Sutter Mutual Water Company**

TABLE 6

Sutter Mutual Water Company – 2018 District Water Balance

(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	167,720
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	4,249
Available Soil Moisture[c]	Estimated	2,976
	Total Water Supplies =	**174,946**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	14,935
Evaporation - Precipitation (Canals/Laterals)	Table 4	2,210
Riparian ET[d] (Canals/Laterals)	Estimated	500
Conveyance System Filling[e] (Canals/Laterals)	Estimated	1,677
	Total Distribution System =	**19,323**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	111,401
Evapotranspiration of Precip - ET_{pr}	Table 5	2,524
Cultural Practices *(includes Leaching Requirement)*	Table 5	3,399
	Total Crop Water Needs =	**117,323**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	4,546
Rice Cultural and Ecosystem Requirement[h]	Estimated	29,175
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	24,790
	Total District Outflow *(from District Records)* **=**	58,511
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**53,285**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**(20,212)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f] Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

District/Company **_Sutter Mutual Water Company_**

TABLE 7

Sutter Mutual Water Company – 2018 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2009	153,526	35,436	-	-	188,962	57,303	-
2010	142,185	58,326	0	0	200,511	62,316	77,886
2011	136,388	57,423	0	0	193,811	55,954	98,092
2012	134,711	47,314	0	0	182,025	68,493	60,618
2013	163,680	41,675	0	0	205,355	33,062	71,625
2014	127,125	20,028	0	0	147,153	74,162	5,123
2015	126,193	16,662	0	0	142,855	73,068	2,603
2016	140,290	26,124	0	0	166,414	69,499	53,551
2017	128,676	38,505	0	0	167,181	44,571	64,513
2018	143,984	23,736	0	0	167,720	53,285	58,511
Total	1,396,758	365,229	0	0	1,761,987	591,713	492,522
Average	139,676	36,523	0	0	176,199	59,171	54,725

[a]Federal Ag Water Supply from Reclamation Water Account Records. Includes Project water transferred into SMWC in 2006 and 2010.
[b]Non-Federal Ag Water Supply from District Records. Data prior to 2010 are not available.
[c]Estimated by District based on observation and historical information. Data prior to 2010 are not available.
[d]The Department quit measuring outflow Karnak after 2003; SMWC has calculated outflow since 2010. Data prior to 2010 are not available.

District/Company **_Natomas Central Mutual Water District_**

TABLE 1

Natomas Central Mutual Water District – 2018 Surface Water Supply

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[b] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	252	0	0	0	252
May	15,939	0	0	0	15,939
June	14,215	0	0	0	14,215
July	13,449	7,200	0	0	20,649
August	3,900	8,556	0	0	12,456
September	2,210	0	0	0	2,210
October	560	0	0	0	560
TOTAL	50,525	15,756	0	0	66,281

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Water from non-Company lands enters the drainage system throughout the April through October period. The quantity for 2018 is unknown at this time but is included in the quantity recycled and reused shown in Table 6.

TABLE 2

Natomas Central Mutual Water District – 2018 Groundwater Supply

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	10	0
June	10	0
July	10	0
August	10	0
September	10	0
October	0	0
TOTAL	50	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Natomas Central Mutual Water District – 2018 Total District Water Supply (excluding reuse)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	252	0	252
May	15,939	10	15,949
June	14,215	10	14,225
July	20,649	10	20,659
August	12,456	10	12,466
September	2,210	10	2,220
October	560	0	560
TOTAL	66,281	50	66,331

[a]In addition to the water supplies shown in Table 3, 59,978 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Natomas Central Mutual Water District**

Natomas Central Mutual Water District – 2018 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2018	**Precipitation[a]**		**Evaporation[b]**	
	inches	**feet**	**inches**	**feet**
Jan	3.3	0.28	1.0	0.09
Feb	0.3	0.02	3.3	0.28
Mar	3.6	0.30	3.7	0.31
Apr	1.3	0.11	5.4	0.45
May	0.2	0.02	7.8	0.65
Jun	0.0	0.00	8.6	0.72
Jul	0.0	0.00	8.4	0.70
Aug	0.0	0.00	7.0	0.59
Sept	0.0	0.00	5.9	0.49
Oct	0.3	0.02	4.8	0.40
Nov	2.5	0.21	2.5	0.21
Dec	1.6	0.14	1.6	0.13
TOTAL-YR	13.2	1.10	60.1	5.01
TOTAL-Apr-Oct	**1.9**	**0.16**	**48.0**	**4.00**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Natomas Central Mutual Water District – 2018 Distribution System Evaporation and Seepage

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	**Length[a] (feet)**	**Width[b] (feet)**	**Surface Area (acres)**	**Precipitation[c] (acre-feet)**	**Evaporation[d] (acre-feet)**	**Seepage[e] (acre-feet)**	**Total (acre-feet)**
Bennet System	44,700	56	58	9	231	579	(801)
Northern System	146,400	54	180	28	721	1,805	(2,498)
Prichard Lake Sys	204,400	54	252	39	1,005	2,515	(3,481)
Elkhorn System	75,100	44	76	12	305	762	(1,055)
Riverside System	65,800	46	69	11	277	692	(958)
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
TOTAL			635	99	2,539	6,353	(8,793)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Natomas Central Mutual Water District**

TABLE 5

Natomas Central Mutual Water District – 2018 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	51	2.95	0.04	2	148	0.11	6
Corn	190	1.84	0.04	8	341	0.14	27
Golf Course	209	3.38	0.04	9	698	0.03	6
Hops	4	0.94	0.04	0	4	0.18	1
Managed Marsh	608	2.97	0.04	26	1,780	0.00	0
Melons	10	1.09	0.00	0	11	0.04	0
Oats	150	0.70	0.04	6	99	0.02	3
Onions	33	0.83	0.04	1	26	0.28	9
Pasture	32	3.21	0.04	1	101	0.03	1
Pears	7	2.81	0.04	0	19	0.18	1
Peppers	5	1.56	0.04	0	8	0.08	0
Pumpkins	37	1.09	0.00	0	40	0.04	1
Rice	15,373	2.82	0.04	648	42,651	0.06	922
Rice Straw Decomp	9,294	0.50	0.04	392	4,255	0.00	0
Safflowers	564	1.62	0.04	24	888	0.06	34
Squash	339	1.09	0.00	0	370	0.04	14
Sunflowers	377	1.62	0.04	16	594	0.06	23
Tomatoes	50	1.56	0.04	2	76	0.08	4
Wheat	521	0.70	0.04	22	342	0.03	16
Crop Acres	27,854			1,158	52,451		1,068
Total Irrig. Acres	17,475	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 19,500 to 23,500 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field

District/Company **Natomas Central Mutual Water District**

TABLE 6

Natomas Central Mutual Water District – 2018 District Water Balance

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	66,331
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	2,257
Available Soil Moisture[c]	Estimated	474
	Total Water Supplies =	**69,062**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	6,353
Evaporation - Precipitation (Canals/Laterals)	Table 4	2,440
Riparian ET[d] (Canals/Laterals)	Estimated	592
Conveyance System Filling[e] (Canals/Laterals)	Estimated	663
	Total Distribution System =	**10,048**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	52,451
Evapotranspiration of Precip - ET_{pr}	Table 5	1,158
Cultural Practices *(includes Leaching Requirement)*	Table 5	1,068
	Total Crop Water Needs =	**54,677**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Rice Cultural and Ecosystem Requirement[h]	Estimated	15,373
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* =	7,052
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**59,978**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**(2,715)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

District/Company **_Natomas Central Mutual Water District_**

TABLE 7

Natomas Central Mutual Water District – 2018 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag	Upslope		District	
	Base Supply (acre-feet)	Project Water (acre-feet)	Water Supply[b] (acre-feet)	Drainwater[c] (acre-feet)	Total (acre-feet)	Recapture (acre-feet)	Outflow[d] (acre-feet)
2009	48,297	8,919	-	-	57,216	43,359	-
2010	41,778	10,997	-	-	52,775	44,224	-
2011	37,349	8,707	0	0	46,056	39,989	15,000
2012	35,685	8,322	0	0	44,007	59,923	15,115
2013	48,050	13,073	0	28,288	89,411	51,433	10,317
2014	57,654	16,397	0	0	74,051	49,466	3,952
2015	58,255	15,093	0	0	73,348	65,147	2,028
2016	54,200	13,418	0	0	67,618	53,092	2,167
2017	53,451	16,882	0	0	70,333	55,967	3,418
2018	50,525	15,756	0	0	66,281	59,978	7,052
Total	485,244	127,564	0	28,288	641,096	522,579	59,049
Average	48,524	12,756	0	3,536	64,110	52,258	7,381

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records. Data prior to 2010 not available.

[c]Estimated by District based on observation and historical information. Data prior to 2010 not available.

[d]Data prior to 2010 are not available.

2019 Water Balance Summaries

District/Company **Anderson Cottonwood Irrigation District**

TABLE 1

Anderson Cottonwood Irrigation District – 2019 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	0	0	0	0	0
May	14,885	0	0	0	14,885
June	16,086	0	0	0	16,086
July	17,421	0	0	0	17,421
August	15,887	0	0	0	15,887
September	13,587	0	0	0	13,587
October	10,452	0	0	0	10,452
TOTAL	88,318	0	0	0	88,318

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Anderson Cottonwood Irrigation District – 2019 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
TOTAL	0	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Anderson Cottonwood Irrigation District – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	0	0	0
May	14,885	0	14,885
June	16,086	0	16,086
July	17,421	0	17,421
August	15,887	0	15,887
September	13,587	0	13,587
October	10,452	0	10,452
TOTAL	88,318	0	88,318

[a]In addition to the water supplies shown in Table 3, 3,350 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Anderson Cottonwood Irrigation District_**

Anderson Cottonwood Irrigation District – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	5.5	0.46	1.4	0.12
Feb	8.7	0.73	1.8	0.15
Mar	4.6	0.39	3.3	0.27
Apr	0.6	0.05	5.5	0.46
May	3.0	0.25	7.0	0.58
Jun	0.0	0.00	9.8	0.81
Jul	0.0	0.00	9.2	0.76
Aug	0.0	0.00	8.0	0.67
Sept	0.3	0.03	6.1	0.51
Oct	0.0	0.00	5.3	0.44
Nov	0.1	0.01	2.7	0.23
Dec	2.7	0.23	1.9	0.16
TOTAL-YR	25.6	2.14	61.9	5.16
TOTAL-Apr-Oct	**4.0**	**0.33**	**50.9**	**4.24**

[a]Precipitation is precipitation reported for CIMIS Station at Gerber South (#222).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the reference ET (ETo) reported for the Gerber South CIMIS Station.

TABLE 4

Anderson Cottonwood Irrigation District – 2019 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	177,952	30	123	40	519	24,511	(24,990)
Laterals	871,324	10	200	66	848	11,202	(11,984)
TOTAL			323	106	1,367	35,713	(36,974)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season (April-October).

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Anderson Cottonwood Irrigation District_**

TABLE 5

Anderson Cottonwood Irrigation District – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop Et[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	230	3.20	0.13	30	706	0.11	25
Pasture	6,772	3.26	0.13	880	21,186	0.03	203
Walnuts	1,700	3.41	0.13	221	5,583	0.16	272
Crop Acres	8,702			1,131	27,475		500
Total Irrig. Acres	8,702	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Station at Gerber South (#222) x Kc based on ITRC Wet Year ETc for Zone 14 surface irrigation for water balances. Water Needs do not include water required for cultural practices.

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season.

District/Company **Anderson Cottonwood Irrigation District**

TABLE 6

Anderson Cottonwood Irrigation District – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	88,318
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	0
Available Soil Moisture[c]	Estimated	3,971
	Total Water Supplies =	**92,289**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	35,713
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,261
Riparian ET[d] (Canals/Laterals)	Estimated	1,433
Conveyance System Filling[e] (Canals/Laterals)	Estimated	883
	Total Distribution System =	**39,290**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	27,475
Evapotranspiration of Precip - ET_{pr}	Table 5	1,131
Cultural Practices *(includes Leaching Requirement)*	Table 5	500
	Total Crop Water Needs =	**29,106**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Upslope Drainwater Flow Through[h]	Estimated	0
Remainder Drainwater Outflow[i]	District Records	1,536
	Total District Outflow *(from District Records)* **=**	**1,536**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**3,350**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**22,357**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs. Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on crop acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for cultural practices.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Anderson Cottonwood Irrigation District**

TABLE 7

Anderson Cottonwood Irrigation District – 2019 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2010	100,009	-	-	-	100,009	3,151	15,000
2011	89,814	0	0	0	89,814	3,150	15,000
2012	101,229	0	0	0	101,229	3,239	15,000
2013	108,600	0	0	0	108,600	3,340	2,755
2014	86,702	0	0	0	86,702	3,215	1,240
2015	87,315	0	0	0	87,315	3,350	1,150
2016	103,104	0	0	0	103,104	3,350	1,536
2017	91,478	0	0	0	91,478	3,350	1,536
2018	91,401	0	0	0	91,401	3,350	1,536
2019	88,318	0	0	0	88,318	3,350	1,536
Total	947,970	0	0	0	947,970	32,845	56,289
Average	94,797	0	0	0	94,797	3,285	5,629

[a]Federal Ag Water Supply from Reclamation Water Account Records. Data prior to 2011 are not available.

[b]Non-Federal Ag Water Supply from District Records. Data prior to 2011 are not available.

[c]Estimated by District based on observation and historical information. Data prior to 2011 are not available.

[d]Estimated by District based on observation and historical information.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 1

Glenn-Colusa Irrigation District – 2019 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	32,614	3	0	48	32,665
May	128,616	1	0	491	129,108
June	138,972	5	0	472	139,449
July	130,000	28,240	0	488	158,728
August	90,000	39,645	0	167	129,812
September	28,778	9	0	49	28,836
October	26,959	12	0	0	26,971
TOTAL	575,939	67,915	0	1,715	645,569

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Glenn-Colusa Irrigation District – 2019 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	1,239
May	0	1,858
June	0	1,858
July	0	2,478
August	0	2,478
September	0	1,239
October	0	1,239
TOTAL	0	12,389

[a]Estimated by District based on observation and historical information.

TABLE 3

Glenn-Colusa Irrigation District – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	32,665	0	32,665
May	129,108	0	129,108
June	139,449	0	139,449
July	158,728	0	158,728
August	129,812	0	129,812
September	28,836	0	28,836
October	26,971	0	26,971
TOTAL	645,569	0	645,569

[a]In addition to the water supplies shown in Table 3, 165,728 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Glenn-Colusa Irrigation District_**

Glenn-Colusa Irrigation District – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Glenn-Colusa Irrigation District – 2019 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	341,200	70	548	139	2,307	10,966	(13,134)
Pipeline	26,400	2	0	0	0	0	0
Laterals	3,495,360	12	963	243	4,051	4,815	(8,622)
Watershed Drains	2,919,840	15	1,005	254	4,230	5,027	(9,003)
TOTAL			2,517	636	10,588	20,808	(30,760)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Glenn-Colusa Irrigation District**

TABLE 5

Glenn-Colusa Irrigation District – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	1,452	2.86	0.09	129	4,029	0.11	160
Almonds	12,473	2.88	0.09	1,110	34,805	0.18	2,245
Beans	205	0.38	0.09	18	60	0.47	96
Corn	667	2.04	0.09	59	1,303	0.14	93
Cotton	199	2.64	0.09	18	507	0.02	4
Grain	50	0.38	0.09	4	15	0.02	1
Habitat	602	3.24	0.09	54	1,897	0.03	18
Misc. Deciduous	2	2.82	0.09	0	5	0.16	0
Olives	245	2.82	0.09	22	670	0.09	22
Onions	43	0.60	0.09	4	22	0.28	12
Pasture	2,898	3.07	0.09	258	8,633	0.03	87
Prunes	141	2.92	0.09	13	399	0.18	25
Rice	100,122	2.96	0.09	8,911	287,229	0.06	6,007
Rice Straw Decomp	35,121	0.50	0.09	3,126	14,435	0.00	0
Rye Grass	150	0.87	0.09	13	117	0.02	3
Safflowers	0	1.34	0.09	0	0	0.06	0
Sudan	147	3.07	0.09	13	438	0.07	10
Sunflowers	1,017	1.34	0.09	91	1,267	0.06	61
Tomatoes	1,201	1.73	0.09	107	1,973	0.08	96
Vegetables	10	0.71	0.09	1	6	0.18	2
Vineseed	1,409	0.71	0.09	125	880	0.18	254
Walnuts	9,181	3.22	0.09	817	28,783	0.16	1,469
Crop Acres	167,335			14,893	387,474		10,665
Total Irrig. Acres	132,214	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 123,750 to 148,500 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 6

Glenn-Colusa Irrigation District – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	645,569
Private Groundwater	Table 2	12,389
Inflow From Precip[b]	Estimated	25,291
Available Soil Moisture[c]	Estimated	12,678
	Total Water Supplies =	**695,927**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	20,808
Evaporation - Precipitation (Canals/Laterals)	Table 4	9,952
Riparian ET[d] (Canals/Laterals)	Estimated	6,500
Conveyance System Filling[e] (Canals/Laterals)	Estimated	8,000
	Total Distribution System =	**45,260**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	387,474
Evapotranspiration of Precip - ET_{pr}	Table 5	14,893
Cultural Practices *(includes Leaching Requirement)*	Table 5	10,665
	Total Crop Water Needs =	**413,032**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	35,397
Irrigation Season Rainfall Runoff[g]	Estimated	25,309
Rice Cultural and Ecosystem Requirement[h]	Estimated	50,000
Upslope Drainwater Flow Through[i]	Estimated	506
Remainder Drainwater Outflow[j]	Calculated	34,296
	Total District Outflow *(from District Records)* **=**	145,507
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**165,728**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**92,128**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 7

Glenn-Colusa Irrigation District – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow (acre-feet)
2010	572,352	91,017	0	22,500	685,869	194,677	229,665
2011	571,617	86,014	0	40,500	698,131	190,994	255,999
2012	605,963	90,277	0	40,500	736,740	206,542	197,899
2013	698,625	72,274	0	1,650	772,549	217,694	207,154
2014	496,915	52,171	0	1,700	550,786	131,520	102,168
2015	452,681	60,381	0	1,360	514,422	115,694	79,238
2016	623,198	66,038	0	1,600	690,836	167,918	148,275
2017	601,963	66,394	0	1,850	670,207	166,397	136,716
2018	629,818	51,319	0	1,633	682,770	167,293	148,418
2019	575,939	67,915	0	1,715	645,569	165,728	145,507
Total	5,829,071	703,800	0	115,008	6,647,879	1,724,457	1,651,039
Average	582,907	70,380	0	11,501	664,788	172,446	165,104

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013.

District/Company **Provident Irrigation District**

TABLE 1

Provident Irrigation District – 2019 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	2,794	0	340	143	3,277
May	8,146	0	3,749	3,537	15,432
June	9,515	0	4,661	3,253	17,429
July	6,300	3,458	6,784	4,326	20,868
August	2,500	1,000	5,749	5,451	14,700
September	106	0	0	2,236	2,342
October	2,570	0	544	295	3,409
TOTAL	31,931	4,458	21,827	19,241	77,457

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Provident Irrigation District – 2019 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	57	0
May	292	0
June	260	0
July	482	0
August	189	0
September	0	0
October	112	0
TOTAL	1,392	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Provident Irrigation District – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	3,277	57	3,334
May	15,432	292	15,724
June	17,429	260	17,689
July	20,868	482	21,350
August	14,700	189	14,889
September	2,342	0	2,342
October	3,409	112	3,521
TOTAL	77,457	1,392	78,849

[a]In addition to the water supplies shown in Table 3, 5,657 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Provident Irrigation District**

Provident Irrigation District – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Provident Irrigation District – 2019 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	65,472	35	53	13	221	1,315	(1,523)
Laterals	206,448	12	57	14	239	569	(794)
Water Shed Drains	175,276	15	60	15	254	302	(540)
TOTAL			170	43	715	2,186	(2,857)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season (April-October).

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Provident Irrigation District**

TABLE 5

Provident Irrigation District – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Acres[a]	Crop ET[b]	Effective Precipitation[c]		ETAW	Leaching Requirement	
Crop Name	**(crop acres)**	**(AF/Ac)**	**(AF/Ac)**	**(acre-feet)**	**(acre-feet)**	**(AF/Ac)**	**(acre-feet)**
Rice	14,207	2.96	0.09	1,264	40,757	0.06	852
Rice Straw Decomp	7,410	0.50	0.09	659	3,046	0.00	0
Crop Acres	21,617			1,924	43,802		852
Total Irrig. Acres	14,207	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 17,000 to 21,000 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Provident Irrigation District_**

TABLE 6

Provident Irrigation District – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	78,849
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	3,589
Available Soil Moisture[c]	Estimated	0
	Total Water Supplies =	**82,438**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	2,186
Evaporation - Precipitation (Canals/Laterals)	Table 4	672
Riparian ET[d] (Canals/Laterals)	Estimated	100
Conveyance System Filling[e] (Canals/Laterals)	Estimated	775
	Total Distribution System =	**3,732**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	43,802
Evapotranspiration of Precip - ET_{pr}	Table 5	1,924
Cultural Practices *(includes Leaching Requirement)*	Table 5	852
	Total Crop Water Needs =	**46,578**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	4,623
Irrigation Season Rainfall Runoff[g]	Estimated	3,591
Rice Cultural and Ecosystem Requirement[h]	Estimated	14,207
Upslope Drainwater Flow Through	Estimated	3,467
Remainder Drainwater Outflow[i]	Calculated	53
	Total District Outflow *(from District Records)* **=**	**25,940**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**5,657**
	Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**6,187**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Provident Irrigation District_**

TABLE 7

Provident Irrigation District – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b,c] (acre-feet)	Upslope Drainwater[c,d] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[d] (acre-feet)
2010	31,879	4,500	6,727	70,534	113,640	10,233	49,935
2011	26,671	3,346	6,619	73,953	110,589	9,983	53,382
2012	31,466	3,278	27,068	23,651	85,463	9,210	25,268
2013	34,154	2,429	22,195	47,283	106,061	6,022	30,493
2014	27,847	40	2,798	30,338	61,023	2,617	20,618
2015	32,830	0	273	29,494	62,597	6,619	22,479
2016	31,978	1,193	23,035	21,856	78,062	6,836	18,893
2017	33,240	3,723	19,342	19,901	76,206	6,644	30,254
2018	35,413	2,698	20,443	18,475	77,029	6,601	28,352
2019	31,931	4,458	21,827	19,241	77,457	5,657	25,940
Total	317,409	25,665	150,327	354,726	848,127	70,422	305,614
Average	31,741	2,567	15,033	35,473	84,813	7,042	30,561

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013.

[d]Data prior to 2010 are not available.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 1

Princeton-Codora-Glenn Irrigation District – 2019 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	2,191	0	193	0	2,384
May	11,550	0	1,845	0	13,395
June	11,651	0	3,004	0	14,655
July	6,740	5,108	4,931	0	16,779
August	2,780	6,484	3,785	0	13,049
September	1,121	0	809	0	1,930
October	1,400	0	77	0	1,477
TOTAL	37,433	11,592	14,644	0	63,669

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Princeton-Codora-Glenn Irrigation District – 2019 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	140	0
May	322	1,339
June	400	1,339
July	1,357	1,339
August	1,603	1,339
September	72	1,339
October	0	0
TOTAL	3,894	6,695

[a]Estimated by District based on observation and historical information.

TABLE 3

Princeton-Codora-Glenn Irrigation District – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	2,384	140	2,524
May	13,395	322	13,717
June	14,655	400	15,055
July	16,779	1,357	18,136
August	13,049	1,603	14,652
September	1,930	72	2,002
October	1,477	0	1,477
TOTAL	63,669	3,894	67,563

[a]In addition to the water supplies shown in Table 3, 5,831 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

Princeton-Codora-Glenn Irrigation District – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Princeton-Codora-Glenn Irrigation District – 2019 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	68,640	30	47	12	199	11,818	(12,005)
Laterals	219,384	15	76	19	318	5,666	(5,965)
Water Shed Drains	113,520	15	39	10	164	1,955	(2,109)
TOTAL			162	41	681	19,439	(20,079)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 5

Princeton-Codora-Glenn Irrigation District – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Almonds	80	2.88	0.09	7	223	0.18	14
Pasture	23	3.07	0.09	2	69	0.03	1
Persimmons	1	2.92	0.09	0	3	0.18	0
Rice	7,442	2.96	0.09	662	21,350	0.06	447
Rice Straw Decomp	1,046	0.50	0.09	93	430	0.00	0
Sudan	20	3.07	0.09	2	60	0.07	1
Sunflowers	34	1.34	0.09	3	42	0.06	2
Walnuts	1,339	3.22	0.09	119	4,198	0.16	214
Wheat	6	0.38	0.09	1	2	0.03	0
Crop Acres	9,991			889	26,376		679
Total Irrig. Acres	8,945	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 9,000 to 11,000 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 6

Princeton-Codora-Glenn Irrigation District – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	67,563
Private Groundwater	Table 2	6,695
Inflow From Precip[b]	Estimated	1,879
Available Soil Moisture[c]	Estimated	605
	Total Water Supplies =	**76,743**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	19,439
Evaporation - Precipitation (Canals/Laterals)	Table 4	640
Riparian ET[d] (Canals/Laterals)	Estimated	100
Conveyance System Filling[e] (Canals/Laterals)	Estimated	637
	Total Distribution System =	**20,816**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	26,376
Evapotranspiration of Precip - ET_{pr}	Table 5	889
Cultural Practices *(includes Leaching Requirement)*	Table 5	679
	Total Crop Water Needs =	**27,944**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	1,881
Rice Cultural and Ecosystem Requirement[h]	Estimated	7,442
Upslope Drainwater Flow Through	Estimated	0
Remainder Drainwater Outflow[i]	Calculated	5,663
	Total District Outflow *(from District Records)* **=**	**14,987**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**5,831**
	Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**12,997**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Princeton-Codora-Glenn Irrigation District**

TABLE 7

Princeton-Codora-Glenn Irrigation District – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[c] (acre-feet)
2010	44,869	14,428	0	23,736	83,033	5,531	27,428
2011	38,257	12,485	0	26,189	76,931	7,664	26,460
2012	43,303	12,950	17,908	12,856	87,017	8,702	26,388
2013	47,890	10,231	11,453	16,828	86,402	7,383	26,388
2014	38,389	2,789	1,084	15,095	51,822	3,138	17,747
2015	38,888	6,457	99	12,524	57,968	2,627	13,598
2016	43,899	8,269	6,498	0	58,666	3,514	16,408
2017	38,780	10,792	11,375	0	60,947	4,316	15,564
2018	39,831	7,427	11,696	0	58,954	5,581	15,576
2019	37,433	11,592	14,644	0	63,669	5,831	14,987
Total	411,539	97,420	74,758	107,228	685,410	54,287	200,542
Average	41,154	9,742	7,476	10,723	68,541	5,429	20,054

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. Data prior to 2010 are not available.

[d] Estimated by District based on observation and historical information.

District/Company **Reclamation District 108**

TABLE 1

Reclamation District 108 – 2019 Surface Water Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	1,977	0	0	0	1,977
May	25,653	0	0	217	25,870
June	32,597	0	0	205	32,802
July	31,922	9,301	0	283	41,506
August	16,500	13,699	0	519	30,718
September	5,047	0	0	121	5,168
October	3,851	0	0	39	3,890
TOTAL	117,547	23,000	0	1,384	141,931

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Reclamation District 108 – 2019 Groundwater Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
TOTAL	0	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Reclamation District 108 – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	1,977	0	1,977
May	25,870	0	25,870
June	32,802	0	32,802
July	41,506	0	41,506
August	30,718	0	30,718
September	5,168	0	5,168
October	3,890	0	3,890
TOTAL	141,931	0	141,931

[a]In addition to the water supplies shown in Table 3, 61,656acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Reclamation District 108**

Reclamation District 108 – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Reclamation District 108 – 2019 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	528,000	24	291	74	1,224	2,909	(4,059)
Laterals	158,400	24	87	22	367	873	(1,218)
Water Shed Drains	0	0	0	0	0	0	0
TOTAL			378	96	1,591	3,782	(5,277)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Reclamation District 108_**

TABLE 5

Reclamation District 108 – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	1,373	2.86	0.09	122	3,810	0.11	151
Beans	372	0.38	0.09	33	109	0.47	175
Corn	69	2.04	0.09	6	135	0.14	10
Cotton	77	2.64	0.09	7	196	0.02	2
Melons	410	1.40	0.09	36	539	0.04	16
Pasture	163	3.07	0.09	15	486	0.03	5
Persimmons	2	2.92	0.09	0	6	0.18	0
Rice	30,123	2.96	0.09	2,681	86,417	0.06	1,807
Rice Straw Decomp	18,616	0.50	0.09	1,657	7,651	0.00	0
Safflowers	404	1.34	0.09	36	503	0.06	24
Sunflowers	2,698	1.34	0.09	240	3,362	0.06	162
Tomatoes	3,637	1.73	0.09	324	5,976	0.08	291
Vineseed	1,279	0.71	0.09	114	799	0.18	230
Walnuts	2,771	3.22	0.09	247	8,687	0.16	443
Wheat	1,537	0.38	0.09	137	449	0.03	46
		2.00					
Crop Acres	63,531			5,654	119,125		3,362
Total Irrig. Acres	44,915	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 36,000 to 42,950 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Reclamation District 108**

TABLE 6

Reclamation District 108 – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	141,931
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	7,611
Available Soil Moisture[c]	Estimated	5,955
	Total Water Supplies =	**155,498**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	3,782
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,495
Riparian ET[d] (Canals/Laterals)	Estimated	3,770
Conveyance System Filling[e] (Canals/Laterals)	Estimated	1,419
	Total Distribution System =	10,466
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	119,125
Evapotranspiration of Precip - ET_{pr}	Table 5	5,654
Cultural Practices *(includes Leaching Requirement)*	Table 5	3,362
	Total Crop Water Needs =	**128,141**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	4,534
Irrigation Season Rainfall Runoff[g]	Estimated	290
Rice Cultural and Ecosystem Requirement[h]	Estimated	30,123
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**30,413**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**61,656**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**(13,523)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Reclamation District 108**

TABLE 7

Reclamation District 108 – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[c] (acre-feet)
2010	124,132	20,245	0	2,984	147,361	84,430	22,080
2011	143,793	14,913	0	1,415	160,121	51,819	50,434
2012	141,324	17,967	0	1,160	160,451	53,739	39,975
2013	161,668	25,604	0	1,877	189,149	28,616	78,495
2014	122,334	0	0	780	123,114	51,216	41,217
2015	115,098	1,210	1,396	821	118,525	45,510	33,121
2016	137,703	16,237	0	629	154,569	43,537	33,146
2017	115,384	18,562	0	945	134,891	41,533	34,776
2018	129,991	16,132	0	732	146,855	59,405	25,870
2019	117,547	23,000	0	1,384	141,931	61,656	30,413
Total	1,308,974	153,870	1,396	12,728	1,476,968	521,461	389,527
Average	130,897	15,387	140	1,273	147,697	52,146	38,953

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

District/Company **Reclamation District 1004**

TABLE 1

Reclamation District 1004 – 2019 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	508	0	288	0	796
May	6,944	0	2,178	0	9,122
June	8,101	0	2,594	0	10,695
July	6,100	5,955	4,523	0	16,578
August	3,600	3,343	3,810	0	10,753
September	2,602	0	2,647	0	5,249
October	10,147	0	1,198	0	11,345
TOTAL	38,002	9,298	17,239	0	64,539

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Reclamation District 1004 – 2019 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	175	0
August	176	0
September	0	0
October	201	0
TOTAL	553	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Reclamation District 1004 – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	796	0	796
May	9,122	0	9,122
June	10,695	0	10,695
July	16,578	175	16,753
August	10,753	176	10,929
September	5,249	0	5,249
October	11,345	201	11,545
TOTAL	64,539	553	65,091

[a]In addition to the water supplies shown in Table 3, 7,500 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Reclamation District 1004_**

Reclamation District 1004 – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Reclamation District 1004 – 2019 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canals	25,872	135	80	20	337	2,000	(2,316)
Canals	28,512	51	34	8	141	838	(970)
Canals	23,232	41	22	5	91	540	(625)
Laterals	42,768	32	31	8	130	773	(895)
Laterals	63,096	22	32	8	134	797	(923)
Laterals	47,256	15	16	4	69	410	(474)
Drains	29,568	44	30	7	125	742	(859)
Drains	29,568	28	19	5	81	480	(556)
Drains	85,536	15	29	7	124	736	(853)
Drains	12,144	12	3	1	14	84	(97)
TOTAL			296	75	1,245	7,399	(8,569)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Reclamation District 1004_**

TABLE 5

Reclamation District 1004 – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Beans	93	0.38	0.09	8	27	0.47	44
Corn	616	2.04	0.09	55	1,203	0.14	86
Habitat	5,886	3.24	0.09	524	18,547	0.03	177
Rice	11,955	2.96	0.09	1,064	34,296	0.06	717
Sunflowers	412	1.34	0.09	37	513	0.06	25
Tomatoes	244	1.73	0.09	22	401	0.08	20
Walnuts	181	3.22	0.09	16	567	0.16	29
Wheat	41	0.38	0.09	4	12	0.03	1
Crop Acres	19,428			1,729	55,567		1,099
Total Irrig. Acres	19,428	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface water irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 12,300 to 14,900 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Reclamation District 1004**

TABLE 6

Reclamation District 1004 – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	65,091
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	3,020
Available Soil Moisture[c]	Estimated	639
	Total Water Supplies =	**68,750**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	7,399
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,170
Riparian ET[d] (Canals/Laterals)	Estimated	550
Conveyance System Filling[e] (Canals/Laterals)	Estimated	645
	Total Distribution System =	**9,764**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	55,567
Evapotranspiration of Precip - ET_{pr}	Table 5	1,729
Cultural Practices *(includes Leaching Requirement)*	Table 5	1,099
	Total Crop Water Needs =	**58,396**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Rice Cultural and Ecosystem Requirement[h]	Estimated	11,955
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**0**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**7,500**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**590**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Habitat Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Reclamation District 1004**

TABLE 7

Reclamation District 1004 – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[e] (acre-feet)
2010	48,218	11,250	23,473	0	82,941	12,500	0
2011	35,874	10,639	23,395	0	69,908	7,436	0
2012	43,022	10,048	23,395	0	76,465	16,095	0
2013	41,573	10,802	25,677	0	78,052	16,095	0
2014	40,066	0	26,865	0	66,931	12,070	0
2015	30,276	5,044	8,944	0	44,264	8,050	0
2016	37,414	9,638	28,013	0	75,065	16,095	0
2017	33,980	9,293	18,947	0	62,220	7,500	0
2018	54,254	8,660	15,354	0	78,268	16,095	0
2019	38,002	9,298	17,239	0	64,539	7,500	0
Total	402,679	84,672	211,302	0	698,653	119,436	0
Average	40,268	8,467	21,130	0	69,865	11,944	0

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records; quantities prior to 2008 are estimated.

[c]Estimated by District based on observation and historical information.

[d]Estimated by District based on observation and historical information.

[e]District operates a closed system with little or no outflow; drainwater from rice fields is recaptured and delivered for rice straw decomposition and habitat lands.

District/Company **Meridian Farms Water Company**

TABLE 1

Meridian Farms Water Company – 2019 Surface Water Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Federal Ag Water Supply[a]				
Month	Base Supply (acre-feet)	Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	470	0	0	0	470
May	3,666	0	0	100	3,766
June	4,558	0	0	200	4,758
July	2,000	3,235	0	400	5,635
August	1,100	2,984	0	400	4,484
September	1,535	0	0	200	1,735
October	691	0	0	400	1,091
TOTAL	14,020	6,219	0	1,700	21,939

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Meridian Farms Water Company – 2019 Groundwater Supply
(April through December Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	850	370
June	327	601
July	350	857
August	504	778
September	0	0
October	0	0
TOTAL	2,031	2,606

[a]Estimated by District based on observation and historical information.

TABLE 3

Meridian Farms Water Company – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	470	0	470
May	3766	850	4616
June	4758	327	5085
July	5635	350	5985
August	4484	504	4988
September	1735	0	1735
October	1091	0	1091
TOTAL	21939	2031	23970

[a]In addition to the water supplies shown in Table 3, 16,876 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Meridian Farms Water Company**

Meridian Farms Water Company – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sep	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Meridian Farms Water Company – 2019 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	84,480	12	23	6	98	698	(790)
Pipeline	0	0	0	0	0	0	0
Laterals	100,320	12	28	7	116	829	(938)
Water Shed Drains	0	0	0	0	0	0	0
Reservoir	0	0	0	0	0	0	0
TOTAL			51	13	214	1,527	(1,729)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Meridian Farms Water Company**

TABLE 5

Meridian Farms Water Company – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	502	2.86	0.09	45	1,393	0.11	55
Beans	108	0.38	0.09	10	32	0.47	51
Corn	502	2.04	0.09	45	981	0.14	70
Cotton	76	2.64	0.09	7	193	0.02	2
Milo	33	2.04	0.09	3	64	0.02	1
Pecans	103	2.88	0.09	9	287	0.18	19
Persimmons	26	2.92	0.09	2	74	0.18	5
Prunes	63	2.92	0.09	6	178	0.18	11
Rice	4,206	2.96	0.09	374	12,066	0.06	252
Safflowers	17	1.34	0.09	2	21	0.06	1
Sunflowers	252	1.34	0.09	22	314	0.06	15
Tomatoes	964	1.73	0.09	86	1,584	0.08	77
Vineseed	88	0.71	0.09	8	55	0.18	16
Walnuts	946	3.22	0.09	84	2,966	0.16	151
Wheat	600	0.38	0.09	53	175	0.03	18
Crop Acres	8,486			755	20,384		744

Total Irrig. Acres 8,486 (If this number is larger than your known total, it may be due to double cropping.)

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 4,500,to 5,000 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Meridian Farms Water Company**

TABLE 6

Meridian Farms Water Company – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	23,970
Private Groundwater	Table 2	2,606
Inflow From Precip[b]	Estimated	1,062
Available Soil Moisture[c]	Estimated	1,723
	Total Water Supplies =	**29,361**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	1,527
Evaporation - Precipitation (Canals/Laterals)	Table 4	201
Riparian ET[d] (Canals/Laterals)	Estimated	1,706
Conveyance System Filling[e] (Canals/Laterals)	Estimated	219
	Total Distribution System =	**3,654**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	20,384
Evapotranspiration of Precip - ET_{pr}	Table 5	755
Cultural Practices *(includes Leaching Requirement)*	Table 5	744
	Total Crop Water Needs =	**21,883**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	1,063
Rice Cultural and Ecosystem Requirement[h]	Estimated	4,206
Uplslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**2,304**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**16,876**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**1,521**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Meridian Farms Water Company_**

TABLE 7

Meridian Farms Water Company – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2010	17,530	9,512	0	8,695	35,737	8,695	5,499
2011	16,792	10,565	0	10,915	38,272	10,915	6,750
2012	19,349	11,208	0	11,625	42,182	11,625	5,825
2013	20,899	9,281	0	800	30,980	20,618	3,871
2014	16,630	4,043	0	900	21,573	10,663	2,574
2015	16,353	2,229	0	750	19,332	11,000	2,426
2016	18,170	8,563	0	900	27,633	19,503	3,052
2017	11,214	7,313	0	1,700	20,227	12,734	2,750
2018	17,492	7,476	0	1,700	26,668	15,509	2,628
2019	14,020	6,219	0	1,700	21,939	16,876	2,304
Total	168,449	76,409	0	39,685	284,543	138,138	37,678
Average	16,845	7,641	0	3,969	28,454	13,814	3,768

[a]Federal Ag Water Supply from Reclamation Water Account Records. Data prior to 2010 are not available.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013

[d]Estimated by District based on observation and historical information.

District/Company **_Sutter Mutual Water Company_**

Sutter Mutual Water Company – 2019 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	4,345	0	0	0	4,345
May	35,444	0	0	0	35,444
June	40,101	0	0	0	40,101
July	28,500	20,235	0	0	48,735
August	20,000	22,475	0	0	42,475
September	5,000	1,794	0	0	6,794
October	8,213	0	0	0	8,213
TOTAL	141,603	44,504	0	0	186,107

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2
Sutter Mutual Water Company – 2019 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	0
October	0	0
TOTAL	0	0

[a]Estimated by District based on observation and historical information.

TABLE 3
Sutter Mutual Water Company – 2019 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	4,345	0	4,345
May	35,444	0	35,444
June	40,101	0	40,101
July	48,735	0	48,735
August	42,475	0	42,475
September	6,794	0	6,794
October	8,213	0	8,213
TOTAL	186,107	0	186,107

[a]In addition to the water supplies shown in Table 3, 52,679 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Sutter Mutual Water Company**

Sutter Mutual Water Company – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Sutter Mutual Water Company – 2019 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Main Canal	39,690	90	82	21	345	2,460	(2,784)
West Canal	52,530	90	109	27	457	3,256	(3,685)
Central Canal	50,640	75	87	22	367	2,180	(2,525)
East Canal	71,970	75	124	31	521	3,098	(3,588)
Laterals	533,390	12	147	37	618	3,673	(4,255)
Sub-Laterals	146,060	8	27	7	113	268	(374)
TOTAL			575	145	2,421	14,935	(17,211)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Sutter Mutual Water Company**

TABLE 5

Sutter Mutual Water Company – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Acres	Crop ET[a]	Effective Precipitation[b]		ETAW	Leaching Requirement	
Crop Name	(crop acres)	(AF/Ac)	(AF/Ac)	(acre-feet)	(acre-feet)	(AF/Ac)	(acre-feet)
Alfalfa	440	2.86	0.09	39	1,221	0.11	48
Beans	940	0.38	0.09	84	275	0.47	442
Corn	1,909	2.04	0.09	170	3,729	0.14	267
Melons	271	1.40	0.09	24	356	0.04	11
Milo	395	2.04	0.09	35	772	0.02	8
Rice	30,155	2.96	0.09	2,684	86,508	0.06	1,809
Rice Straw Decomp	16,485	0.50	0.09	1,467	6,775	0.00	0
Safflowers	188	1.34	0.09	17	234	0.06	11
Sunflowers	5,301	1.34	0.09	472	6,606	0.06	318
Tomatoes	3,906	1.73	0.09	348	6,418	0.08	312
Vineseed	626	0.71	0.09	56	391	0.18	113
Walnuts	44	3.22	0.09	4	138	0.16	7
Wheat	1,248	0.38	0.09	111	365	0.03	37
Crop Acres	61,908			5,510	113,788		3,383
Total Irrig. Acres	45,423	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 30,000 to 36,000 acre-feet in 2019).

[b]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Sutter Mutual Water Company_**

TABLE 6

Sutter Mutual Water Company – 2019 District Water Balance

(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	186,107
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	7,619
Available Soil Moisture[c]	Estimated	6,147
	Total Water Supplies =	**199,873**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	14,935
Evaporation - Precipitation (Canals/Laterals)	Table 4	2,275
Riparian ET[d] (Canals/Laterals)	Estimated	500
Conveyance System Filling[e] (Canals/Laterals)	Estimated	1,861
	Total Distribution System =	**19,572**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	113,788
Evapotranspiration of Precip - ET_{pr}	Table 5	5,510
Cultural Practices *(includes Leaching Requirement)*	Table 5	3,383
	Total Crop Water Needs =	**122,681**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	7,623
Rice Cultural and Ecosystem Requirement[h]	Estimated	30,155
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	29,474
	Total District Outflow *(from District Records)* =	67,252
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**52,679**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**(9,632)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f] Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

District/Company **_Sutter Mutual Water Company_**

TABLE 7

Sutter Mutual Water Company – 2019 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2010	142,185	58,326	0	0	200,511	62,316	77,886
2011	136,388	57,423	0	0	193,811	55,954	98,092
2012	134,711	47,314	0	0	182,025	68,493	60,618
2013	163,680	41,675	0	0	205,355	33,062	71,625
2014	127,125	20,028	0	0	147,153	74,162	5,123
2015	126,193	16,662	0	0	142,855	73,068	2,603
2016	140,290	26,124	0	0	166,414	69,499	53,551
2017	128,676	38,505	0	0	167,181	44,571	64,513
2018	143,984	23,736	0	0	167,720	53,285	58,511
2019	141,603	44,504	0	0	186,107	52,679	67,252
Total	1,384,835	374,297	0	0	1,759,132	587,089	559,774
Average	138,484	37,430	0	0	175,913	58,709	55,977

[a]Federal Ag Water Supply from Reclamation Water Account Records. Includes Project water transferred into SMWC in 2006 and 2010.

[b]Non-Federal Ag Water Supply from District Records. Data prior to 2010 are not available.

[c]Estimated by District based on observation and historical information. Data prior to 2010 are not available.

[d]The Department quit measuring outflow Karnak after 2003; SMWC has calculated outflow since 2010. Data prior to 2010 are not available.

District/Company **Natomas Central Mutual Water District**

TABLE 1

Natomas Central Mutual Water District – 2019 Surface Water Supply

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[b] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	104	0	0	0	104
May	10,794	0	0	0	10,794
June	11,406	0	0	0	11,406
July	11,500	3,705	0	0	15,205
August	3,900	8,415	0	0	12,315
September	3,645	0	0	0	3,645
October	247	0	0	0	247
TOTAL	41,596	12,120	0	0	53,716

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Water from non-Company lands enters the drainage system throughout the April through October period. The quantity for 2019 is unknown at this time but is included in the quantity recycled and reused shown in Table 6.

TABLE 2

Natomas Central Mutual Water District – 2019 Groundwater Supply

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	10	100
June	10	0
July	10	0
August	10	0
September	10	0
October	0	0
TOTAL	50	100

[a]Estimated by District based on observation and historical information.

TABLE 3

Natomas Central Mutual Water District – 2019 Total District Water Supply (excluding reuse)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	104	0	104
May	10,794	10	10,804
June	11,406	10	11,416
July	15,205	10	15,215
August	12,315	10	12,325
September	3,645	10	3,655
October	247	0	247
TOTAL	53,716	50	53,766

[a]In addition to the water supplies shown in Table 3, 42,513 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Natomas Central Mutual Water District**

Natomas Central Mutual Water District – 2019 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2019	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	4.9	0.41	1.5	0.12
Feb	7.8	0.65	1.8	0.15
Mar	4.0	0.33	3.4	0.28
Apr	0.3	0.02	6.2	0.51
May	2.3	0.19	6.8	0.57
Jun	0.0	0.00	9.4	0.78
Jul	0.0	0.00	8.7	0.73
Aug	0.0	0.00	7.9	0.65
Sept	0.5	0.04	6.0	0.50
Oct	0.0	0.00	5.5	0.46
Nov	0.8	0.07	2.5	0.21
Dec	4.8	0.40	1.0	0.09
TOTAL-YR	25.4	2.11	60.7	5.06
TOTAL-Apr-Oct	**3.0**	**0.25**	**50.5**	**4.21**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Natomas Central Mutual Water District – 2019 Distribution System Evaporation and Seepage

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Bennet System	44,700	56	58	15	243	579	(808)
Northern System	146,400	54	180	46	759	1,805	(2,518)
Prichard Lake Sys	204,400	54	252	64	1,058	2,515	(3,510)
Elkhorn System	75,100	44	76	19	321	762	(1,063)
Riverside System	65,800	46	69	17	291	692	(965)
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
TOTAL			635	161	2,673	6,353	(8,865)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Natomas Central Mutual Water District_**

TABLE 5

Natomas Central Mutual Water District – 2019 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

	Acres[a]	Crop ET[b]	Effective Precipitation[c]		ETAW	Leaching Requirement	
Crop Name	(crop acres)	(AF/Ac)	(AF/Ac)	(acre-feet)	(acre-feet)	(AF/Ac)	(acre-feet)
Alfalfa	42	2.86	0.09	4	117	0.11	5
Beans	168	0.38	0.09	15	49	0.47	79
Corn	174	2.04	0.09	15	340	0.14	24
Golf Course	150	3.38	0.09	13	494	0.03	5
Hops	4	0.71	0.09	0	2	0.18	1
Managed Marsh	612	2.97	0.09	54	1,763	0.00	0
Melons	77	1.40	0.09	7	101	0.04	3
Misc. field crops	10	1.79	0.09	1	17	0.18	2
Oats	230	0.38	0.09	20	67	0.02	5
Onions	10	0.60	0.09	1	5	0.28	3
Pasture	25	3.07	0.09	2	74	0.03	1
Pears	7	2.92	0.09	1	20	0.18	1
Peppers	5	1.73	0.09	0	8	0.08	0
Pumpkins	32	1.40	0.09	3	42	0.04	1
Rice	13,391	2.96	0.09	1,192	38,416	0.06	803
Rice Straw Decomp	9,988	0.50	0.09	889	4,105	0.00	0
Safflowers	62	1.34	0.09	6	77	0.06	4
Squash	5	1.40	0.09	0	7	0.04	0
Sunflowers	103	1.34	0.09	9	128	0.06	6
Tomatoes	146	1.73	0.09	13	240	0.08	12
Wheat	903	0.38	0.09	80	264	0.03	27
Crop Acres	26,144			2,327	46,337		982
Total Irrig. Acres	14,961	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 15,000 to 18,000 acre-feet in 2019).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Natomas Central Mutual Water District**

TABLE 6

Natomas Central Mutual Water District – 2019 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	53,766
Private Groundwater	Table 2	100
Inflow From Precip[b]	Estimated	3,384
Available Soil Moisture[c]	Estimated	867
	Total Water Supplies =	**58,117**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	6,353
Evaporation - Precipitation (Canals/Laterals)	Table 4	2,512
Riparian ET[d] (Canals/Laterals)	Estimated	592
Conveyance System Filling[e] (Canals/Laterals)	Estimated	537
	Total Distribution System =	**9,994**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	46,337
Evapotranspiration of Precip - ET_{pr}	Table 5	2,327
Cultural Practices *(includes Leaching Requirement)*	Table 5	982
	Total Crop Water Needs =	**49,646**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Rice Cultural and Ecosystem Requirement[h]	Estimated	13,391
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* =	8,396
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**42,513**
	Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**(9,919)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

District/Company **Natomas Central Mutual Water District**

TABLE 7

Natomas Central Mutual Water District – 2019 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag	Upslope		District	
	Base Supply (acre-feet)	Project Water (acre-feet)	Water Supply[b] (acre-feet)	Drainwater[c] (acre-feet)	Total (acre-feet)	Recapture (acre-feet)	Outflow[d] (acre-feet)
2010	41,778	10,997	-	-	52,775	44,224	-
2011	37,349	8,707	0	0	46,056	39,989	15,000
2012	35,685	8,322	0	0	44,007	59,923	15,115
2013	48,050	13,073	0	28,288	89,411	51,433	10,317
2014	57,654	16,397	0	0	74,051	49,466	3,952
2015	58,255	15,093	0	0	73,348	65,147	2,028
2016	54,200	13,418	0	0	67,618	53,092	2,167
2017	53,451	16,882	0	0	70,333	55,967	3,418
2018	50,525	15,756	0	0	66,281	59,978	7,052
2019	41,596	12,120	0	0	53,716	42,513	8,396
Total	478,543	130,765	0	28,288	637,596	521,732	67,445
Average	47,854	13,077	0	3,143	63,760	52,173	7,494

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records. Data prior to 2010 not available.

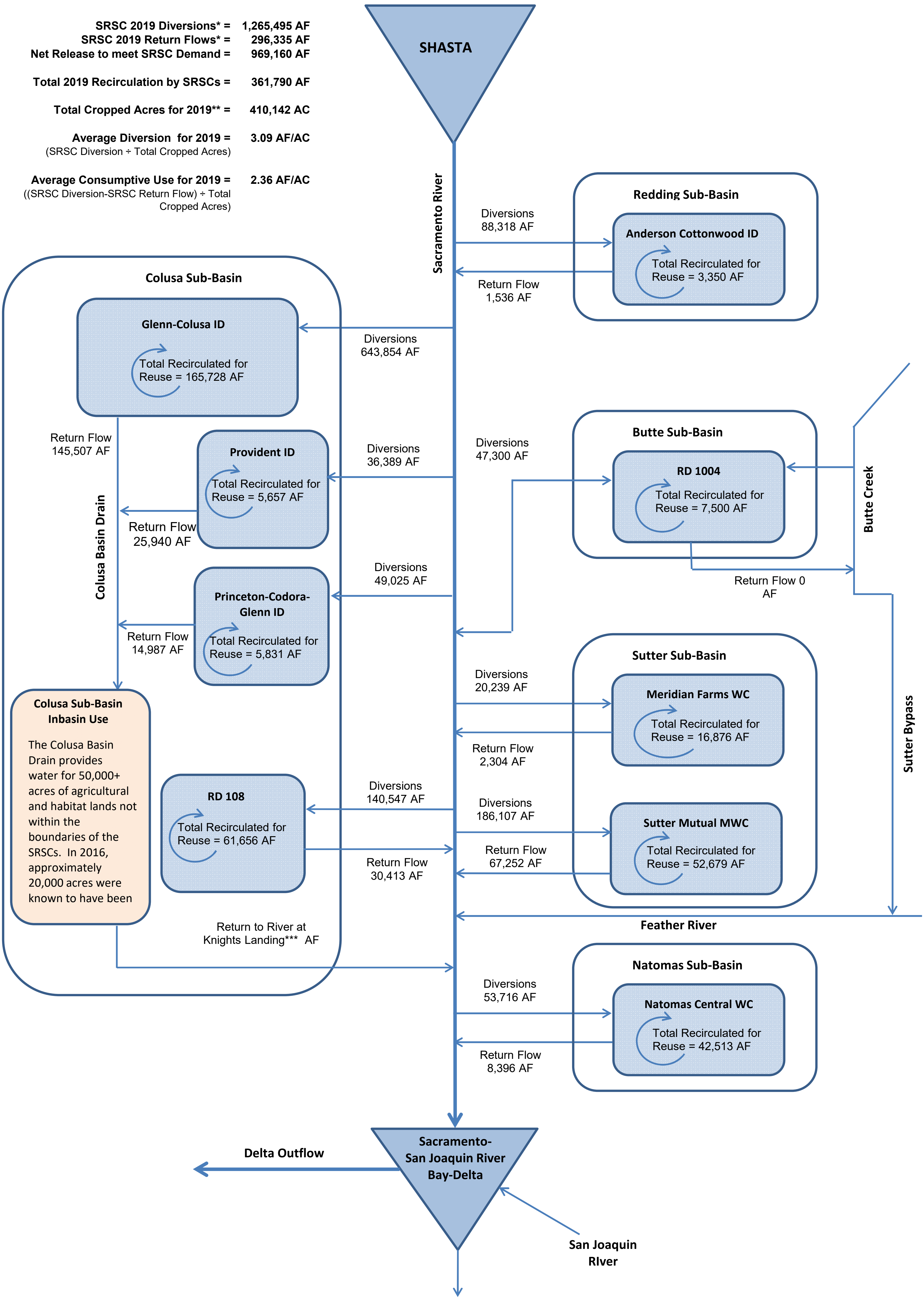
[c]Estimated by District based on observation and historical information. Data prior to 2010 not available.

[d]Data prior to 2010 are not available.

2019 Summary Graphic

Summary of SRSC Diversions and Return Flows
2019

SRSC 2019 Diversions* =	**1,265,495 AF**
SRSC 2019 Return Flows* =	**296,335 AF**
Net Release to meet SRSC Demand =	**969,160 AF**
Total 2019 Recirculation by SRSCs =	**361,790 AF**
Total Cropped Acres for 2019 =**	**410,142 AC**
Average Diversion for 2019 = (SRSC Diversion ÷ Total Cropped Acres)	**3.09 AF/AC**
Average Consumptive Use for 2019 = ((SRSC Diversion-SRSC Return Flow) ÷ Total Cropped Acres)	**2.36 AF/AC**



Notes: * Diversions and Return Flows are from 2019 SRSC Water Balance tables.
** Total Cropped Acres for 2019 includes 20,000 acres within the Colusa Sub-basin that rely on return flows from the SRSCs for surface water supplies.
*** Return to River at Knights Landing is currently not publicaly available data, and thus is not available for 2019.

MBK*ENGINEERS*
10/21/2020

2020 Water Balance Summaries

District/Company **Anderson Cottonwood Irrigation District**

TABLE 1

Anderson Cottonwood Irrigation District – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	6,522	0	0	0	6,522
May	14,744	0	0	0	14,744
June	18,424	0	0	0	18,424
July	14,012	0	0	0	14,012
August	17,024	0	0	0	17,024
September	14,408	0	0	0	14,408
October	13,227	0	0	0	13,227
TOTAL	98,361	0	0	0	98,361

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Anderson Cottonwood Irrigation District – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	773	0
August	711	0
September	764	0
October	0	0
TOTAL	2,248	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Anderson Cottonwood Irrigation District – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	6,522	0	6,522
May	14,744	0	14,744
June	18,424	0	18,424
July	14,012	773	14,785
August	17,024	711	17,735
September	14,408	764	15,172
October	13,227	0	13,227
TOTAL	98,361	2,248	100,609

[a]In addition to the water supplies shown in Table 3, 3,350 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Anderson Cottonwood Irrigation District_**

Anderson Cottonwood Irrigation District – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.3	0.11	1.5	0.12
Feb	0.0	0.00	3.6	0.30
Mar	2.3	0.19	4.1	0.34
Apr	0.4	0.04	5.9	0.50
May	2.0	0.17	7.8	0.65
Jun	0.2	0.02	9.2	0.77
Jul	0.0	0.00	9.5	0.80
Aug	0.1	0.01	7.0	0.58
Sept	0.0	0.00	6.0	0.50
Oct	0.0	0.00	5.2	0.44
Nov	0.3	0.02	2.6	0.22
Dec	1.6	0.14	2.0	0.17
TOTAL-YR	8.1	0.68	64.5	5.38
TOTAL-Apr-Oct	**2.7**	**0.23**	**50.7**	**4.22**

[a]Precipitation is precipitation reported for CIMIS Station at Gerber South (#222).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the reference ET (ETo) reported for the Gerber South CIMIS Station.

TABLE 4

Anderson Cottonwood Irrigation District – 2020 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	177,952	30	123	28	518	24,511	(25,001)
Laterals	866,724	10	199	45	840	11,142	(11,938)
TOTAL			322	72	1,358	35,654	(36,940)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season (April-October).

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Anderson Cottonwood Irrigation District_**

TABLE 5

Anderson Cottonwood Irrigation District – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop Et[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Pasture	6,808	3.11	0.08	517	20,661	0.03	204
Crop Acres	6,808			517	20,661		204
Total Irrig. Acres	6,808	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Station at Gerber South (#222) x Kc based on ITRC Typical Year ETc for Zone 14 surface irrigation for water balances. Water Needs do not include water required for cultural practices.

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season.

District/Company **Anderson Cottonwood Irrigation District**

TABLE 6

Anderson Cottonwood Irrigation District – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	100,609
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	0
Available Soil Moisture[c]	Estimated	711
	Total Water Supplies =	**101,320**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	35,654
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,286
Riparian ET[d] (Canals/Laterals)	Estimated	1,366
Conveyance System Filling[e] (Canals/Laterals)	Estimated	984
	Total Distribution System =	**39,290**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	20,661
Evapotranspiration of Precip - ET_{pr}	Table 5	517
Cultural Practices *(includes Leaching Requirement)*	Table 5	204
	Total Crop Water Needs =	**21,383**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Upslope Drainwater Flow Through[h]	Estimated	0
Remainder Drainwater Outflow[i]	District Records	1,536
	Total District Outflow *(from District Records)* **=**	**1,536**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**3,350**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**39,111**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs. Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on crop acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for cultural practices.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Anderson Cottonwood Irrigation District_**

TABLE 7

Anderson Cottonwood Irrigation District – 2020 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2011	89,814	0	0	0	89,814	3,150	15,000
2012	101,229	0	0	0	101,229	3,239	15,000
2013	108,600	0	0	0	108,600	3,340	2,755
2014	86,702	0	0	0	86,702	3,215	1,240
2015	87,315	0	0	0	87,315	3,350	1,150
2016	103,104	0	0	0	103,104	3,350	1,536
2017	91,478	0	0	0	91,478	3,350	1,536
2018	91,401	0	0	0	91,401	3,350	1,536
2019	88,318	0	0	0	88,318	3,350	1,536
2020	98,361	0	0	0	98,361	3,350	1,536
Total	946,322	0	0	0	946,322	33,044	42,825
Average	94,632	0	0	0	94,632	3,304	4,283

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

[d]Estimated by District based on observation and historical information.

District/Company **Glenn-Colusa Irrigation District**

TABLE 1

Glenn-Colusa Irrigation District – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	77,236	9	0	48	77,293
May	118,576	2	0	491	119,069
June	136,794	7	0	472	137,273
July	130,000	18,447	0	488	148,935
August	90,000	19,615	0	167	109,782
September	37,856	12	0	49	37,917
October	42,846	13	0	0	42,859
TOTAL	633,308	38,105	0	1,715	673,128

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Glenn-Colusa Irrigation District – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	1,239
May	0	1,858
June	0	1,858
July	0	2,478
August	0	2,478
September	0	1,239
October	0	1,239
TOTAL	0	12,389

[a]Estimated by District based on observation and historical information.

TABLE 3

Glenn-Colusa Irrigation District – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	77,293	0	77,293
May	119,069	0	119,069
June	137,273	0	137,273
July	148,935	0	148,935
August	109,782	0	109,782
September	37,917	0	37,917
October	42,859	0	42,859
TOTAL	673,128	0	673,128

[a]In addition to the water supplies shown in Table 3, 181,544 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Glenn-Colusa Irrigation District**

Glenn-Colusa Irrigation District – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Glenn-Colusa Irrigation District – 2020 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	341,200	70	548	56	2,290	10,966	(13,200)
Pipeline	26,400	2	0	0	0	0	0
Laterals	3,495,360	12	963	98	4,021	4,815	(8,738)
Watershed Drains	2,919,840	15	1,005	102	4,199	5,027	(9,124)
TOTAL			2,517	255	10,510	20,808	(31,062)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 5

Glenn-Colusa Irrigation District – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	1,254	3.08	0.02	20	3,838	0.11	138
Almonds	13,747	2.75	0.00	0	37,828	0.18	2,474
Beans	181	0.75	0.02	3	133	0.47	85
Corn	577	1.93	0.02	9	1,106	0.14	81
Cotton	140	2.37	0.02	2	330	0.02	3
Oats	510	0.75	0.02	8	376	0.02	10
Habitat	645	2.54	0.02	10	1,629	0.03	19
Misc. Deciduous	98	2.82	0.02	2	275	0.16	16
Olives	245	2.82	0.02	4	687	0.09	22
Onions	54	0.89	0.02	1	47	0.28	15
Pasture	2,956	3.35	0.02	48	9,856	0.03	89
Prunes	60	2.92	0.02	1	174	0.18	11
Rice	96,501	2.94	0.02	1,560	281,681	0.06	5,790
Rice Straw Decomp	30,352	0.50	0.02	491	14,685	0.00	0
Rye Grass	57	0.75	0.02	1	42	0.02	1
Safflowers	0	1.70	0.02	0	0	0.06	0
Sudan	293	3.35	0.02	5	977	0.07	21
Sunflowers	795	1.70	0.02	13	1,338	0.06	48
Tomatoes	1,276	1.64	0.02	21	2,068	0.08	102
Vineseed	711	1.01	0.02	11	703	0.18	128
Walnuts	7,671	3.20	0.02	124	24,392	0.16	1,227
Crop Acres	158,123			2,334	382,165		10,280
Total Irrig. Acres	127,771	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 120,600 - 145,000 acre-feet in 2020).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 6

Glenn-Colusa Irrigation District – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	673,128
Private Groundwater	Table 2	12,389
Inflow From Precip[b]	Estimated	9,766
Available Soil Moisture[c]	Estimated	1,449
	Total Water Supplies =	**696,731**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	20,808
Evaporation - Precipitation (Canals/Laterals)	Table 4	10,255
Riparian ET[d] (Canals/Laterals)	Estimated	6,500
Conveyance System Filling[e] (Canals/Laterals)	Estimated	8,000
	Total Distribution System =	**45,562**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	382,165
Evapotranspiration of Precip - ET_{pr}	Table 5	2,334
Cultural Practices *(includes Leaching Requirement)*	Table 5	10,280
	Total Crop Water Needs =	**394,779**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	18,483
Irrigation Season Rainfall Runoff[g]	Estimated	9,784
Rice Cultural and Ecosystem Requirement[h]	Estimated	50,000
Upslope Drainwater Flow Through[i]	Estimated	506
Remainder Drainwater Outflow[j]	Calculated	107,566
	Total District Outflow *(from District Records)* =	186,339
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**181,544**
	Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**70,051**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Glenn-Colusa Irrigation District_**

TABLE 7

Glenn-Colusa Irrigation District – 2020 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow (acre-feet)
2011	571,617	86,014	0	40,500	698,131	190,994	255,999
2012	605,963	90,277	0	40,500	736,740	206,542	197,899
2013	698,625	72,274	0	1,650	772,549	217,694	207,154
2014	496,915	52,171	0	1,700	550,786	131,520	102,168
2015	452,681	60,381	0	1,360	514,422	115,694	79,238
2016	623,198	66,038	0	1,600	690,836	167,918	148,275
2017	601,963	66,394	0	1,850	670,207	166,397	136,716
2018	629,818	51,319	0	1,633	682,770	167,293	148,418
2019	575,939	67,915	0	1,715	645,569	165,728	145,507
2020	633,308	38,105	0	1,715	673,128	181,544	186,339
Total	5,890,027	650,888	0	94,223	6,635,138	1,711,324	1,607,713
Average	589,003	65,089	0	9,422	663,514	171,132	160,771

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013.

District/Company **Provident Irrigation District**

TABLE 1

Provident Irrigation District – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	6,547	0	1,320	597	8,464
May	4,416	0	4,239	2,518	11,173
June	9,214	0	4,565	2,942	16,721
July	6,300	3,404	6,021	4,541	20,266
August	2,500	369	3,800	5,487	12,156
September	80	0	3	1,662	1,745
October	13,165	0	411	898	14,474
TOTAL	42,222	3,773	20,359	18,645	84,999

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Provident Irrigation District – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	143	0
May	206	0
June	189	0
July	14	0
August	8	0
September	0	0
October	9	0
TOTAL	569	0

[a]Estimated by District based on observation and historical information.

TABLE 3

Provident Irrigation District – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	8,464	143	8,607
May	11,173	206	11,379
June	16,721	189	16,910
July	20,266	14	20,280
August	12,156	8	12,164
September	1,745	0	1,745
October	14,474	9	14,483
TOTAL	84,999	569	85,568

[a]In addition to the water supplies shown in Table 3, 5,141 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Provident Irrigation District_**

Provident Irrigation District – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at Davis (#6),Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Provident Irrigation District – 2020 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	65,472	35	53	5	220	1,315	(1,530)
Laterals	206,448	12	57	6	238	569	(800)
Water Shed Drains	175,276	15	60	6	252	302	(548)
TOTAL			170	17	709	2,186	(2,878)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season (April-October).

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Provident Irrigation District_**

TABLE 5

Provident Irrigation District – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Rice	13,083	2.94	0.02	212	38,189	0.06	785
Rice Straw Decomp	0	0.50	0.02	0	0	0.00	0
Crop Acres	13,083			212	38,189		785
Total Irrig. Acres	13,083	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 16,400 to 19,600 acre-feet in 2020).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Provident Irrigation District**

TABLE 6

Provident Irrigation District – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	85,568
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	1,323
Available Soil Moisture[c]	Estimated	0
	Total Water Supplies =	**86,891**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	2,186
Evaporation - Precipitation (Canals/Laterals)	Table 4	692
Riparian ET[d] (Canals/Laterals)	Estimated	100
Conveyance System Filling[e] (Canals/Laterals)	Estimated	850
	Total Distribution System =	**3,828**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	38,189
Evapotranspiration of Precip - ET_{pr}	Table 5	212
Cultural Practices *(includes Leaching Requirement)*	Table 5	785
	Total Crop Water Needs =	**39,185**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	3,157
Irrigation Season Rainfall Runoff[g]	Estimated	1,326
Rice Cultural and Ecosystem Requirement[h]	Estimated	13,083
Upslope Drainwater Flow Through	Estimated	3,029
Remainder Drainwater Outflow[i]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**15,700**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**5,141**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**28,178**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Provident Irrigation District_**

TABLE 7

Provident Irrigation District – 2020 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b,c] (acre-feet)	Upslope Drainwater[c,d] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[d] (acre-feet)
2011	26,671	3,346	6,619	73,953	110,589	9,983	53,382
2012	31,466	3,278	27,068	23,651	85,463	9,210	25,268
2013	34,154	2,429	22,195	47,283	106,061	6,022	30,493
2014	27,847	40	2,798	30,338	61,023	2,617	20,618
2015	32,830	0	273	29,494	62,597	6,619	22,479
2016	35,413	2,698	20,443	18,475	77,029	6,836	18,893
2017	33,240	3,723	19,342	19,901	76,206	6,644	30,254
2018	35,413	2,698	20,443	18,475	77,029	6,601	28,352
2019	31,931	4,458	21,827	19,241	77,457	5,657	25,940
2020	42,222	3,773	20,359	18,645	84,999	5,141	15,700
Total	331,187	26,443	161,367	299,456	818,453	65,330	271,378
Average	33,119	2,644	16,137	29,946	81,845	6,533	27,138

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013.

District/Company **Princeton-Codora-Glenn Irrigation District**

TABLE 1

Princeton-Codora-Glenn Irrigation District – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	6,706	0	712	0	7,418
May	9,437	0	2,430	0	11,867
June	10,573	0	3,401	0	13,974
July	6,740	3,967	4,658	0	15,365
August	2,780	3,164	3,317	0	9,261
September	640	0	227	0	867
October	5,401	0	751	0	6,152
TOTAL	42,277	7,131	15,496	0	64,904

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Princeton-Codora-Glenn Irrigation District – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	651	0
May	1,423	1,339
June	1,337	1,339
July	1,486	1,339
August	728	1,339
September	66	1,339
October	0	0
TOTAL	5,691	6,695

[a]Estimated by District based on observation and historical information.

TABLE 3

Princeton-Codora-Glenn Irrigation District – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	7,418	651	8,069
May	11,867	1,423	13,290
June	13,974	1,337	15,311
July	15,365	1,486	16,851
August	9,261	728	9,989
September	867	66	933
October	6,152	0	6,152
TOTAL	64,904	5,691	70,595

[a]In addition to the water supplies shown in Table 3, 5,141 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

Princeton-Codora-Glenn Irrigation District – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Princeton-Codora-Glenn Irrigation District – 2020 Distribution System Evaporation and Seepage (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	68,640	30	47	5	197	11,818	(12,011)
Laterals	219,384	15	76	8	315	5,666	(5,974)
Water Shed Drains	113,520	15	39	4	163	1,955	(2,114)
TOTAL			162	16	676	19,439	(20,098)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 5

Princeton-Codora-Glenn Irrigation District – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Almonds	80	2.75	0.00	0	220	0.18	14
Pasture	13	3.35	0.02	0	42	0.03	0
Rice	6,520	2.94	0.02	105	19,032	0.06	391
Rice Straw Decomp	0	0.50	0.02	0	0	0.00	0
Vineseed	0	1.01	0.02	0	0	0.18	0
Walnuts	1,339	3.20	0.02	22	4,258	0.16	214
Watermelon	0	1.14	0.00	0	0	0.04	0
Wheat	6	0.75	0.02	0	4	0.03	0
Alfalfa	19	3.08	0.02	0	58	0.11	2
Crop Acres	7,977			128	23,614		621
Total Irrig. Acres	7,977	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 7,800 to 9,400 acre-feet in 2020).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Princeton-Codora-Glenn Irrigation District_**

TABLE 6

Princeton-Codora-Glenn Irrigation District – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	70,595
Private Groundwater	Table 2	6,695
Inflow From Precip[b]	Estimated	659
Available Soil Moisture[c]	Estimated	69
	Total Water Supplies =	**78,018**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	19,439
Evaporation - Precipitation (Canals/Laterals)	Table 4	660
Riparian ET[d] (Canals/Laterals)	Estimated	100
Conveyance System Filling[e] (Canals/Laterals)	Estimated	649
	Total Distribution System =	**20,847**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	23,614
Evapotranspiration of Precip - ET_{pr}	Table 5	128
Cultural Practices *(includes Leaching Requirement)*	Table 5	621
	Total Crop Water Needs =	**24,363**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	661
Rice Cultural and Ecosystem Requirement[h]	Estimated	6,520
Upslope Drainwater Flow Through	Estimated	0
Remainder Drainwater Outflow[i]	Calculated	4,784
	Total District Outflow *(from District Records)* **=**	**11,965**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**5,101**
	Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**20,843**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[j]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Princeton-Codora-Glenn Irrigation District**

TABLE 7

Princeton-Codora-Glenn Irrigation District – 2020 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[c] (acre-feet)
2011	38,257	12,485	0	26,189	76,931	7,664	26,460
2012	43,303	12,950	17,908	12,856	87,017	8,702	26,388
2013	47,890	10,231	11,453	16,828	86,402	7,383	26,388
2014	38,389	2,789	1,084	15,095	51,822	3,138	17,747
2015	38,888	6,457	99	12,524	57,968	2,627	13,598
2016	43,899	8,269	6,498	0	58,666	3,514	16,408
2017	38,780	10,792	11,375	0	60,947	4,316	15,564
2018	39,831	7,427	11,696	0	58,954	5,581	15,576
2019	37,433	11,592	14,644	0	63,669	5,831	14,987
2020	42,277	7,131	15,496	0	64,904	5,101	11,965
Total	408,947	90,123	90,253	83,492	667,280	53,857	185,080
Average	40,895	9,012	9,025	8,349	66,728	5,386	18,508

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

[d] Estimated by District based on observation and historical information.

District/Company **Reclamation District 108**

TABLE 1

Reclamation District 108 – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	12,014	0	0	0	12,014
May	36,301	0	0	0	36,301
June	43,115	0	0	0	43,115
July	31,500	11,706	0	0	43,206
August	16,500	5,750	0	0	22,250
September	2,090	0	0	0	2,090
October	16,797	0	0	0	16,797
TOTAL	158,317	17,456	0	0	175,773

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Reclamation District 108 – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	0	0
August	0	0
September	0	52
October	0	0
TOTAL	0	52

[a]Estimated by District based on observation and historical information.

TABLE 3

Reclamation District 108 – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	12,014	0	12,014
May	36,301	0	36,301
June	43,115	0	43,115
July	43,206	0	43,206
August	22,250	0	22,250
September	2,090	0	2,090
October	16,797	0	16,797
TOTAL	175,773	0	175,773

[a]In addition to the water supplies shown in Table 3, 73,373acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Reclamation District 108**

Reclamation District 108 – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Reclamation District 108 – 2020 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	528,000	24	291	29	1,215	2,909	(4,094)
Laterals	158,400	24	87	9	364	873	(1,228)
Water Shed Drains	0	0	0	0	0	0	0
TOTAL			378	38	1,579	3,782	(5,323)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Reclamation District 108**

TABLE 5

Reclamation District 108 – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c]		ETAW (acre-feet)	Leaching Requirement	
			(AF/Ac)	(acre-feet)		(AF/Ac)	(acre-feet)
Alfalfa	1,289	3.08	0.02	21	3,945	0.11	142
Beans	683	0.75	0.02	11	503	0.47	321
Corn	307	1.93	0.02	5	589	0.14	43
Cotton	186	2.37	0.02	3	438	0.02	4
Pasture	163	3.35	0.02	3	543	0.03	5
Grain	1,817	0.75	0.02	29	1,339	0.02	36
Rice	31,119	2.94	0.02	503	90,835	0.06	1,867
Rice Straw Decomp	0	0.50	0.02	0	0	0.00	0
Safflowers	293	1.70	0.02	5	493	0.06	18
Sunflowers	1,689	1.70	0.02	27	2,842	0.06	101
Tomatoes	3,627	1.64	0.02	59	5,878	0.08	290
Almonds	2,778	2.75	0.00	0	7,644	0.18	500
Walnuts	0	3.20	0.02	0	0	0.16	0
Vineseed	1,160	1.01	0.02	19	1,147	0.18	209
Crop Acres	45,111			684	116,196		3,536
Total Irrig. Acres	45,111	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 38,900 to 58,350 acre-feet in 2020).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Reclamation District 108**

TABLE 6

Reclamation District 108 – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	175,773
Private Groundwater	Table 2	52
Inflow From Precip[b]	Estimated	3,146
Available Soil Moisture[c]	Estimated	662
	Total Water Supplies =	**179,633**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	3,782
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,541
Riparian ET[d] (Canals/Laterals)	Estimated	3,770
Conveyance System Filling[e] (Canals/Laterals)	Estimated	1,758
	Total Distribution System =	10,851
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	116,196
Evapotranspiration of Precip - ET_{pr}	Table 5	684
Cultural Practices *(includes Leaching Requirement)*	Table 5	3,536
	Total Crop Water Needs =	**120,417**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	8,092
Irrigation Season Rainfall Runoff[g]	Estimated	3,155
Rice Cultural and Ecosystem Requirement[h]	Estimated	31,119
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**38,723**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**73,373**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**9,643**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **Reclamation District 108**

TABLE 7

Reclamation District 108 – 2020 Annual Water Quantities Delivered under Each Right or Contract (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[c] (acre-feet)
2011	143,793	14,913	0	1,415	160,121	51,819	50,434
2012	141,324	17,967	0	1,160	160,451	53,739	39,975
2013	161,668	25,604	0	1,877	189,149	28,616	78,495
2014	122,334	0	0	780	123,114	51,216	41,217
2015	115,098	1,210	1,396	821	118,525	45,510	33,121
2016	137,703	16,237	0	629	154,569	43,537	33,146
2017	115,384	18,562	0	945	134,891	41,533	34,776
2018	129,991	16,132	0	732	146,855	59,405	25,870
2019	117,547	23,000	0	1,384	141,931	61,656	30,413
2020	158,317	17,456	0	0	175,773	73,373	38,723
Total	1,343,159	151,081	1,396	9,744	1,505,380	510,404	406,170
Average	134,316	15,108	140	974	150,538	51,040	40,617

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

District/Company **_Reclamation District 1004_**

TABLE 1

Reclamation District 1004 – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	1,863	0	1,004	0	2,867
May	5,652	0	4,614	0	10,266
June	10,507	0	4,202	0	14,709
July	5,606	5,757	5,724	0	17,087
August	3,115	2,841	3,155	0	9,111
September	2,400	0	916	0	3,316
October	13,166	0	39	0	13,205
TOTAL	42,309	8,598	19,654	0	70,561

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Reclamation District 1004 – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	428	26
May	1,273	445
June	404	443
July	1,071	187
August	568	0
September	577	0
October	110	465
TOTAL	4,431	1,566

[a]Estimated by District based on observation and historical information.

TABLE 3

Reclamation District 1004 – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	2,867	428	3,295
May	10,266	1,273	11,539
June	14,709	404	15,113
July	17,087	1,071	18,158
August	9,111	568	9,679
September	3,316	577	3,893
October	13,205	110	13,315
TOTAL	70,561	4,431	74,992

[a]In addition to the water supplies shown in Table 3, 8,050 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Reclamation District 1004**

Reclamation District 1004 – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Reclamation District 1004 – 2020 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canals	25,872	135	80	8	334	2,000	(2,326)
Canals	28,512	51	34	3	140	838	(974)
Canals	23,232	41	22	2	90	540	(628)
Laterals	42,768	32	31	3	129	773	(899)
Laterals	63,096	22	32	3	133	797	(927)
Laterals	47,256	15	16	2	68	410	(476)
Drains	29,568	44	30	3	124	742	(862)
Drains	29,568	28	19	2	80	480	(559)
Drains	85,536	15	29	3	123	736	(856)
Drains	12,144	12	3	0	14	84	(97)
TOTAL			296	30	1,236	7,399	(8,605)

[a]From District statistics.
[b]Average width of the conveyance facilities.
[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.
[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.
[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Reclamation District 1004_**

TABLE 5

Reclamation District 1004 – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c]		ETAW (acre-feet)	Leaching Requirement	
			(AF/Ac)	(acre-feet)		(AF/Ac)	(acre-feet)
Beans	0	0.75	0.02	0	0	0.47	0
Corn	299	1.93	0.02	5	573	0.14	42
Habitat	4,913	2.54	0.02	79	12,410	0.03	147
Rice	13,189	2.94	0.02	213	38,497	0.06	791
Sunflowers	71	1.70	0.02	1	119	0.06	4
Tomatoes	175	1.64	0.02	3	284	0.08	14
Walnuts	181	3.20	0.02	3	576	0.16	29
Watermelon	0	1.14	0.00	0	0	0.04	0
Safflowers	95	1.70	0.02	2	160	0.06	6
Cotton	182	2.37	0.02	3	427	0.02	4
Sudan	41	3.35	0.02	1	136	0.07	3
Crop Acres	19,144			309	53,182		1,040
Total Irrig. Acres	19,144	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface water irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 16,500 to 19,800 acre-feet in 2020).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Reclamation District 1004**

TABLE 6

Reclamation District 1004 – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	74,992
Private Groundwater	Table 2	1,566
Inflow From Precip[b]	Estimated	1,335
Available Soil Moisture[c]	Estimated	49
	Total Water Supplies =	**77,942**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	7,399
Evaporation - Precipitation (Canals/Laterals)	Table 4	1,206
Riparian ET[d] (Canals/Laterals)	Estimated	550
Conveyance System Filling[e] (Canals/Laterals)	Estimated	706
	Total Distribution System =	**9,861**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	53,182
Evapotranspiration of Precip - ET_{pr}	Table 5	309
Cultural Practices *(includes Leaching Requirement)*	Table 5	1,040
	Total Crop Water Needs =	**54,531**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	0
Rice Cultural and Ecosystem Requirement[h]	Estimated	13,189
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**0**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**8,050**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**13,550**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Habitat Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Reclamation District 1004_**

TABLE 7

Reclamation District 1004 – 2020 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture[d] (acre-feet)	Outflow[e] (acre-feet)
2011	35,874	10,639	23,395	0	69,908	7,436	0
2012	43,022	10,048	23,395	0	76,465	16,095	0
2013	41,573	10,802	25,677	0	78,052	16,095	0
2014	40,066	0	26,865	0	66,931	12,070	0
2015	30,276	5,044	8,944	0	44,264	8,050	0
2016	37,414	9,638	28,013	0	75,065	16,095	0
2017	33,980	9,293	18,947	0	62,220	7,500	0
2018	54,254	8,660	15,354	0	78,268	16,095	0
2019	38,002	9,298	17,239	0	64,539	7,500	0
2020	42,309	8,598	19,654	0	70,561	8,050	0
Total	396,770	82,020	207,483	0	686,273	114,986	0
Average	39,677	8,202	20,748	0	68,627	11,499	0

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

[d]Estimated by District based on observation and historical information.

[e]District operates a closed system with little or no outflow; drainwater from rice fields is recaptured and delivered for rice straw decomposition and habitat lands.

District/Company **Meridian Farms Water Company**

Meridian Farms Water Company – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	2,232	0	0	0	2,232
May	4,196	0	0	0	4,196
June	5,100	0	0	0	5,100
July	2,000	2,971	0	0	4,971
August	1,100	4,292	0	0	5,392
September	1,571	0	0	0	1,571
October	280	0	0	0	280
TOTAL	16,479	7,263	0	0	23,742

100

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2

Meridian Farms Water Company – 2020 Groundwater Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater (acre-feet)	Private Groundwater[a] (acre-feet)
Method	M-1	E-1
April	0	0
May	850	407
June	327	661
July	350	943
August	504	856
September	0	0
October	0	0
TOTAL	2,031	2,867

[a]Estimated by District based on observation and historical information.

TABLE 3

Meridian Farms Water Company – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	2232	0	2232
May	4196	850	5046
June	5100	327	5427
July	4971	350	5321
August	5392	504	5896
September	1571	0	1571
October	280	0	280
TOTAL	23742	2031	25773

[a]In addition to the water supplies shown in Table 3, 19,181 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Meridian Farms Water Company_**

Meridian Farms Water Company – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sep	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

TABLE 4

Meridian Farms Water Company – 2020 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Canal	84,480	12	23	2	97	698	(793)
Pipeline	0	0	0	0	0	0	0
Laterals	100,320	12	28	3	115	829	(942)
Water Shed Drains	0	0	0	0	0	0	0
Reservoir	0	0	0	0	0	0	0
TOTAL			51	5	213	1,527	(1,735)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **Meridian Farms Water Company**

TABLE 5

Meridian Farms Water Company – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	502	3.08	0.02	8	1,536	0.11	55
Beans	108	0.75	0.02	2	80	0.47	51
Corn	502	1.93	0.02	8	963	0.14	70
Cotton	76	2.37	0.02	1	179	0.02	2
Milo	33	1.93	0.02	1	63	0.02	1
Pecans	33	2.98	0.02	1	98	0.18	6
Persimmons	26	2.92	0.02	0	76	0.18	5
Prunes	63	2.92	0.02	1	183	0.18	11
Rice	4,206	2.94	0.02	68	12,277	0.06	252
Safflowers	17	1.70	0.02	0	29	0.06	1
Sunflowers	252	1.70	0.02	4	424	0.06	15
Tomatoes	964	1.64	0.02	16	1,562	0.08	77
Melons	5	1.14	0.00	0	6	0.04	0
Vineseed	83	1.01	0.02	1	82	0.18	15
Walnuts	946	3.20	0.02	15	3,008	0.16	151
Wheat	600	0.75	0.02	10	442	0.03	18
Almonds	70	2.75	0.00	0	193	0.18	13
Crop Acres	8,486			136	21,007		730
Total Irrig. Acres	8,486	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 5,250 to 6,300 acre-feet in 2020).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **Meridian Farms Water Company**

TABLE 6

Meridian Farms Water Company – 2020 District Water Balance
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	25,773
Private Groundwater	Table 2	2,867
Inflow From Precip[b]	Estimated	425
Available Soil Moisture[c]	Estimated	202
	Total Water Supplies =	**29,267**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	1,527
Evaporation - Precipitation (Canals/Laterals)	Table 4	207
Riparian ET[d] (Canals/Laterals)	Estimated	1,706
Conveyance System Filling[e] (Canals/Laterals)	Estimated	237
	Total Distribution System =	**3,678**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	21,007
Evapotranspiration of Precip - ET_{pr}	Table 5	136
Cultural Practices *(includes Leaching Requirement)*	Table 5	730
	Total Crop Water Needs =	**21,873**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	426
Rice Cultural and Ecosystem Requirement[h]	Estimated	4,206
Uplslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	0
	Total District Outflow *(from District Records)* **=**	**2,696**
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**19,181**
Percolation from Agricultural Lands[k] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**1,021**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

[k]Percolation from Agricultural Lands is the closure term in the mass water balance. As such, in addition to any percolation to the groundwater basin, the quantity shown includes unaccounted for drain water outflow, any errors in assumptions used in calculations or estimated uses such as crop water use (ET), effective precipitation, evaporation, groundwater recharge, etc. A positive value indicates assumed percolation to groundwater greater than groundwater pumping. A negative value may indicate uncounted for groundwater pumping from privately owned wells.

District/Company **_Meridian Farms Water Company_**

TABLE 7

Meridian Farms Water Company – 2020 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2011	16,792	10,565	0	10,915	38,272	10,915	6,750
2012	19,349	11,208	0	11,625	42,182	11,625	5,825
2013	20,899	9,281	0	800	30,980	20,618	3,871
2014	16,630	4,043	0	900	21,573	10,663	2,574
2015	16,353	2,229	0	750	19,332	11,000	2,426
2016	18,170	8,563	0	900	27,633	19,503	3,052
2017	11,214	7,313	0	1,700	20,227	12,734	2,750
2018	17,492	7,476	0	1,700	26,668	15,509	2,628
2019	14,020	6,219	0	1,700	21,939	16,876	2,304
2020	16,479	7,263	0	0	23,742	19,181	2,696
Total	167,398	74,160	0	30,990	272,548	148,624	34,876
Average	16,740	7,416	0	3,099	27,255	14,862	3,488

[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information. The methods for estimating and accounting for quantities were refined in 2013

[d]Estimated by District based on observation and historical information.

District/Company **Sutter Mutual Water Company**

Sutter Mutual Water Company – 2020 Surface Water Supply
(April through October Period Only)
2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)
	Base Supply (acre-feet)	Project Water (acre-feet)			
Method	M-1	M-1	M-1	E-3	
April	14,961	0	0	0	14,961
May	34,648	0	0	0	34,648
June	39,318	0	0	0	39,318
July	26,320	17,034	0	0	43,354
August	17,406	10,381	0	0	27,787
September	4,008	0	0	0	4,008
October	9,501	0	0	0	9,501
TOTAL	146,162	27,415	0	0	173,577

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.

TABLE 2
Sutter Mutual Water Company – 2020 Groundwater Supply
(April through October Period Only)
2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater[a] (acre-feet)	Private Groundwater[b] (acre-feet)
Method	M-1	E-1
April	0	0
May	0	0
June	0	0
July	2,180	0
August	2,594	0
September	548	0
October	0	0
November	0	0
December	0	0
TOTAL	5,322	0

[a]Quantities in 2020 inlcude private groundwater pumping that occurred for a district wide water transfer.
[b]Estimated by District based on observation and historical information.

TABLE 3
Sutter Mutual Water Company – 2020 Total District Water Supply (excluding reuse)
(April through October Period Only)
2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	14,961	0	14,961
May	34,648	0	34,648
June	39,318	0	39,318
July	43,354	2,180	45,534
August	27,787	2,594	30,381
September	4,008	548	4,556
October	9,501	0	9,501
TOTAL	173,577	5,322	178,899

[a]In addition to the water supplies shown in Table 3, 57,857 acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **Sutter Mutual Water Company**

Sutter Mutual Water Company – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Sutter Mutual Water Company – 2020 Distribution System Evaporation and Seepage
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Main Canal	39,690	90	82	8	342	2,460	(2,794)
West Canal	52,530	90	109	11	453	3,256	(3,698)
Central Canal	50,640	75	87	9	364	2,180	(2,535)
East Canal	71,970	75	124	13	517	3,098	(3,603)
Laterals	533,390	12	147	15	614	3,673	(4,272)
Sub-Laterals	146,060	8	27	3	112	268	(378)
TOTAL			575	58	2,403	14,935	(17,280)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Sutter Mutual Water Company_**

TABLE 5

Sutter Mutual Water Company – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres (crop acres)	Crop ET[a] (AF/Ac)	Effective Precipitation[b] (AF/Ac)	Effective Precipitation[b] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	0	3.08	0.02	0	0	0.11	0
Beans	580	0.75	0.02	9	427	0.47	273
Corn	2,366	1.93	0.02	38	4,537	0.14	331
Milo	101	1.93	0.02	2	194	0.02	2
Melons	226	1.14	0.00	0	257	0.04	9
Rice	29,207	2.94	0.02	472	85,254	0.06	1,752
Rice Straw Decomp	16,500	0.50	0.02	267	7,983	0.00	0
Safflowers	556	1.70	0.02	9	936	0.06	33
Sunflowers	4,616	1.70	0.02	75	7,768	0.06	277
Tomatoes	3,771	1.64	0.02	61	6,111	0.08	302
Vineseed	556	1.01	0.02	9	550	0.18	100
Walnuts	44	3.20	0.02	1	140	0.16	7
Wheat	505	0.75	0.02	8	372	0.03	15
Crop Acres	59,028			951	114,529		3,101
Total Irrig. Acres	42,528	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 36,500 to 43,810 acre-feet in 2020).

[b]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field and flooded habitat, irrigation-season precipitation increases the volume of water in the flooded basin, but it typically flows through the field and, therefore, is assumed to be unavailable to meet the crop water needs.

District/Company **_Sutter Mutual Water Company_**

TABLE 6

Sutter Mutual Water Company – 2020 District Water Balance

(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	178,899
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	2,958
Available Soil Moisture[c]	Estimated	630
	Total Water Supplies =	**182,487**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	14,935
Evaporation - Precipitation (Canals/Laterals)	Table 4	2,345
Riparian ET[d] (Canals/Laterals)	Estimated	500
Conveyance System Filling[e] (Canals/Laterals)	Estimated	1,736
	Total Distribution System =	**19,516**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	114,529
Evapotranspiration of Precip - ET_{pr}	Table 5	951
Cultural Practices *(includes Leaching Requirement)*	Table 5	3,101
	Total Crop Water Needs =	**118,580**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	2,961
Rice Cultural and Ecosystem Requirement[h]	Estimated	29,207
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	45,415
	Total District Outflow *(from District Records)* =	77,583
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**57,857**
	Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*	**(33,193)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f] Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to result from the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and utilized by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

District/Company **Sutter Mutual Water Company**

TABLE 7

Sutter Mutual Water Company – 2020 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow[d] (acre-feet)
2011	136,388	57,423	0	0	193,811	55,954	98,092
2012	134,711	47,314	0	0	182,025	68,493	60,618
2013	163,680	41,675	0	0	205,355	33,062	71,625
2014	127,125	20,028	0	0	147,153	74,162	5,123
2015	126,193	16,662	0	0	142,855	73,068	2,603
2016	140,290	26,124	0	0	166,414	69,499	53,551
2017	128,676	38,505	0	0	167,181	44,571	64,513
2018	143,984	23,736	0	0	167,720	53,285	58,511
2019	141,603	44,504	0	0	186,107	52,679	67,252
2020	146,162	27,415	0	0	173,577	57,857	77,583
Total	1,388,812	343,386	0	0	1,732,198	582,630	559,471
Average	138,881	34,339	0	0	173,220	58,263	55,947

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Non-Federal Ag Water Supply from District Records.
[c]Estimated by District based on observation and historical information.
[d]SMWC has calculated outflow since 2010.

District/Company **_Natomas Central Mutual Water District_**

TABLE 1

Natomas Central Mutual Water District – 2020 Surface Water Supply
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Federal Ag Water Supply[a] Base Supply (acre-feet)	Federal Ag Water Supply[a] Project Water (acre-feet)	Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[b] (acre-feet)	Total (acre-feet)
Method	M-1	M-1	M-1	E-3	
April	2,923	0	0	0	2,923
May	19,785	0	0	0	19,785
June	16,166	0	0	0	16,166
July	11,500	8,387	0	0	19,887
August	3,900	9,860	0	0	13,760
September	2,532	0	0	0	2,532
October	593	0	0	0	593
TOTAL	57,399	18,247	0	0	75,646

[a]Federal Ag Water Supply from Reclamation Water Account Records.
[b]Water from non-Company lands enters the drainage system throughout the April through October period. The quantity for 2018 is unknown at this time but is included in the quantity recycled and reused shown in Table 6.

TABLE 2

Natomas Central Mutual Water District – 2020 Groundwater Supply

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	District Groundwater[a] (acre-feet)	Private Groundwater[b] (acre-feet)
Method	M-1	E-1
April	0	0
May	10	0
June	10	0
July	2,842	0
August	2,612	0
September	2,046	0
October	0	0
TOTAL	7,520	0

[a]Quantities in 2020 inlcude private groundwater pumping that occurred for a district wide water transfer.
[b]Estimated by District based on observation and historical information.

TABLE 3

Natomas Central Mutual Water District – 2020 Total District Water Supply (excluding reuse)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Month	Surface Water Total (acre-feet)	District Groundwater (acre-feet)	Total District Water Supply[a] (acre-feet)
Method	M-1	M-1	M-1
April	2,923	0	2,923
May	19,785	10	19,795
June	16,166	10	16,176
July	19,887	2,842	22,729
August	13,760	2,612	16,372
September	2,532	2,046	4,578
October	593	0	593
TOTAL	75,646	7,520	83,166

[a]In addition to the water supplies shown in Table 3, 58,404acre-feet were recirculated by the District for reuse within its boundaries. This recirculation and reuse is an integral component of the District's total water supply.

District/Company **_Natomas Central Mutual Water District_**

Natomas Central Mutual Water District – 2020 Distribution System Evaporation and Seepage Worksheet

2020 Sacramento Valley Regional Water Management Plan Annual Update

2020	Precipitation[a]		Evaporation[b]	
	inches	feet	inches	feet
Jan	1.1	0.09	1.4	0.12
Feb	0.0	0.00	3.8	0.32
Mar	0.9	0.08	4.2	0.35
Apr	0.8	0.07	6.0	0.50
May	0.3	0.03	8.0	0.67
Jun	0.0	0.00	9.0	0.75
Jul	0.0	0.00	9.0	0.75
Aug	0.0	0.00	7.3	0.61
Sept	0.0	0.00	5.8	0.48
Oct	0.0	0.00	5.0	0.42
Nov	0.5	0.04	2.5	0.21
Dec	1.3	0.11	1.8	0.15
TOTAL-YR	5.0	0.41	63.8	5.32
TOTAL-Apr-Oct	**1.2**	**0.10**	**50.1**	**4.18**

[a]Average precipitation reported for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235).

[b]Monthly evaporation from Distribution System water surfaces is estimated as 1.1 x the average reference ET (ETo) reported for for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

TABLE 4

Natomas Central Mutual Water District – 2020 Distribution System Evaporation and Seepage

2020 Sacramento Valley Regional Water Management Plan Annual Update

Canal, Pipeline, Lateral, Reservoir	Length[a] (feet)	Width[b] (feet)	Surface Area (acres)	Precipitation[c] (acre-feet)	Evaporation[d] (acre-feet)	Seepage[e] (acre-feet)	Total (acre-feet)
Bennet System	44,700	56	58	6	242	579	(815)
Northern System	146,400	54	180	18	754	1,805	(2,540)
Prichard Lake Sys	204,400	54	252	26	1,050	2,515	(3,540)
Elkhorn System	75,100	44	76	8	318	762	(1,073)
Riverside System	65,800	46	69	7	289	692	(974)
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
TOTAL			635	64	2,653	6,353	(8,941)

[a]From District statistics.

[b]Average width of the conveyance facilities.

[c]Estimated inflow resulting from precipitation on canals, laterals, and drains during the irrigation season.

[d]Estimated evaporation from canals, laterals, and drains during the irrigation season.

[e]Estimated seepage from canals, laterals, and drains during the irrigation season.

District/Company **_Natomas Central Mutual Water District_**

TABLE 5

Natomas Central Mutual Water District – 2020 Crop Consumptive Use Water Needs (April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Crop Name	Acres[a] (crop acres)	Crop ET[b] (AF/Ac)	Effective Precipitation[c] (AF/Ac)	Effective Precipitation[c] (acre-feet)	ETAW (acre-feet)	Leaching Requirement (AF/Ac)	Leaching Requirement (acre-feet)
Alfalfa	113	3.08	0.02	2	346	0.11	12
Clover	119	0.75	0.02	2	88	0.47	56
Corn	119	1.93	0.02	2	228	0.14	17
Idle	288	0.16	0.02	5	41	0.00	0
Golf Course	130	3.38	0.02	2	437	0.03	4
Hops	5	1.01	0.02	0	5	0.18	1
Kiwis	2	2.92	0.02	0	6	0.18	0
Managed Marsh	695	2.97	0.02	11	2,053	0.00	0
Melons	22	1.14	0.00	0	25	0.04	1
Oats	230	0.75	0.02	4	170	0.02	5
Onions	26	0.89	0.02	0	23	0.28	7
Pasture	23	3.35	0.02	0	77	0.03	1
Pears	2	2.92	0.02	0	6	0.18	0
Peppers	7	1.64	0.02	0	11	0.08	1
Pumpkins	29	1.14	0.00	0	33	0.04	1
Rice	16,400	2.94	0.02	265	47,871	0.06	984
Rice Straw Decomp	5,688	0.50	0.02	92	2,752	0.00	0
Safflowers	193	1.70	0.02	3	325	0.06	12
Squash	19	1.14	0.00	0	22	0.04	1
Sunflowers	43	1.70	0.02	1	72	0.06	3
Tomatoes	108	1.64	0.02	2	175	0.08	9
Trees	4	0.00	0.00	0	0	0.18	1
Mixed Truck	41	0.85	0.02	1	34	0.18	7
Wild Rice	150	0.00	0.00	0	0	0.06	9
Hay	76	0.75	0.02	1	56	0.03	2
Beans	94	0.75	0.02	2	69	0.47	44
Wheat	564	0.75	0.02	9	416	0.03	17
Crop Acres	25,190			404	55,340		1,195
Total Irrig. Acres	24,151	(If this number is larger than your known total, it may be due to double cropping.)					

[a]Acres include lands, if any, irrigated by private wells.

[b]Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250), and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres. This quantity is estimated to be approximately 1.25 to 1.5 acre-feet per acre (approximately 19,500 to 23,500 acre-feet in 2018).

[c]Effective Precipitation is estimated as 60% of monthly precipitation greater than 0.5 inch during crop growing season. Because of the nature of flooded areas, such as rice field

District/Company **Natomas Central Mutual Water District**

TABLE 6

Natomas Central Mutual Water District – 2020 District Water Balance

2020 Sacramento Valley Regional Water Management Plan Annual Update

Water Supplies (excluding recirculation) [a]		
District Water Supply *(includes District Groundwater)*	Table 3	83,166
Private Groundwater	Table 2	0
Inflow From Precip[b]	Estimated	1,660
Available Soil Moisture[c]	Estimated	114
	Total Water Supplies =	**84,940**
Distribution System Evaporation and Seepage		
Seepage (Canals/Laterals)	Table 4	6,353
Evaporation - Precipitation (Canals/Laterals)	Table 4	2,588
Riparian ET[d] (Canals/Laterals)	Estimated	592
Conveyance System Filling[e] (Canals/Laterals)	Estimated	756
	Total Distribution System =	**10,289**
Crop Consumptive Use Water Needs [f]		
Evapotranspiration of Applied Water - ETAW *(includes Evap from Rice Straw Decomposition)*	Table 5	55,340
Evapotranspiration of Precip - ET_{pr}	Table 5	404
Cultural Practices *(includes Leaching Requirement)*	Table 5	1,195
	Total Crop Water Needs =	**56,938**
District Outflows		
Water Supply Delivered to Other Districts or Users	District Records	0
Irrigation Season Rainfall Runoff[g]	Estimated	1,663
Rice Cultural and Ecosystem Requirement[h]	Estimated	16,400
Upslope Drainwater Flow Through[i]	Estimated	0
Remainder Drainwater Outflow[j]	Calculated	2,443
	Total District Outflow *(from District Records)* =	20,506
Internal Recirculation and Reuse		
Total Quantity Recirculated for Reuse	District Records	**58,404**
Percolation from Agricultural Lands[j] *(Total Supplies - Distribution System - Crop Water Needs - District Outflows)*		**(2,793)**

[a]Water Supplies - Includes surface and groundwater supplies diverted or pumped into the District to meet Crop Consumptive Use Water Needs, District Operational needs, and water required for cultural practice needs (e.g., flooding, reflooding, and flow through for rice cultivation). Does not include water recirculated by the District.

[b]Inflow from Precipitation is calculated as total April - September precipitation x Total Rice Acres plus October precipitation X Total Rice Straw Decomp Acres.

[c]Available Soil Moisture is estimated as a 10% of Jan precip + 30% of Feb precip + 50% of Mar precip on Non-Rice and Non-Habitat acres.

[d]Riparian ET is estimated based on observation.

[e]Conveyance System Filling - Quantity estimated by the District required to initially fill conveyance canals and laterals. The conveyance systems are typically drained after October 31.

[f]Crop Consumptive Use Water Needs do not include quantities required for flood-up or flow through for rice.

[g]Irrigation Season Rainfall Runoff - Portion of District Outflow estimated to be the result of rainfall that cannot be captured or recirculated. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[h]Rice Cultural and Ecosystem Requirement - Portion of District Outflow estimated to be due to the cultural requirements for rice flood-up and flow through. This water is available to downstream water users, for instream flow, and to meet Delta Outflow requirements.

[i]Upslope drainwater flow through is 50% of April, May, and June upslope water, limited by the Total District Outflow.

[j]Drainwater Outflow - Outflow from operational spills and end-of-season drainage. This water is available to (and used by) downstream water users, for instream flow, and to meet Delta Outflow requirements.

District/Company **_Natomas Central Mutual Water District_**

TABLE 7

Natomas Central Mutual Water District – 2020 Annual Water Quantities Delivered under Each Right or Contract
(April through October Period Only)

2020 Sacramento Valley Regional Water Management Plan Annual Update

Year	Federal Ag Water Supply[a]		Non-Federal Ag Water Supply[b] (acre-feet)	Upslope Drainwater[c] (acre-feet)	Total (acre-feet)	District	
	Base Supply (acre-feet)	Project Water (acre-feet)				Recapture (acre-feet)	Outflow (acre-feet)
2011	37,349	8,707	0	0	46,056	39,989	15,000
2012	35,685	8,322	0	0	44,007	59,923	15,115
2013	48,050	13,073	0	28,288	89,411	51,433	10,317
2014	57,654	16,397	0	0	74,051	49,466	3,952
2015	58,255	15,093	0	0	73,348	65,147	2,028
2016	54,200	13,418	0	0	67,618	53,092	2,167
2017	53,451	16,882	0	0	70,333	55,967	3,418
2018	50,525	15,756	0	0	66,281	59,978	7,052
2019	41,596	12,120	0	0	66,281	59,978	7,052
2020	57,399	18,247	0	0	75,646	58,404	20,506
Total	494,164	138,015	0	28,288	673,032	553,377	86,607
Average	49,416	13,802	0	2,829	67,303	55,338	8,661

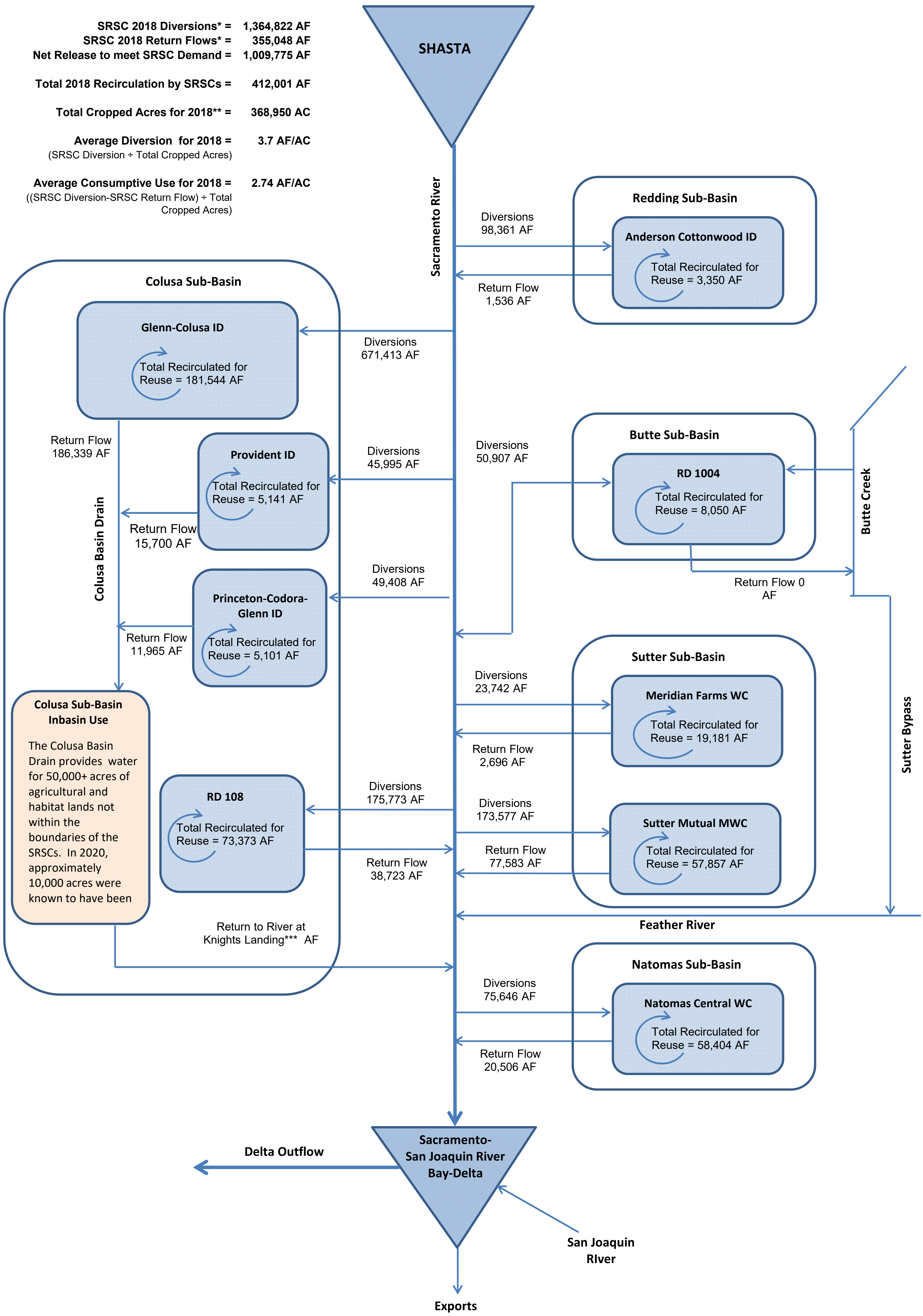
[a]Federal Ag Water Supply from Reclamation Water Account Records.

[b]Non-Federal Ag Water Supply from District Records.

[c]Estimated by District based on observation and historical information.

2020 Summary Graphic

Summary of SRSC Diversions and Return Flows
2020



Notes: * Diversions and Return Flows are from 2018 SRSC Water Balance tables.
** Total Cropped Acres for 2018 includes 20,000 acres within the Colusa Sub-basin that rely on return flows from the SRSCs for surface water supplies.
*** Return to River at Knights Landing is currently not publicaly available data, and thus is not available for 2018.

MBK*ENGINEERS*
11/17/2021

Attachment M2 Evaporation and Effective Precipitation

2018 Crop Evapotranspiration Tables: Redding Sub-basin

Regional Water Management Plan Update

Evapotranspiration and Effective Precipitation - 2018

2020 Sacramento Valley Regional Water Management Plan Annual Update

	2018	April	May	June	July	August	September	October	Total Growing Season Etc	April	May	June	July	August	September	October	Effective Precip
	Precipitation	**2.71**	**1.05**	**0.13**	**0**	**0**	**0**	**0.45**		**2.71**	**1.05**	**0.13**	**0**	**0**	**0**	**0.45**	
	Grass Reference ETo	**4.93**	**7.43**	**9.01**	**8.22**	**6.53**	**5.67**	**4.19**									**60%**
Crop Type	**ITRC Representative Crop**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(AF)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(feet)**
Alfalfa	Alfalfa Hay and Clover	4.08	6.27	7.79	6.79	5.32	4.81	0.00	2.92	1.33	0.33	0.00	0.00	0.00	0.00	0.00	0.14
Pasture	Pasture and Misc. Grasses	3.81	6.82	8.38	7.56	6.13	5.15	0.00	3.15	1.33	0.33	0.00	0.00	0.00	0.00	0.00	0.14
Walnuts	Walnuts	1.52	5.66	9.46	8.46	6.81	5.36	0.00	3.10	1.33	0.33	0.00	0.00	0.00	0.00	0.00	0.14

Source: Kc values from *California Crop and Soil Evapotranspiration* , ITRC Report 03-001, January 2003.

Notes:

Crop ET (ETc) was calculated as ETo for CIMIS Station at Gerber South (#222) x Kc based on ITRC Typical Year ETc for Zone 14 surface irrigation for water balances. Water Needs do not include water required for cultural practices

Precipitation is the 2018 monthly precipitation reported for the CIMIS Station at Gerber South (#222).

Effective precipitation was estimated as 60% of rainfall greater than 0.5 inch per month occurring during the growing season.

2018 Crop Evapotranspiration Tables: Colusa, Butte, Sutter, and American Sub-basin

Regional Water Management Plan Update

Evapotranspiration and Effective Precipitation - 2018

2020 Sacramento Valley Regional Water Management Plan Annual Update

	2018	April	May	June	July	August	September	October	Total Growing Season Etc	April	May	June	July	August	September	October	Effective Precip
	Precipitation	**2.71**	**1.05**	**0.13**	**0.00**	**0.00**	**0.00**	**0.45**		**2.71**	**1.05**	**0.13**	**0.00**	**0.00**	**0.00**	**0.45**	
	Grass Reference ETo	**4.93**	**7.43**	**9.01**	**8.22**	**6.53**	**5.67**	**4.19**									**60%**
Crop Type	**ITRC Representative Crop**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(AF)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(feet)**
Alfalfa	Alfalfa Hay and Clover	4.16	4.16	5.97	6.70	6.36	5.19	4.49	2.95	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Almonds	Almonds	0.00	0.00	5.81	6.49	6.38	5.46	4.32	2.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Beans	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Buckwheat	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cantelope	Melons, Squash, and Cucumbers	0.00	0.00	0.89	1.41	4.47	4.88	1.45	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chestnuts	Almonds	2.40	2.40	5.81	6.49	6.38	5.46	4.32	2.86	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cilantro	Small Vegetables	4.70	4.70	1.64	0.19	0.00	0.90	1.37	0.80	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Corn	Corn and Grain Sorghum	1.12	1.12	2.30	6.65	7.19	4.78	0.00	1.84	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cotton	Cotton	0.81	0.81	1.53	4.47	7.47	6.44	4.75	2.28	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cover Crop	Pasture and Misc. Grasses	3.72	3.72	6.47	7.18	6.96	5.80	4.87	3.21	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Cucumbers	Melons, Squash, and Cucumbers	0.00	0.00	0.89	1.41	4.47	4.88	1.45	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Golf course	N/A	3.72	3.72	6.47	7.18	6.96	5.80	4.87	3.38	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Grain	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Grapes	Grape Vines with 80% canopy	0.92	0.92	3.14	5.63	5.64	4.27	2.85	1.87	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
	Citrus (no ground cover)									0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Habitat	N/A	3.42	4.67	5.11	4.97	4.33	3.37	3.31	2.43	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Hay	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Hops	Small Vegetables	4.80	4.80	1.70	0.20	0.13	1.26	1.41	0.94	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Idle	Idle	0.18	0.18	0.19	0.20	0.13	0.30	0.07	0.15	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Kiwis	N/A								2.92	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Managed Marsh	N/A								2.97	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Melons	Melons, Squash, and Cucumbers	0.00	0.00	0.89	1.41	4.47	4.88	1.45	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Melons, Squash	Melons, Squash, and Cucumbers	0.00	0.00	0.89	1.41	4.47	4.88	1.45	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Milo	Corn and Grain Sorghum	1.12	1.12	2.30	6.65	7.19	4.78	0.00	1.84	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Misc. Deciduous	Misc. Deciduous	1.84	1.84	5.31	6.52	6.43	5.46	4.18	2.71	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Misc. field crops	Misc. field crops	1.12	1.12	2.27	6.79	6.85	2.54	0.00	1.63	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Mixed Truck	Small Vegetables	4.70	4.70	1.64	0.19	0.00	0.90	1.37	0.80	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Oats	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Olives	Avocado	1.84	1.84	5.31	6.52	6.43	5.46	4.18	2.71	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Onions	Onions and Garlic	4.03	4.03	4.88	1.10	0.00	0.00	0.00	0.83	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Pasture	Pasture and Misc. Grasses	3.72	3.72	6.47	7.18	6.96	5.80	4.87	3.21	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Peach	Peach, Nectarine and Apricots	1.75	1.75	5.45	6.75	6.67	5.61	4.36	2.78	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Pears	Apple, Pear, Cherry, Plum and Prune	1.91	1.91	5.62	6.76	6.77	5.63	4.44	2.81	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Pecans	Almonds	2.40	2.40	5.81	6.49	6.38	5.46	4.32	2.86	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Peppers	Tomatoes and Peppers	0.63	0.63	3.36	7.73	6.20	0.79	0.00	1.56	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Persimmons	Apple, Pear, Cherry, Plum and Prune	1.91	1.91	5.62	6.76	6.77	5.63	4.44	2.81	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Prunes	Apple, Pear, Cherry, Plum and Prune	1.91	1.91	5.62	6.76	6.77	5.63	4.44	2.81	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Pumpkins	Melons, Squash, and Cucumbers	0.00	0.00	0.89	1.41	4.47	4.88	1.45	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	Rice	0.61	0.61	6.36	8.76	8.62	7.15	2.31	2.82	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Rice Straw Decomp	N/A								0.50	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Rye Grass	Grain and Grain Hay	4.95	4.95	3.44	0.00	0.00	0.00	0.00	0.70	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Safflowers	Safflower and Sunflower	4.21	4.21	7.50	6.85	0.84	0.00	0.00	1.62	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Squash	Melons, Squash, and Cucumbers	0.00	0.00	0.89	1.41	4.47	4.88	1.45	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strawberries	Strawberries	1.12	1.12	2.27	6.79		2.54	0.00	1.63	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Sudan	Pasture and Misc. Grasses	3.72	3.72	6.47	7.18	6.96	5.80	4.87	3.21	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Sunflowers	Safflower and Sunflower	4.21	4.21	7.50	6.85	0.84	0.00	0.00	1.62	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Tomatoes	Tomatoes and Peppers	0.63	0.63	3.36	7.73	6.20	0.79	0.00	1.56	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Vegetable Seed	Small Vegetables	4.70	4.70	1.64	0.19	0.00	0.90	1.37	0.80	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Vegetables	Small Vegetables	4.70	4.70	1.64	0.19	0.00	0.90	1.37	0.80	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Vetch	Pasture and Misc. Grasses	3.72	3.72	6.47	7.18	6.96	5.80	4.87	3.21	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Vineseed	Small Vegetables	4.80	4.80	1.70	0.20	0.13	1.26	1.41	0.94	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.04

Source: Kc values from *California Crop and Soil Evapotranspiration* , ITRC Report 03-001, January 2003.

Notes:

Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres.

Precipitation is the 2018 average monthly precipitation reported for the CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

Effective precipitation was estimated as 60% of rainfall greater than 0.5 inch per month occurring during the growing season.

2019 Crop Evapotranspiration Tables: Redding Sub-basin

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	2019	April	May	June	July	August	September	October	Total Growing Season Etc	April	May	June	July	August	September	October	Effective Precip
	Precipitation	**0.56**	**3.04**	**0**	**0.00**	**0**	**0.33**	**0.02**		**0.56**	**3.04**	**0**	**0.00**	**0**	**0.33**	**0.02**	
	Grass Reference ETo	**5.04**	**6.37**	**8.89**	**8.33**	**7.26**	**5.55**	**4.8**									**60%**
Crop Type	**ITRC Representative Crop**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(AF)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(feet)**
Alfalfa	Alfalfa Hay and Clover	5.50	7.06	8.37	6.95	5.97	4.53	0.00	3.20	0.04	1.52	0.00	0.00	0.00	0.00	0.00	0.13
Pasture	Pasture and Misc. Grasses	4.77	6.62	8.30	7.66	6.66	5.10	0.00	3.26	0.04	1.52	0.00	0.00	0.00	0.00	0.00	0.13
Walnuts	Walnuts	3.57	6.72	9.29	8.61	7.42	5.35	0.00	3.41	0.04	1.52	0.00	0.00	0.00	0.00	0.00	0.13

Source: Kc values from *California Crop and Soil Evapotranspiration* , ITRC Report 03-001, January 2003.
Notes:
Crop ET (ETc) was calculated as ETo for CIMIS Station at Gerber South (#222) x Kc based on ITRC Wet Year ETc for Zone 14 surface irrigation for water balances. Water Needs do not include water required for cultural practices
Precipitation is the 2019 monthly precipitation reported for the CIMIS Station at Gerber South (#222).
Effective precipitation was estimated as 60% of rainfall greater than 0.5 inch per month occurring during the growing season.

2019 Crop Evapotranspiration Tables: Colusa, Butte, Sutter, and American Sub-basin

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	2019	April	May	June	July	August	September	October	Total Growing Season Etc	April	May	June	July	August	September	October	Effective Precip
	Precipitation	**0.25**	**2.28**	**0.02**	**0.01**	**0.01**	**0.46**	**0.00**		**0.25**	**2.28**	**0.02**	**0.01**	**0.01**	**0.46**	**0.00**	
	Grass Reference ETo	**5.61**	**6.22**	**8.50**	**7.93**	**7.14**	**5.47**	**5.02**									**60%**
Crop Type	**ITRC Representative Crop**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(AF)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(feet)**
Alfalfa	Alfalfa Hay and Clover	0.00	6.81	7.93	6.56	5.85	4.47	2.74	2.86	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Almonds	Almonds	0.00	6.33	7.60	6.32	5.89	4.58	3.84	2.88	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Barley	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Beans	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Buckwheat	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Cantelope	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Chestnuts	Almonds	0.00	6.33	7.60	6.32	5.89	4.58	3.84	2.88	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Cilantro	Small Vegetables	5.67	3.90	0.74	0.00	1.03	1.20	1.69	1.19	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Corn	Corn and Grain Sorghum	0.00	4.47	7.34	7.49	5.21	0.00	0.00	2.04	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Cotton	Cotton	0.00	3.77	5.20	7.62	7.13	5.15	2.76	2.64	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Cover Crop	Pasture and Misc. Grasses	0.00	6.28	7.77	7.17	6.52	4.95	4.13	3.07	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Cucumbers	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Golf course	N/A								3.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Grain	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Grapes	Grape Vines with 80% canopy	0.00	5.08	6.53	5.80	4.61	2.82	0.00	2.07	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Habitat	N/A								3.24	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Hay	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Hops	Small Vegetables	0.00	3.90	0.74	0.00	1.03	1.20	1.69	0.71	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Idle	Idle	0.00	3.02	0.74	0.00	0.02	0.14	0.79	0.39	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Kiwis	N/A								2.92	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Managed Marsh	N/A								2.97	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Melons	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Melons, Squash	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Milo	Corn and Grain Sorghum	0.00	4.47	7.34	7.49	5.21	0.00	0.00	2.04	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Misc. Deciduous	Misc. Deciduous	0.00	6.25	7.49	6.41	5.92	4.44	3.39	2.82	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Misc. field crops	Misc. field crops	0.00	4.47	7.62	6.97	2.45	0.00	0.00	1.79	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Mixed Truck	Small Vegetables	0.00	3.90	0.74	0.00	1.03	1.20	1.69	0.71	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Oats	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Olives	Avocado	0.00	6.25	7.49	6.41	5.92	4.44	3.39	2.82	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Onions	Onions and Garlic	0.00	5.24	1.98	0.00	0.00	0.00	0.00	0.60	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Pasture	Pasture and Misc. Grasses	0.00	6.28	7.77	7.17	6.52	4.95	4.13	3.07	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Peach	Peach, Nectarine and Apricots	0.00	6.27	7.87	6.72	6.10	4.61	3.32	2.91	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Pears	Apple, Pear, Cherry, Plum and Prune	0.00	6.33	7.83	6.66	6.30	4.52	3.39	2.92	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Pecans	Almonds	0.00	6.33	7.60	6.32	5.89	4.58	3.84	2.88	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Peppers	Tomatoes and Peppers	0.00	5.02	8.35	6.69	0.72	0.00	0.00	1.73	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Persimmons	Apple, Pear, Cherry, Plum and Prune	0.00	6.33	7.83	6.66	6.30	4.52	3.39	2.92	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Prunes	Apple, Pear, Cherry, Plum and Prune	0.00	6.33	7.83	6.66	6.30	4.52	3.39	2.92	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Pumpkins	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Rice	Rice	0.00	6.57	9.40	8.91	7.96	2.66	0.00	2.96	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Rice Straw Decomp	N/A								0.50	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Rye Grass	Grain and Grain Hay	5.85	4.57	0.00	0.00	0.00	0.00	0.00	0.87	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Safflowers	Safflower and Sunflower	0.00	6.66	8.02	1.35	0.00	0.00	0.00	1.34	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Squash	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Strawberries	Strawberries	0.00	4.47	7.62	6.97	2.45	0.00	0.00	1.79	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Sudan	Pasture and Misc. Grasses	0.00	6.28	7.77	7.17	6.52	4.95	4.13	3.07	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Sunflowers	Safflower and Sunflower	0.00	6.66	8.02	1.35	0.00	0.00	0.00	1.34	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Tomatoes	Tomatoes and Peppers	0.00	5.02	8.35	6.69	0.72	0.00	0.00	1.73	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Vegetable Seed	Small Vegetables	5.67	3.90	0.74	0.00	1.03	1.20	1.69	1.19	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Vegetables	Small Vegetables	0.00	3.90	0.74	0.00	1.03	1.20	1.69	0.71	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Vetch	Pasture and Misc. Grasses	0.00	6.28	7.77	7.17	6.52	4.95	4.13	3.07	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Vineseed	Small Vegetables	0.00	3.90	0.74	0.00	1.03	1.20	1.69	0.71	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Walnuts	Walnuts	0.00	6.31	8.61	7.97	7.19	4.89	3.72	3.22	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Watermelon	Melons, Squash, and Cucumbers	0.00	3.54	1.63	4.42	5.41	1.85	0.00	1.40	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09
Wheat	Grain and Grain Hay	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.38	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.09

Source: Kc values from *California Crop and Soil Evapotranspiration* , ITRC Report 03-001, January 2003.

Notes:

Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235) x Kc based on ITRC Wet Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres.

Precipitation is the 2019 average monthly precipitation reported for the CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

Effective precipitation was estimated as 60% of rainfall greater than 0.5 inch per month occurring during the growing season.

2020 Crop Evapotranspiration Tables: Redding Sub-basin

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	2020	April	May	June	July	August	September	October	Total Growing Season Etc	April	May	June	July	August	September	October	Effective Precip
	Precipitation	**0.43**	**2.02**	**0.19**	**0**	**0.06**	**0**	**0.00**		**0.43**	**2.02**	**0.19**	**0**	**0.06**	**0**	**0.00**	
	Grass Reference ETo	**5.4**	**7.08**	**8.37**	**8.68**	**6.34**	**5.44**	**4.77**									**60%**
Crop Type	**ITRC Representative Crop**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(AF)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(feet)**
Alfalfa	Alfalfa Hay and Clover	4.47	5.97	7.24	7.17	5.16	4.62	0.00	2.89	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.08
Pasture	Pasture and Misc. Grasses	4.18	6.49	7.78	7.98	5.95	4.94	0.00	3.11	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.08
Walnuts	Walnuts	1.66	5.39	8.79	8.93	6.61	5.14	0.00	3.04	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.08

Source: Kc values from *California Crop and Soil Evapotranspiration* , ITRC Report 03-001, January 2003.

Notes:

Crop ET (ETc) was calculated as ETo for CIMIS Station at Gerber South (#222) x Kc based on ITRC Typical Year ETc for Zone 14 surface irrigation for water balances. Water Needs do not include water required for cultural practices

Precipitation is the 2020 monthly precipitation reported for the CIMIS Station at Gerber South (#222).

Effective precipitation was estimated as 60% of rainfall greater than 0.5 inch per month occurring during the growing season.

2020 Crop Evapotranspiration Tables: Colusa, Butte, Sutter, and American Sub-basin

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	2020	April	May	June	July	August	September	October	Total Growing Season Etc	April	May	June	July	August	September	October	Effective Precip
	Precipitation	**0.82**	**0.34**	**0.03**	**0.00**	**0.01**	**0.00**	**0.00**		**0.82**	**0.34**	**0.03**	**0.00**	**0.01**	**0.00**	**0.00**	
	Grass Reference ETo	**5.44**	**7.26**	**8.18**	**8.21**	**6.66**	**5.24**	**4.57**									**60%**
Crop Type	**ITRC Representative Crop**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(AF)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(inches)**	**(feet)**
Alfalfa	Alfalfa Hay and Clover	4.64	6.10	6.97	6.80	5.41	4.39	2.61	3.08	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Almonds	Almonds	0.00	5.94	6.76	6.83	5.69	4.22	3.58	2.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Barley	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Beans	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Buckwheat	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Cantelope	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chestnuts	Almonds	2.68	5.94	6.76	6.83	5.69	4.22	3.58	2.98	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Cilantro	Small Vegetables	5.24	1.68	0.19	0.00	0.94	1.34	0.87	0.85	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Clover	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Corn	Corn and Grain Sorghum	1.25	2.35	6.92	7.70	4.99	0.00	0.00	1.93	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Cotton	Cotton	0.90	1.57	4.65	8.00	6.71	4.64	1.98	2.37	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Cover Crop	Pasture and Misc. Grasses	4.15	6.61	7.47	7.45	6.05	4.76	3.71	3.35	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Cucumbers	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Golf course	N/A								3.38	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Grain	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Grapes	Grape Vines with 80% canopy	1.03	3.21	5.86	6.04	4.45	2.79	0.00	1.95	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Habitat	Citrus (no ground cover)	3.82	4.77	5.32	5.32	4.51	3.29	3.48	2.54	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Habitat	N/A								3.24	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Hay	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Hops	Corn and Grain Sorghum	5.35	1.73	0.21	0.14	1.31	1.38	1.94	1.01	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Idle	**Idle**	0.21	0.20	0.21	0.14	0.32	0.07	0.76	0.16	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Kiwis	N/A								2.92	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Managed Marsh	N/A								2.97	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Melons	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Melons, Squash	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Milo	Corn and Grain Sorghum	1.25	2.35	6.92	7.70	4.99	0.00	0.00	1.93	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Misc. Deciduous	Misc. Deciduous	2.05	5.42	6.79	6.89	5.69	4.08	2.90	2.82	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Misc. field crops	Misc. field crops	1.25	2.32	7.07	7.33	2.65	0.00	0.00	1.72	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Mixed Truck	Small Vegetables	5.24	1.68	0.19	0.00	0.94	1.34	0.87	0.85	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Oats	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Olives	Avocado	2.05	5.42	6.79	6.89	5.69	4.08	2.90	2.82	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Onions	Onions and Garlic	4.50	4.99	1.14	0.00	0.00	0.00	0.00	0.89	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Pasture	Pasture and Misc. Grasses	4.15	6.61	7.47	7.45	6.05	4.76	3.71	3.35	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Peach	Peach, Nectarine and Apricots	1.96	5.57	7.03	7.14	5.84	4.26	2.87	2.89	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Pears	Apple, Pear, Cherry, Plum and Prune	2.13	5.74	7.04	7.25	5.87	4.33	2.73	2.92	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Pecans	Almonds	2.68	5.94	6.76	6.83	5.69	4.22	3.58	2.98	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Peppers	Tomatoes and Peppers	0.70	3.43	8.04	6.64	0.83	0.00	0.00	1.64	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Persimmons	Apple, Pear, Cherry, Plum and Prune	2.13	5.74	7.04	7.25	5.87	4.33	2.73	2.92	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Prunes	Apple, Pear, Cherry, Plum and Prune	2.13	5.74	7.04	7.25	5.87	4.33	2.73	2.92	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Pumpkins	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rice	Rice	0.68	6.50	9.12	9.22	7.45	2.25	0.00	2.94	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Rice Straw Decomp	N/A								0.5	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Rye Grass	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Safflowers	Safflower and Sunflower	4.70	7.66	7.13	0.90	0.00	0.00	0.00	1.70	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Squash	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Strawberries	Strawberries	1.25	2.32	7.07	7.33	2.65	0.00	0.00	1.72	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Sudan	Pasture and Misc. Grasses	4.15	6.61	7.47	7.45	6.05	4.76	3.71	3.35	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Sunflowers	Safflower and Sunflower	4.70	7.66	7.13	0.90	0.00	0.00	0.00	1.70	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Tomatoes	Tomatoes and Peppers	0.70	3.43	8.04	6.64	0.83	0.00	0.00	1.64	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Trees	Almonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Truck	Misc. field crops	1.25	2.32	7.07	7.33	2.65	0.00	0.00	1.72	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Vegetable Seed	Small Vegetables	5.24	1.68	0.19	0.00	0.94	1.34	0.87	0.85	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Vegetables	Small Vegetables	5.24	1.68	0.19	0.00	0.94	1.34	0.87	0.85	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Vetch	Pasture and Misc. Grasses	4.15	6.61	7.47	7.45	6.05	4.76	3.71	3.35	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Vineseed	Small Vegetables	5.35	1.73	0.21	0.14	1.31	1.38	1.94	1.01	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Walnuts	Walnuts	1.59	5.25	8.42	8.25	6.67	4.68	3.48	3.20	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Watermelon	Melons, Squash, and Cucumbers	0.00	0.91	1.47	4.79	5.08	1.42	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat	Grain and Grain Hay	5.52	3.52	0.00	0.00	0.00	0.00	0.00	0.75	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Wild Rice	Rice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Kc values from California Crop and Soil Evapotranspiration , ITRC Report 03‐001, January 2003.

Notes: Crop ET (ETc) was calculated as average ETo for CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235) x Kc based on ITRC Typical Year ETc for Zone 12 surface irrigation for water balances. Crop ET does not include water required for initial flooding, reflooding, or flow through on rice acres.

Precipitation is the 2020 average monthly precipitation reported for the CIMIS Stations at Davis (#6), Williams (#250) and Verona (#235).

Effective precipitation was estimated as 60% of rainfall greater than 0.5 inch per month occurring during the growing season.

Attachment N
Communications Examples

Resources for Landowners

Your water district/company participates in annual and five-year water management planning horizons with the U.S. Bureau of Reclamation through the Sacramento Valley Regional Water Management Plan. As part of this process, a webpage has been developed to list various resources available to you as a landowner and/or water user. These resources include listing entities that offer on-farm evaluations, water quantity and quality data, and opportunities for financial assistance. This webpage is accessible at www.gcid.net/rwur . For questions regarding this resource, please contact your district/company representative, <insert name>, at <insert phone and/or email.>

Month, Day, 2021

Attachment O
Final Sacramento Valley Water Quality Coalition 2019 Annual Monitoring Report

M A Y 2 0 2 0

S A C R A M E N T O V A L L E Y W A T E R Q U A L I T Y C O A L I T I O N

Monitoring and Reporting Program

Annual Monitoring Report 2019:

October 2018 – September 2019

Prepared by

LARRY WALKER ASSOCIATES

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Executive Summary

SUMMARY OF MONITORING PROGRAM

The Sacramento Valley Water Quality Coalition (Coalition) has developed and implemented a Monitoring and Reporting Program (MRP) to meet the requirements of the *Waste Discharge Requirements General Order for Growers within the Sacramento River Watershed that are Members of a Third-Party Group* (*R5-2014-0030*) (WDR).[1] The scope of the MRP and the sampling and analytical methods used in 2019 Coalition Monitoring have been approved by the Central Valley Regional Water Quality Control Board (Regional Water Board).

In accordance with the WDR requirements, the Coalition is achieving these objectives by implementing a MRP that evaluates samples for the presence of statistically significant toxicity and exceedances of applicable numeric water quality objectives and Irrigated Lands Regulatory Program (ILRP) Trigger Limits. The Coalition initiates follow-up actions designed to identify constituents causing significant toxicity when toxicity is of sufficient magnitude. Exceedances of numeric objectives and ILRP Trigger Limits for chemical, physical, and microbiological parameters trigger follow-up actions designed to identify potential sources and to inform potential users of the products that contain constituents of concern. Additionally, the Coalition is evaluating the degree of implementation of current management practices in priority watersheds (i.e., those where Management Plans have been triggered) and recommending additional practices as water quality results indicate a need to do so. The Coalition is committed to the principle of adaptive management to control specific discharges of waste from agricultural lands that are having an impact on water quality. This iterative approach allows for the most effective use of limited human and fiscal resources.

The 2019 Coalition Monitoring was conducted in coordination with the Northeastern California Water Association (Pit River Subwatershed), the Placer-Nevada-South Sutter-North Sacramento Watershed Group, the Goose Lake Watershed Group, and the Upper Feather River Watershed Group. Additional monitoring in the Upper Feather River and Pit River subwatersheds was conducted in coordination with California's Surface Water Ambient Monitoring Program (SWAMP) beginning in 2012.

The parameters monitored in 2019 by the Coalition to achieve these objectives are as specified in the current WDR and MRP (*Order No. R5-2014-0030*):

- Water column and sediment toxicity
- Physical and conventional parameters in water
- Organic carbon
- Pathogen indicator organisms in water
- Trace metals in water

[1] Prior to adoption of the WDR, the Coalition was subject to a Conditional Waiver of Waste Discharge Requirements for the Irrigated Lands Regulatory Program (ILRP) and subsequent amendments to the ILRP requirements (WQO-2004-0003, SWRCB 2004, R5-2005-0833, R5-2008-0005, R5-2009-0875).

- Pesticides in water
- Nitrogen and phosphorus compounds in water

The current WDR and MRP also requires testing for 303(d)-listed constituents identified in water bodies downstream from Coalition sites and discharged within the watershed, if irrigated agriculture has been identified as a contributing source within the Sacramento River Watershed and such monitoring has been requested by the Regional Water Board's Executive Officer.

Note that not all parameters are monitored at every site for every monitoring event. Specific individual parameters measured for 2019 Coalition Monitoring are listed in **Table 2**.

A total of 22 sampling sites were monitored by the Coalition and coordinating subwatershed monitoring programs during 2019 (**Table 3**). A map of these sites is presented in **Figure 1**.

As required by the MRP, Coalition monitoring events include storm season monitoring and irrigation season monitoring. The sites and numbers of samples scheduled for collection for 2019 Coalition Monitoring are summarized in **Table 4**.

This *2019 Annual Monitoring Report* (AMR) includes results for October 2018 through September 2019.

Sample collection and analysis has been performed by the following agencies and subcontractors.

- Pacific EcoRisk (Fairfield, California) performs toxicity analyses and conducts sampling for all sites, with the specific exceptions noted below:
  - Placer County Resource Conservation District conducted sampling for the Placer-Nevada-South Sutter-North Sacramento Subwatershed;
  - Vestra Environmental conducted sampling on behalf of the Northeastern California Water Association for the Pit River subwatershed site and conducted sampling for one event for the Goose Lake Watershed Group for the Lower Lassen Creek site; and
  - The Modoc Resource Conservation District conducted sampling for the Goose Lake Watershed Group for the Lower Lassen Creek site for two events.
- Caltest Analytical Laboratory (Napa, California) conducted all conventional, microbiological, and pyrethroid pesticide analyses.
- Agriculture & Priority Pollutant Laboratories, Inc. (APPL) (Clovis, California) conducted pesticide analyses.
- North Coast Laboratories (Arcata, CA) conducted pesticide analyses.
- PHYSIS Environmental Lab (Anaheim, CA) conducted pesticide analyses.
- Basic Laboratory (Redding) conducted conventional and microbiological analyses for samples collected in the Pit River, Upper Feather River, and Goose Lake subwatersheds.

TREND ANALYSIS

The Coalition's 2019 Monitoring Plan Update[2] was approved by Regional Water Board staff as meeting the requirements of the WDR, MPR, and Pesticides Evaluation Protocol. The WDR provides no additional guidance or criteria for making a determination that there are "deficiencies in monitoring" or that additional locations or events are needed, and none were identified as a result of the trend analysis conducted for this report.

In summary, the results of the trend analyses conducted for this AMR did not indicate a need for monitoring any additional locations, events, or parameters. The adoption of the Pesticides Evaluation Protocol has already expanded the number of parameters that the Coalition analyzes. We continue to recommend that the trend analysis evaluation be performed no more than once per assessment year, with the next evaluation occurring in the 2022 Monitoring Year. By that monitoring year, two to three years of additional assessment monitoring will have been conducted under the Pesticides Evaluation Protocol, which will increase the amount of data evaluated and the robustness of the analysis.

MANAGEMENT PRACTICES AND ACTIONS TAKEN

Response to Exceedances

To address specific water quality exceedances, the Coalition and its partners developed a Management Plan in 2009, subsequently approved by the Regional Water Board. The Coalition also previously developed a *Landowner Outreach and Management Practices Implementation Communications Process for Monitoring Results (Management Practices Process)* to address exceedances. The 2009 Management Plan was reorganized into the Comprehensive Surface Water Quality Management Plan (CSQMP) in 2015. The CSQMP was last updated in September 2016 and approved by the Central Valley Regional Water Quality Control Board (Regional Water Board) in November 2016. Implementation of the approved 2016 CSQMP is the primary mechanism for addressing exceedances observed in the Coalition's surface water monitoring.

Management Plan Status Update

The Coalition's Management Plan Progress Report (MPPR), a document that describes the status and progress toward meeting individual Management Plan element requirements for 2019, is provided to the Regional Water Board with this Annual Monitoring Report. Activities conducted in 2019 to implement the Coalition's CSQMP included addressing exceedances of objectives for registered pesticides, development of a new Management Plan, evaluation of existing Management Plan elements that could be deemed complete, and monitoring required for toxicity and pesticide Management Plans and Total Maximum Daily Loads (TMDLs).

Implementation completed specifically for registered pesticides and toxicity included review and evaluation of pesticide application data, identification of potential sources, and determination of likely agricultural sources. Prior to 2015, surveys of Coalition members operating on high

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[2] On August 1 of each year, the Coalition is required to submit to the Regional Water Board an updated monitoring plan for the upcoming monitoring year (October through September). This annual monitoring plan is called the Monitoring Plan Update, and for 2019 it was developed to follow the requirements of the 2014 WDR and MRP and the Regional Water Board's 2016 Pesticides Evaluation Protocol.

priority parcels were conducted to determine the degree of implementation of relevant management practices related to individual Management Plan elements for registered pesticides and identified causes of toxicity. Beginning in 2015, these surveys were replaced with data compiled from Coalition Member Farm Evaluations. Farm Evaluation data have been used to establish goals for additional management practice implementation needed to address exceedances of Basin Plan water quality objectives and ILRP Trigger Limits.

CONCLUSIONS AND RECOMMENDATIONS

The Coalition submits this *2019 Annual Monitoring Report* as required under the Regional Water Board's Irrigated Lands Regulatory Program. The AMR provides a detailed description of the Coalition's monitoring results as part of its ongoing efforts to characterize irrigated agricultural and wetlands related water quality in the Sacramento River Basin.

To summarize, the results from the Coalition's monitoring conducted in 2019 continue to indicate that with few exceptions, there are no major water quality problems with agricultural and managed wetlands discharges in the Sacramento River Basin.

This AMR characterizes potential water quality impacts of agricultural drainage from a broad geographic area in the Sacramento Valley from October 2018 through September 2019. To date, a total of 163 Coalition storm and irrigation season events have been completed since the beginning of Coalition monitoring in January 2005, with additional events collected by coordinating programs and for follow-up evaluations. For the period of record considered in this AMR (October 2018 through September 2019), samples were collected for ten scheduled monthly events and 2 wet weather ("storm") events.

Pesticides were infrequently detected (~10% of all pesticide results collected in 2019 were for detected concentrations), and, when detected, rarely exceeded applicable objectives. One sample for the registered pesticide malathion and twelve pyrethroid pesticide samples exceeded applicable water quality objectives or ILRP Trigger Limits during the 2019 Monitoring Year.

Many of the pesticides specifically required to be monitored in the past by the ILRP have rarely been detected in Coalition water samples, including glyphosate and paraquat. Over 98.2% of all pesticide analyses performed to date for the Coalition have been below detection. Coalition monitoring of pesticides for the ILRP for 2019 was conducted based on the 2016 Pesticides Evaluation Protocol (PEP) and active Management Plan element requirements. The Regional Water Board's PEP requires the Coalition to monitor specific registered pesticides based on (1) their rate of application in a given drainage (lbs. applied per drainage) and (2) a pesticide-specific relative risk (the ratio of the amount of chemical applied to a reference value with a specific averaging period). The Coalition also conducted monitoring of the ILRP-required trace elements (arsenic, boron, copper, and zinc) informed by the Coalition's past monitoring results, which have demonstrated that most of these metals rarely approach or exceed objectives and are not likely to cause adverse impacts to aquatic life or human health in waters receiving agricultural runoff in the Sacramento River Watershed. This strategy for monitoring trace metals was implemented in 2010 in accordance with the Coalition's 2009 MRP (*Order No. R5-2009-0875*, CVRWQCB 2009), and this same strategy is consistent with the requirements of the current WDR and MRP (*Order No. R5-2014-0030*).

The majority of exceedances of adopted numeric objectives continue to consist of specific conductivity, dissolved oxygen, pH, and *E. coli*. Agricultural runoff and irrigation return flows may contribute to exceedances of these objectives, but these parameters are primarily controlled or significantly affected by natural processes and sources that are not controllable by agricultural management practices.

The Coalition has implemented the requirements of the ILRP since 2004. The Coalition developed a Watershed Evaluation Report (WER) that set the priorities for development and implementation of the initial Monitoring and Reporting Program Plan (MRPP). The Coalition successfully developed the MRPP, Quality Assurance Project Plan (QAPP), and Management Plan as required by the ILRP, and all were approved by the Regional Water Board. Subsequent revisions requested by the Regional Water Board and the Coalition were incorporated into the Coalition's program and implemented through the Coalition's ongoing ILRP monitoring efforts. The Coalition also continues to adapt and improve elements of its monitoring program based on the knowledge gained through its monitoring efforts.

The 2019 monitoring program, as specified in the 2019 Monitoring Plan Update, was developed to be consistent with the requirements of the WDR and MRP (*Order No. R5-2014-0030*) and 2016 PEP, and was approved by the Regional Water Board for this purpose with the understanding that it would serve as an "Assessment" monitoring period for the Coalition. The Coalition has implemented the approved monitoring program in coordination with its subwatershed partners, has initiated follow-up activities required to address observed exceedances, and continued to implement the approved 2016 CSQMP and approved individual Management Plan elements. Throughout this process, the Coalition has kept an open line of communication with the Regional Water Board and has made every effort to fulfill the requirements of the ILRP in a cost-effective, scientifically defensible, and management-focused manner. This AMR is documentation of the success and continued progress of the Coalition in achieving these objectives.

Introduction

The primary purpose of this report is to document the monitoring efforts and results of the Sacramento Valley Water Quality Coalition (Coalition) Monitoring and Reporting Program (MRP). This Annual Monitoring Report (AMR) for 2019 also serves to document the Coalition's progress toward fulfilling the requirements of its *Waste Discharge Requirements General Order for Growers within the Sacramento River Watershed that are Members of a Third-Party Group* (*R5-2014-0030-R1*) (WDR).[3]

The AMR includes the following elements noted in **Table 1**, as specified in the WDR's MRP:

Table 1. MRP Annual Monitoring Report Requirements[4]

MRP Section	AMR Requirement	Report Section Headings	Page
V.C.1	Signed Transmittal Letter	NA	-
V.C.2	Title page	Title page	-
V.C.3	Table of Contents	Table of Contents	*i*
V.C.4	Executive Summary	Executive Summary	*vi*
V.C.5	Description of the Coalition Group geographical area	Description of the Watershed	4
V.C.6	Monitoring objectives and design	Monitoring Objectives	5
V.C.7	Sampling site descriptions and rainfall records for the time period covered under the AMR	Sampling Site Locations and Land Uses; Summary of Sampling Conditions	8; 27
V.C.8	Location map(s) of sampling sites, crops and land uses	Appendix E: Drainage Maps	CD
V.A.1;[1] V.C.9; V.C.11	An Excel workbook containing an export of all data records uploaded and/or entered into the CEDEN-comparable database (surface water data). The workbook shall contain, at a minimum, those items detailed in the most recent version of the third-party's approved QAPP Guidelines; Tabulated results of all analyses arranged in tabular form so that the required information is readily discernible; Electronic data submittal.	Appendix C: Tabulated Monitoring Results	CD

[3] Prior to adoption of the WDR, the Coalition was subject to a Conditional Waiver of Waste Discharge Requirements for the Irrigated Lands Regulatory Program (ILRP) and subsequent amendments to the ILRP requirements (WQO-2004-0003, SWRCB 2004, R5-2005-0833, R5-2008-0005, R5-2009-0875).

[4] Monitoring and Reporting Program (Attachment B to R5-2014-0030), Section V.C.

MRP Section	AMR Requirement	Report Section Headings	Page
V.C.10	Discussion of data relative to water quality objectives/Trigger Limits and water quality management plan milestones/Basin Plan Amendment Workplan (BPAW) updates, if applicable	Assessment of Water Quality Objectives	43
V.C.12	Sampling and analytical methods used	Sampling and Analytical Methods	16
V.A.5;[1] V.A.7.c.; V.C.13	Electronic copies of all applicable laboratory analytical reports on a CD; Chain of custody (COCs) and sample receipt documentation; Associated laboratory and field quality control samples results	Appendix B: Lab Reports and Chains of Custody	CD
V.C.14	Summary of Quality Assurance Evaluation results (as identified in the most recent version of the Coalition's QAPP for Precision, Accuracy and Completeness)	Quality Assurance	43
V.A.3-4;[1] V.C.15	Electronic copies of all field sheets; Electronic copies of photos obtained from all surface water monitoring sites, clearly labeled with the CEDEN comparable station code and date; Specification of the method(s) used to obtain estimated flow at each surface water monitoring site during each monitoring event	Appendix A: Field Log Copies	CD
V.C.16	Summary of exceedances of water quality objectives/Trigger Limits occurring during the reporting period and surface water-related pesticide use information	Assessment of Water Quality Objectives; Appendix D: Exceedance Reports	43; CD
V.C.17	Actions taken to address water quality exceedances that have occurred, including, but not limited to, revised or additional management practices implemented	Management Practices and Actions Taken; Appendix F: SVWQC Outreach Materials	71
V.C.18	Evaluation of monitoring data to identify temporal and spatial trends and patterns	Trend Analysis; Appendix G: Trend Analysis Results	65
V.C.19	Summary of Nitrogen Management Plan information submitted to the Coalition	---[2]	NA

MRP Section	AMR Requirement	Report Section Headings	Page
V.C.20	Summary of Management Practice information collected as part of Farm Evaluations	---[3]	NA
V.C.21	Summary of Mitigation Monitoring	---[4]	NA
V.C.22	Summary of education and outreach activities	Management Practices and Actions Taken; Appendix F: SVWQC Outreach Materials	71
V.C.23	Reduced Monitoring/Management Plan Verification Option Reports	Appendix H: Reduced Monitoring Reports	NA
V.C.24	Conclusions and recommendations	Conclusions and Recommendations	74

1. Quarterly Submittals of Monitoring Results (WDR Provision V.A.) are re-submitted with the AMR.
2. The 2019 Nitrogen Management Plan (NMP) Summary Report will be submitted to the ILRP by 30 November 2020.
3. A Farm Evaluation (FE) is not required to be submitted for the 2019 monitoring year.
4. This item is not applicable because no mitigation monitoring was conducted in 2019.

With the exceptions noted in **Table 1,** all report elements required by the WDR are included in this report.

Description of the Watershed

The Sacramento River Watershed drains over 27,000 square miles of land in the northern part of California's Central Valley into the Sacramento River. The upper watersheds of the Sacramento River region include the Pit River watershed above Lake Shasta and the Feather River watershed above Lake Oroville. The Sacramento Valley drainages include the Colusa, Cache Creek, and Yolo Bypass watersheds on the west side of the valley, and the Feather, Yuba, and American River watersheds on the east side of the valley. The Coalition also monitors in the Cosumnes River watershed, which is not part of the Sacramento River Watershed.

Beginning at its northern terminus near the city of Redding, the Sacramento Valley stretches approximately 180 miles to the southeast, where it merges into the Sacramento-San Joaquin River Delta south of the Sacramento metropolitan area at Rio Vista. The valley is 30 to 45 miles wide in the southern to central parts, but narrows to about 5 miles wide near Redding. Its elevation decreases from 300 feet at its northern end to near sea level in the Delta. The greater Sacramento River Watershed includes sites from 5,000 feet in elevation to near sea level.

The Sacramento River Basin is a unique mosaic of farm lands, refuges, and managed wetlands for waterfowl habitat; spawning grounds for numerous salmon species and steelhead trout; and the cities and rural communities that make up this region. This natural and working landscape between the crests of the Sierra Nevada and the Coast Range includes the following:

- More than a million acres of family farms that provide the economic engine for the region; provide a working landscape and pastoral setting; and serve as valuable habitat for waterfowl along the Pacific Flyway. The predominant crops include: rice, general grain and hay, improved pasture, corn, tomatoes, alfalfa, almonds, walnuts, prunes, safflower, and vineyards.
- Habitat for 50% of the threatened and endangered species in California, including the winter-run and spring-run salmon, steelhead, and many other fish species.
- Six National Wildlife Refuges, more than fifty state Wildlife Areas, and other privately managed wetlands that support the annual migration of waterfowl, geese, and water birds in the Pacific Flyway. These seasonal and permanent wetlands provide for 65% of the North American Waterfowl Management Plan objectives.
- The small towns and rural communities that form the backbone of the region, as well as the State Capital that serves as the center of government for the State of California.
- The forests and meadows in the numerous watersheds of the Sierra Nevada and Coast Range.

Monitoring Objectives

The Coalition's monitoring program conforms to the goals of the Nonpoint Source (NPS) Program and achieves the following objectives as a condition of the WDR's MRP:

1. Track, monitor, assess and report program activities;
2. Ensure consistent and accurate reporting of monitoring activities;
3. Target NPS Program activities at the watershed level;
4. Coordinate with public and private partners; and
5. Track implementation of management practices to improve water quality and protect existing beneficial uses.

In accordance with WDR requirements, the Coalition is achieving these objectives by implementing a MRP that evaluates water and sediment samples for the presence of statistically significant toxicity and exceedances of applicable numeric water quality objectives and ILRP Trigger Limits. The Coalition initiates follow-up actions designed to identify constituents causing significant toxicity when toxicity is of sufficient magnitude. Exceedances of numeric objectives and ILRP Trigger Limits for chemical, physical and microbiological parameters trigger follow-up actions designed to identify potential sources of these exceedances and to inform potential users of the products that contain constituents of concern. Additionally, the Coalition is evaluating the degree of implementation of current management practices in priority watersheds (i.e., those where Management Plans have been triggered) and recommending additional practices as water quality results indicate a need to do so. The Coalition is committed to the principle of adaptive management to control specific discharges of waste from agricultural lands that are having an impact on water quality. This iterative approach allows for the most effective use of limited human and fiscal resources.

The parameters monitored in 2019 by the Coalition to achieve these objectives are as specified in the current WDR and MRP (*Order No. R5-2014-0030*):

- Water column and sediment toxicity
- Physical and conventional parameters in water
- Organic carbon
- Pathogen indicator organisms in water
- Trace metals in water
- Pesticides in water
- Nitrogen and phosphorus compounds in water

The proposed frequency and schedule for water quality sample collection used to assess the presence and concentration of the above-listed parameters in Coalition receiving waters are submitted to the Regional Water Board each year on August 1 in the form of the Coalition's Monitoring Plan Update. The WDR does not explicitly state the individual constituents that require monitoring each year, but allows for the Coalition to make that determination based on guidance provided in the WDR and MRP and the amounts and time periods of pesticide applications in representative and integration site drainages using California Department of Pesticide Regulation (CDPR) pesticide use reporting (PUR) data.

Additional guidance for the monitoring of pesticides was established in November 2016 with the Regional Water Board's requirement that all Central Valley agricultural water quality coalitions begin using a protocol for prioritizing and selecting pesticides for surface water monitoring (ILRP Pesticides Evaluation Protocol or PEP). The PEP was developed by a Pesticide Evaluation Advisory Workgroup and outlines the required steps that Coalition's must use to process PUR data when developing annual monitoring plans. The PEP process requires the Coalition to monitor specific registered pesticides based on (1) their rate of application in a given drainage (lbs. applied per drainage) and (2) a pesticide-specific relative risk (the ratio of the amount of chemical applied to a reference value with a specific averaging period). As a result, not all pesticides are monitored at each site for every monitoring event, and instead Coalition pesticide monitoring reflects the frequency and intensity of pesticide use within an individual drainage.

The current WDR and MRP also require testing for 303(d)-listed constituents identified in water bodies downstream from Coalition sites and discharged within the watershed, if irrigated agriculture has been identified as a contributing source within the Sacramento River Watershed and such monitoring has been requested by the Regional Water Board's Executive Officer.

Note that not all parameters were monitored at every site for every monitoring event. Specific individual parameters measured for 2019 Coalition Monitoring are listed in **Table 2**.

Table 2. Constituents Monitored for the 2019 Monitoring Year

Analyte	Quantitation Limit[(a)]	Reporting Unit
Physical Parameters		
Flow	NA	CFS (Ft^3/Sec)
pH	0.1 [(b)]	-log[H^+]
Specific Conductivity	0.1 [(b)]	μS/cm
Dissolved Oxygen	0.1 [(b)]	mg/L
Temperature	0.1 [(b)]	˚C
Hardness, total as $CaCO_3$	10	mg/L
Turbidity	1.0	NTU
Total Suspended Solids	3.0	mg/L
Dissolved Organic Carbon	0.5	mg/L
Total Organic Carbon	0.5	mg/L
Grain size (in sediment)	1	% fraction
Pathogen Indicators		
E. coli bacteria	2	MPN/100 mL
Water Column Toxicity		
Ceriodaphnia, 96-h acute	NA	% Survival
Selenastrum, 96-h short-term chronic	NA	% of Survival
Sediment Toxicity		
Hyalella, 10-day short-term chronic	NA	% Survival
Pesticides		
Carbamates	(c)	μg/L
Fungicide	(c)	μg/L

Analyte	Quantitation Limit[a]	Reporting Unit
Herbicides	(c)	µg/L
Insecticides	(c)	µg/L
Organochlorine	(c)	µg/L
Organophosphorus	(c)	µg/L
Pyrethroids	(c)	µg/L
Triazines	(c)	µg/L
Trace Elements		
Arsenic	0.5	µg/L
Boron	10	µg/L
Copper	0.5	µg/L
Zinc	1	µg/L
Nutrients		
Ammonia as N	0.1	mg/L
Nitrate + Nitrite as N	0.1	mg/L
Orthophosphate as P	0.1	mg/L
Phosphorus, total	0.1	mg/L

Notes:

a. The Quantitation Limit (QL) represents the concentration of an analyte that can be routinely measured in the sampled matrix within the stated limits and confidence in both identification and quantitation.
b. Detection and reporting limits are not strictly defined. Value is required reporting precision.
c. Limits are different for individual pesticides.

Sampling Site Descriptions

To successfully implement the monitoring and reporting program requirements contained in the ILRP adopted by the Regional Water Board in June 2003, the Coalition worked directly with landowners in the 21 counties within the Sacramento River Watershed to identify and develop ten (now 13) subwatershed groups. Representatives from each subwatershed group utilized agronomic and hydrologic data generated by the Coalition in an attempt to prioritize watershed areas for initial evaluation that were used to ultimately select monitoring sites in their respective areas based upon existing infrastructure, historical monitoring data, land use patterns, historical pesticide use, and the presence of 303(d)-listed water bodies.

Coalition members selected sampling sites in watersheds based upon the following fundamental assumptions regarding management of non-point source discharges to surface water bodies: 1) Landscape scale sampling at the bottom of drainage areas allows determination of the presence of water quality problems using a variety of analytical methods, including water column and sediment toxicity testing, water chemistry analyses, and bioassessment; 2) Strategic source investigations utilizing Geographic Information Systems can be used to identify upstream parcels with attributes that may be related to the analytical results, including crops, pesticide applications, and soil type; and 3) Management practice effectiveness can best be assessed by subwatershed coalitions at the drainage and subwatershed scale to determine compliance with water quality objectives in designated water bodies. Results from farm-level management practices evaluations are used to complement Coalition efforts on the watershed scale by providing crop-specific information that supports management practice recommendations.

The Coalition uses a "representative monitoring" approach to achieve the goals of the 2014 MRP:

- Representative monitoring is conducted at sites in drainages representative of larger regions based on shared agricultural and geographic characteristics;
- Representative monitoring includes a cycle of two years of "Assessment" Monitoring for the broader suite of ILRP analytes, followed by two years of sampling needed for Management Plan implementation (referred to as "Core" Monitoring or "Non-Assessment" Monitoring); and
- Monitoring schedules and the analytes monitored are customized based on the characteristics of individual subwatersheds and Management Plans.

Monitoring sites visited in 2019 were all previously monitored and included 15 representative sites, three integration sites, and four special project sites where monitoring requirements were triggered by Management Plans.

SAMPLING SITE LOCATIONS AND LAND USES

The water and sediment sites monitored by the Coalition in 2019 are listed in **Table 3**. All sites monitored in 2019 were approved by the Regional Water Board as MRP compliance sites. An overall map of Coalition and subwatershed sites is presented in **Figure 1**. Site-specific drainage maps with land use patterns for all monitoring locations are provided in **Appendix E**.

Table 3. Monitoring Sites for 2019 Coalition Monitoring

Subwatershed	Site Name	Latitude	Longitude	Agency	Site ID & Category (Fig. 1)	
Butte Yuba Sutter	Gilsizer Slough at George Washington Road	39.009	-121.6716	SVWQC	GILSL	SP
Butte Yuba Sutter	Lower Honcut Creek at Hwy 70	39.30915	-121.59542	SVWQC	LHNCT	REP
Butte Yuba Sutter	Lower Snake River at Nuestro Rd	39.18531	-121.70358	SVWQC	LSNKR	REP
Butte Yuba Sutter	Pine Creek at Highway 32	39.75338	-121.97124	SVWQC	PNCHY	REP
Butte Yuba Sutter	Sacramento Slough bridge near Karnak	38.785	-121.6533	SVWQC	SSKNK	INT
Colusa Glenn	Colusa Basin Drain above KL	38.8121	-121.7741	SVWQC	COLDR	INT
Colusa Glenn	Freshwater Creek at Gibson Rd	39.17664	-122.18915	SVWQC	FRSHC	REP
Colusa Glenn	Rough & Ready Pumping Plant (RD 108)	38.86209	-121.7927	SVWQC	RARPP	SP
Colusa Glenn	Walker Creek near 99W and CR33	39.62423	-122.19652	SVWQC	WLKCH	REP
El Dorado	Coon Hollow Creek	38.75335	-120.72404	SVWQC	COONH	SP
Goose Lake	Lower Lassen Creek	41.89103	-120.35594	SVWQC	LOWLC	REP
Lake	McGaugh Slough at Finley Road East	39.00417	-122.86233	SVWQC	MGSLU	SP
Lake	Middle Creek upstream from Highway 20	39.17641	-122.91271	SVWQC	MDLCR	REP
Pit River	Pit River at Pittville Bridge	41.0454	-121.3317	NECWA	PRPIT	REP
PNSSNS	Coon Creek at Brewer Road	38.93399	-121.45184	PNSSNS	CCBRW	REP
Sacramento Amador	Cosumnes River at Twin Cities Rd	38.29098	-121.38044	SVWQC	CRTWN	REP
Sacramento Amador	Grand Island Drain near Leary Road	38.2399	-121.5649	SVWQC	GIDLR	REP
Shasta Tehama	Anderson Creek at Ash Creek Road	40.418	-122.2136	SVWQC	ACACR	REP
Solano	Shag Slough at Liberty Island Bridge	38.30677	-121.69337	SVWQC	SSLIB	INT
Solano	Ulatis Creek at Brown Road	38.307	-121.794	SVWQC	UCBRD	REP
Upper Feather River	Middle Fork Feather River above Grizzly Creek	39.816	-120.426	UFRW	MFFGR	REP
Yolo	Willow Slough Bypass at Pole Line	38.59015	-121.73058	SVWQC	WLSPL	REP

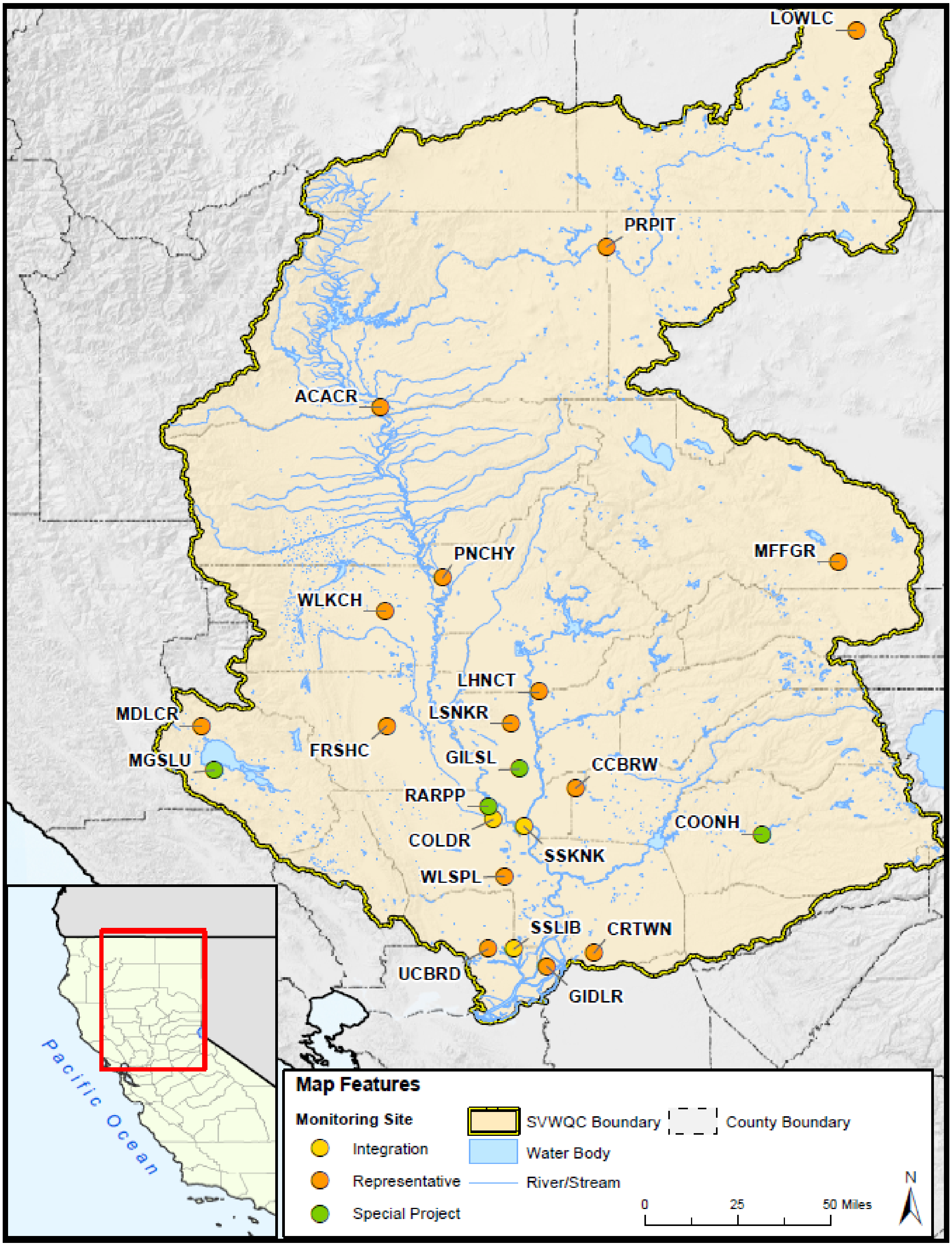

Figure 1. 2019 Coalition Monitoring Sites

SITE DESCRIPTIONS

Butte-Yuba-Sutter Subwatershed

Gilsizer Slough at George Washington Road (GILSL)

Gilsizer Slough is an unlined storm drainage outfall canal that runs from the Gilsizer County Drainage District's north pump station approximately 15 miles to the Sutter Bypass, draining 6,005 total acres. The monitoring location is located roughly 1.5 miles from its confluence with the Sutter Bypass and is a natural drainage channel that historically drained Yuba City and the area south of town. Principal crops grown in this area include prunes, walnuts, peaches, and almonds. This special project site is also a Management Plan site for this subwatershed.

Lower Honcut Creek at Highway 70 (LHNCT)

Lower Honcut Creek (in the Lower Honcut Creek drainage) was selected to represent the drainages in the eastern part of the Butte-Yuba-Sutter Subwatershed. This drainage includes the dominant crops grown in the area and typically has flows allowing sampling through irrigation season. The sampling site is located approximately 3.5 miles from its confluence with the Feather River. Dominant crops in this drainage include rice, walnuts, prunes, pasture, citrus, olive, and grapes. Lower Honcut Creek receives flows from North Honcut Creek and South Honcut Creek, which extend up into the foothills and include more pasture acreage. This is a representative site for this subwatershed.

Lower Snake River at Nuestro Road (LSNKR)

The Lower Snake River is an unlined irrigation supply and runoff canal that serves approximately 25,000 total acres and includes a relatively high percentage of rice acreage. The other predominant crops include prunes, peaches, idle acreage, and operations producing flowers, nursery stock, and Christmas trees. This is a representative site for this subwatershed.

Pine Creek at Highway 32 (PNCHY)

The watershed sampled upstream from the Pine Creek monitoring site represents approximately 28,000 acres of varied farmland, riparian habitat, and farmsteads. The predominant crops in this area are walnuts, almonds, prunes, wheat, oats, barley, beans, squash, cucumbers, alfalfa, pasture, and safflower. This is a representative site for this subwatershed.

Sacramento Slough Bridge near Karnak (SSKNK)

This site aggregates water from all areas in the subwatershed between the Feather and Sacramento Rivers. The major contributing areas include the areas downstream of the Butte Slough and Wadsworth monitoring sites. These areas include Sutter Bypass and its major inputs from Gilsizer Slough, Reclamation District (RD) 1660, RD 1500, and the Lower Snake River. Monitoring at this site is coordinated with the California Rice Commission. This is an integration site for this subwatershed.

Colusa Glenn Subwatershed

Colusa Basin Drain above Knights Landing (COLDR)

This site is near the outfall gates of the Colusa Basin Drain before its confluence with the Sacramento River. This site is downstream of all of the other monitoring sites within the basin. The upstream acreage consists of almonds, tomatoes, wetlands, pasture, corn, and walnuts. Monitoring at this site is coordinated with the California Rice Commission. This is an integration site for this subwatershed.

Freshwater Creek at Gibson Road (FRSHC)

The Freshwater Creek drainage includes approximately 83,000 total acres. Irrigated acreage (excluding rice acreage) is approximately 19,000 acres. Predominant crops in the drainage are rice, tomatoes, idle acreage, squash, grain, pasture, and safflower. This is a representative site for this subwatershed.

Rough and Ready Pumping plant, RD 108 (RARPP)

The Rough & Ready Pumping Plant (owned and operated by Reclamation District 108) aggregates runoff and return flows for the Sycamore Slough drainage. The pumps lift the water into the Sacramento River. This drainage area contains large amounts of tomatoes, safflower, wheat, melons, corn, and pasture. This special project site is also a Management Plan site for this subwatershed.

Walker Creek near 99W and CR33 (WLKCH)

The Walker Creek drainage is located east of Wilson Creek in Glenn County, and the Walker Creek monitoring site is located 1.3 miles north of the Town of Willows. The Walker Creek drainage includes approximately 27,000 total irrigated acres. Predominant crops in this drainage are almonds, rice, corn, and alfalfa. This is a representative site for this subwatershed.

El Dorado Subwatershed

The El Dorado subwatershed is currently operating under the submitted and approved *Reduced Monitoring/Management Practices Verification Option*.

Coon Hollow Creek (COONH)

This site is located in the Apple Hill area of Camino, approximately 1 mile north of the intersection of North Canyon Road and Carson Road and 0.5 mile south of the confluence with South Canyon Creek. Agricultural operations within the drainage include silviculture, apples, wine grapes, cherries, and blueberries. Coon Hollow Creek is considered a low-flow perennial stream. This special project site is also a Management Plan site for this subwatershed.

Goose Lake Subwatershed

Lower Lassen Creek (LOWLC)

The land use pattern in the Lassen Creek drainage is similar to the Goose Lake Basin as a whole. Lassen Creek originates in predominately publicly owned lands that are managed primarily for dispersed recreation and livestock grazing. Lassen Creek flows out of the Warner Mountains towards Goose Lake, and land uses along this waterbody focus on dry-land alfalfa, native meadow hay production, and irrigated pasture for livestock. This is a representative site for this subwatershed.

Lake Subwatershed

The Lake subwatershed is currently operating under the submitted and approved *Reduced Monitoring/Management Practices Verification Option*.

Middle Creek Upstream from Highway 20 (MDLCR)

The Middle Creek drainage contains approximately 60,732 acres. Over 55,000 acres are listed as Native Vegetation with the U.S. Forest Service controlling the majority of the land. Irrigated agriculture constitutes of approximately 1,100 acres farmed by members participating in the Lake County Watershed Group. This includes 374 acres of walnuts, 308 acres of grapes, 186 acres of pears, 159 acres of hay/pasture, 10 acres of specialty crops/nursery crops, and about 70 acres of wild rice.

The sampling location was chosen to avoid influence from the town of Upper Lake, and captures approximately 60% of irrigated agricultural operations within this drainage. This is a representative site for this subwatershed.

McGaugh Slough at Finley Road East (MGSLU)

McGaugh Slough captures irrigated agricultural drainage from about 10,300 acres of orchard and vineyard crops in Lake County. This site characterizes the most prevalent drain for the Big Valley, which is the most intensive area for agricultural operations in Lake County. This special project site is also a Management Plan site for this subwatershed.

Napa Subwatershed

The Napa subwatershed is currently operating under the submitted and approved *Reduced Monitoring/Management Practices Verification Option*.

No water quality samples were collected by the Coalition in this subwatershed during the 2019 monitoring year.

Pit River Subwatershed

Monitoring in this subwatershed was conducted in coordination with the Northeastern California Watershed Association (NECWA) and the California's Surface Water Ambient Monitoring Program (SWAMP).

Pit River at Pittville Bridge (PRPIT)

This site captures drainage from Big Valley, Ash Creek and Horse Creek. This site captures drainage from native pasture (the primary land use), as well as alfalfa, oat hay, grain and duck marsh, ultimately incorporating approximately 9,000 acres in the Fall River Valley. This is a representative site for this subwatershed.

Placer-Nevada-South Sutter-North Sacramento Subwatershed

Monitoring in this subwatershed was conducted in coordination with the Placer-Nevada-South Sutter-North Sacramento (PNSSNS) Subwatershed.

Coon Creek at Brewer Road (CCBRW)

This site captures drainage from the Middle Coon Creek drainage areas as identified in the Placer-Northern Sacramento Drainage Prioritization Table in the Coalition's Watershed Evaluation Report (WER). This site is on Coon Creek about six miles northwest of the town of Lincoln and includes predominantly agricultural acreage. The drainage includes approximately 65,000 irrigated acres of rice, pasture, grains, and Sudan grass, with a high percentage of rice acreage. Irrigated acres (excluding rice) is approximately 13,000. This is a representative site for this subwatershed.

Sacramento/Amador Subwatershed

Cosumnes River at Twin Cities Road (CRTWN)

This site characterizes flows from the eastern portion of the subwatershed via the Cosumnes River and a handful of tributary creeks that originate in the foothills. Contributing agricultural acreage includes pasture, vineyards, corn, and grains. This site captures drainage from the two largest drainages in the subwatershed: Lower Cosumnes and Middle Cosumnes rivers, which drain approximately 55,000 irrigated acres. This is a representative site for this subwatershed.

Grand Island Drain near Leary Road (GIDLR)

Grand Island is located in the heart of the Sacramento Delta. Crops include alfalfa, corn, safflower, apples, pears, cherries, blueberries, asparagus, grapes, and pasture land. Water is pumped on to the island at several locations. The monitoring site is located just up-slough from a station that returns water to the Delta. Approximately 8,000 irrigated acres drains to the monitoring site. This is a representative site for this subwatershed.

Shasta/Tehama Subwatershed

Anderson Creek at Ash Creek Road (ACACR)

Anderson Creek was identified as the highest priority drainage in the Shasta county portion of the Shasta/Tehama subwatershed. This ranking was based on total irrigated acreage, crop types by acreage, and amount and type of pesticide use. Anderson Creek originates about three miles west of the city of Anderson and flows into the Sacramento River. Crops are predominantly pasture, followed by walnuts and alfalfa/hay, and smaller amounts of other field and orchard crops. Total irrigated land is 8,989 acres. This is a representative site for this subwatershed.

Solano Subwatershed

Shag Slough at Liberty Island Bridge (SSLIB)

Shag Slough drains a large portion of the South Yolo Bypass. Crops grown in this drainage area include corn, safflower, grain, vineyards, tomatoes, and irrigated pasture. The Liberty Island Bridge site is approximately 2.5 to 3 miles southwest of the Toe Drain in Shag Slough. Like the

Toe Drain, it is a tidally influenced site and is likely to contain a mixture of Toe Drain water along with water from other sub-drainages within the South Yolo Bypass and the Southwest Yolo Bypass. Due to the difficulty in accessing the Toe Drain for sampling, Shag Slough replaced the original Toe Drain sampling location in late 2005. This is a integration site for this subwatershed.

Ulatis Creek at Brown Road (UCBRD)

Ulatis Creek is a flood control project (FCP) that drains the majority of the central portion of Solano County. The Ulatis Creek FCP monitoring site is located on Brown Road approximately 8.5 miles south of Dixon and 1.5 miles east of State Highway 113. This site drains the Cache Slough area, as designated in the Yolo/Solano subwatershed map, and empties into Cache Slough. The major crops in this area include wheat, corn, pasture, tomatoes, alfalfa, Sudan grass, walnuts, and almonds. This is a representative site for this subwatershed.

Upper Feather River Watershed

Agriculture in this subwatershed is localized in mountain valleys that are suitable for grazing and growing alfalfa, hay, and grain crops. Monitoring in this subwatershed is focused on characterizing drainage from three valleys with considerable agricultural acreage. Monitoring in this subwatershed was conducted in coordination with the Upper Feather River Watershed Group (UFRWG) and the California's Surface Water Ambient Monitoring Program (SWAMP).

Middle Fork Feather River Above Grizzly Creek (MFFGR)

The Middle Fork Feather River above Grizzly Creek is below the last irrigated site in the Sierra Valley subwatershed and has year-round flow in most years. This site replaced Middle Fork Feather River at County Rd A-23, which lacks year-round flows (often dry by mid-July) and has numerous non-agricultural uses, including recreation and filling water trucks. This is a representative site for this subwatershed.

Yolo Subwatershed

Willow Slough Bypass at Pole Line Road (WLSPL)

The Willow Slough Bypass is a large drainage including approximately 102,000 total acres. Irrigated acreage (excluding rice acreage) is approximately 66,000 acres. Predominant crops in the drainage are grain, pasture, corn, tomatoes, rice, almonds, and walnuts. This is a representative site for this subwatershed.

Sampling and Analytical Methods

The objective of data collection for this monitoring program is to produce data that represent, as closely as possible, *in situ* conditions of agricultural discharges and water bodies in the Sacramento Valley. This objective will be achieved by using standard accepted methods to collect and analyze surface water and sediment samples. Assessing the monitoring program's ability to meet this objective will be accomplished by evaluating the resulting laboratory measurements in terms of detection limits, precision, accuracy, representativeness, comparability, and completeness, as described in the Coalition's QAPP (SVWQC 2010; amended 2017) and approved by the Regional Water Board. Additionally, the Coalition submits an electronic QAPP (eQAPP) to the Regional Water Board on a quarterly basis with its quarterly data submittal. The eQAPP alerts Regional Water Board staff to the Coalition's event-based analysis of constituents and their associated analytical methods, along with occasional changes to a laboratory's analytical recovery limits for certain parameters.

Surface water samples were collected for analysis of the constituents listed in **Table 2** as specified in the Coalition's 2019 Monitoring Plan Update. Surface water and sediment samples were collected for chemical analyses and toxicity testing. All samples were collected and analyzed using the methods specified in the QAPP and eQAPP; any deviations from these methods were explained.

SAMPLE COLLECTION METHODS

All samples were collected in a manner appropriate for the specific analytical methods used, and to ensure that water column samples were representative of the flow in the channel cross-section. Water quality samples were collected using clean techniques that minimize sample contamination. Samples were collected as either cross-sectional composite samples or mid-stream, mid-depth grab samples, depending on sampling site and event characteristics. When grab sample collection methods were used, samples were taken at approximately mid-stream and mid-depth at the location of greatest flow (where feasible). Where appropriate, water samples were collected using a standard multi-vertical depth integrating method. Abbreviated sampling methods (i.e., weighted-bottle or dip sample) may be used for collecting representative water samples.

Sediment sampling was conducted at sampling sites on an approximately 50-meter reach of the waterbody near the water sampling location. If USGS methods were applicable, sediment sub-samples were collected from five to ten wadeable depositional zones. Depositional zones include areas on the inside bend of a stream or areas downstream from obstacles such as boulders, islands, sand bars, or simply shallow waters near the shore. In low-energy, low-gradient waterbodies, composite samples may be collected from the bottom of the channel using appropriate equipment, as specified in the Coalition's QAPP.

Details of the standard operating procedures (SOPs) for collection of surface water and sediment samples are provided in the Coalition's QAPP. The sites and number of samples for 2019 Coalition monitoring are summarized in **Table 4**. The Coalition's monitoring strategy for 2019 was designed to characterize high priority drainages that are representative of a subwatershed's dominant agricultural crops and practices. This sampling approach was initially designed to comply with the requirements in *Order No. R5-2008*-0005 and with the later adopted ILRP MRP

(*Monitoring and Reporting Program Order No. R5-2009-0875*); this approach was maintained for the current WDR and MRP (*Order No. R5-2014-0030*). The elements that are key to achieving the Coalition's goals and satisfying the intent of the requirements of the *R5-2014-0030* MRP are (1) the Coalition's prioritization process for selecting representative drainages and monitoring sites, and (2) identification of monitoring parameters and schedules appropriate for these representative drainages. This approach was detailed in the Coalition's 2009 Monitoring and Reporting Program Plan, as required by *Order No. R5-2008-0005*, and the monitoring plan is updated annually in August, as required by *Order No. R5-2014-0030*.

Table 4. 2019 Coalition Monitoring Year: Planned Samples, October 2018 – September 2019

						Core Parameters							Metals				Pesticides in Water																																													Toxicity				
Subwatershed	Representative	SiteID	SITE CATEGORY: REP=Representative INT=Integrative SP=Special Project	Water Column Sample Events	Sediment Sample Events	Field Measured Group	Dissolved Organic Carbon	Total Organic Carbon	Total Suspended Solids	Turbidity	E. coli	Nutrients Group	Arsenic (total)	Boron	Copper	Hardness	Legacy OCLs	2,4-D acids & salts	Acetamiprid	Atrazine	Bifenthrin	Carbaryl	Chloropicrin	Chlorothalonil	Chlorpyrifos	Clothianidin	Cyfluthrin	Cypermethrin	Cyprodinil	Deltamethrin	Diazinon	Dichlorvos	Dimethoate	Diuron	Dodine	Esfenvalerate	Ethalfluralin	Fenpropathrin	Glyphosate	Imidacloprid	Lambda-Cyhalothrin	Linuron	Malathion	Methidathion	Methiocarb	Methomyl	Metribuzin	Oryzalin	Oxyfluorfen	Paraquat Dichloride	Pendimethalin	Permethrin	Phorate	Prometryn	Propiconazole	Pyraclostrobin	Pyridaben	Simazine	Tau-Fluvalinate	Trifluralin	Algae - *Selenastrum*	Water Flea - *Ceriodaphnia*	*Hyalella azteca*	Grain Size	TOC
ButteYubaSutter	Lower Feather River	SSKNK	INT	4	2	4	3	4	4	4	4	4			2	2		2	2		2	2	2				2	2		1						2	2		1	2	2					2	1		2	2	1	2		1		2		1		2	4	4	2	2	2
ButteYubaSutter	Lower Honcut Creek	LHNCT	REP	10	2	10	8	10	10	10	10	10			3	3		1			3		3		3		3	2	1			1		1	2	3		1		2	2								3	3	1	3				1		1			8	8	2	2	2
ButteYubaSutter	Pine Creek	PNCHY	REP	11	2	11	7	11	11	11	11	11			5	5		4	2		4	1	1		8		3	1	1					3	2	5	3		2	4	3					1				3	1	2				3				3	10	10	2	2	2
ButteYubaSutter	Wadsworth	BTTSL	SP																																																													
ButteYubaSutter	Wadsworth	LSNKR	REP	11	2	11	7	11	11	11	11	11	4		3	3		5	4		3	3	2		4		3	3	2		2			3	2	3	3		2	5	2					2			4	3	1	2			1	3	1	3		3	9	11	2	2	2
ButteYubaSutter	Wadsworth	GILSL	SP	5		5											2								4						4																																		
ButteYubaSutter	Wadsworth	WADCN	SP																																																												
ColusaGlenn	Freshwater Creek	FRSHC	REP	11	2	11	8	11	11	11	11	11			4	4			1		3	1					3	3	1				3		2	3	2	1	2	4	4					2			2	5	1	2			1	3				3	11	9	2	2	2
ColusaGlenn	Freshwater Creek	LRLNC	SP																																																												
ColusaGlenn	Freshwater Creek	SCCMR	SP																																																												
ColusaGlenn	Lower Colusa Drain	COLDR	INT	4	2	4	3	4	4	4	4	4			2	2		1	1		2	1			1		1	3	1		1		2		1	2	2	1	2	3	3		1			1	1		2	3	2	2				2				2	4	3	2	2	2
ColusaGlenn	Lower Colusa Drain	RARPP	SP														2																																																
ColusaGlenn	Willow Creek	WLKCH	REP	11	2	11	8	11	11	11	11	11			4	2		3	2	1	3	2	4		3		2	3	2		1		2	3	2	4	3	4	3	3	4		1			1			3	2	1	2	1		2	4	1			4	11	9	2	2	2
ColusaGlenn	Willow Creek	LGNCR	SP																																																												
ColusaGlenn	Willow Creek	STYHY	SP																																																												
ElDorado	Coloma El Dorado	NRTCN	REP																																																												
ElDorado	Coloma El Dorado	COONH	SP	2		2											2																																														
GooseLake	Goose Lake	LOWLC	REP	3		3		3	3	3	3	3																																																			
Lake	Upper Lake	MDLCR	REP	4		4					4	4																																																			
Lake	Upper Lake	MGSLU	REP	4		4						4																																																			
Napa	Pope Creek	PCULB	REP																																																												
Napa	Pope Creek	CCULB	SP																																																												
NECWA	Big Lake	PRPIT	REP	5		5	4	5	5	5	5	5			6	3		3			1	4	1				3						1			3					2		3	1																	4	5			
NECWA	Big Lake	FRRRB	SP	4		4																																																									
NECWA	Big Lake	PRCAN	SP	4		4																																																									
PNSSNS	Middle Coon Creek	CCBRW	REP	9	2	9	8	9	9	9	9	9			6	3		1	1		3		2	1	2		3	3		1						5	2				5								2	4	1	4								2	6	8	2	2	2
PNSSNS	Middle Coon Creek	CCSTR	SP																																																												
SacramentoAmador	Lower Cosumnes	CRTWN	REP	10	2	10	8	10	10	10	10	10			4	2		1		1	3	1		2	2	2	3	4	1				3			3		3		2	3		2		1	1				3	1	2				3	2	3	2	3	9	10	2	2	2
SacramentoAmador	Lower Cosumnes	DCGLT	SP																																																												
SacramentoAmador	Lower Cosumnes	LAGAM	SP																																																												
SacramentoAmador	Sacramento Delta	GIDLR	REP	12	2	12	8	12	12	12	12	12	6		2	2	2			2	3	1			2	1	3	2	1		3		2	4		2		2		2	2					1				3	2	1				2		2		2	9	10	2	2	2
ShastaTehama	Anderson Creek	ACACR	REP	10	2	10	8	10	10	10	10	10			6	3		4	2		4	3	3	2	3	1	3	2	1		1		1	1	2	3	2	2	3		4		2					1		3	1	2				3	2	2			9	9	2	2	2
ShastaTehama	Anderson Creek	BRCWB	SP																																																												
ShastaTehama	Anderson Creek	COYTR	SP																																																												
Solano	Cache Slough	UCBRD	REP	12	2	12	8	12	12	12	12	12			2	2		3		1			2		4						4						1		2		3	1			1	2			5	2		4				1					10	10	2	2	2
Solano	South Yolo Bypass	SSLIB	INT	4	2	4	3	4	4	4	4	4			2	2		2		1	2	1	2	2		1	2	1	1							2	2	1		2	2									2	2	2				2		1		1	4	4	2	2	2
Solano	South Yolo Bypass	ZDDIX	SP																																																												
UpperFeatherRiver	Middle Fork Feather River	MFFGR	REP	6		6		6	6	6	6	6																																																			
UpperFeatherRiver	Middle Fork Feather River	INDAB	SP																																																												
UpperFeatherRiver	Middle Fork Feather River	SPGRN	SP																																																												
Yolo	Willow Slough	WLSPL	REP	11	2	11	8	11	11	11	11	11		4	2	2		3	2	1	3	2	2			1	2	2						1		1	2			4	3		2			5	2		3	3	1	2				3	1	1		3	10	9	2	2	2
Yolo	Willow Slough	CCCPY	SP																																																												
Yolo	Willow Slough	TCHWY	SP																																																												
			Totals	##	28	167	99	144	144	144	148	152	10	4	53	40	8	33	17	7	39	22	24	7	36	6	36	31	12	2	16	1	14	16	13	41	24	15	17	33	44	1	11	1	2	18	4	1	26	41	16	32	1	1	4	32	7	14	2	28	118	119	28	28	28

Note:

(1) Sediment grain size is analyzed along with sediment toxicity. Samples for pyrethroids, chlorpyrifos, diazinon, and TOC in sediment are analyzed if sample is found to be toxic.

ANALYTICAL METHODS

Water chemistry samples were analyzed for filtered and unfiltered fractions of samples depending on analyte. Pesticide analyses were conducted only on unfiltered (whole) samples. Laboratories analyzing samples for this program have demonstrated the ability to meet the minimum performance requirements for each analytical method, including the ability to meet the project-specified quantitation limits (QL), the ability to generate acceptable precision and recovery requirements, and other analytical and quality control parameters documented in the Coalition's QAPP. Analytical methods used for chemical analyses follow accepted standard or USEPA methods or approved modifications to these methods, and all procedures for analyses are documented in the QAPP or are available for review and approval at each laboratory.

Toxicity Testing and Toxicity Identification Evaluations

Water quality samples were analyzed for toxicity to *Ceriodaphnia dubia* and *Selenastrum capricornutum* for 2019 Monitoring. Sediment samples were analyzed for toxicity to *Hyalella azteca*. Toxicity tests were conducted using standard USEPA methods for these species.

- Determination of acute toxicity to *Ceriodaphnia* was performed as described in *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, Fifth Edition* (USEPA 2002a). Toxicity tests with *Ceriodaphnia* were conducted as 96-hour static renewal tests, with renewal 48 hours after test initiation.
- Determination of toxicity to *Selenastrum* was performed using the non-EDTA procedure described in *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, Fourth Edition* (USEPA 2002b). Toxicity tests with *Selenastrum* were conducted as a 96-hour static non-renewal test.

For all initial toxicity screening tests at each site, 100% ambient water and a control were used for the acute water column tests. If 100% mortality to a test species was observed any time after the initiation of the initial screening test, then a multiple dilution test using a minimum of five sample dilutions was conducted with the initial water sample to estimate the magnitude of toxicity.

Procedures in the Coalition's QAPP state that if any measurement endpoint from any of the two aquatic toxicity tests exhibits a statistically significant reduction in survival (*Ceriodaphnia*) or cell density (*Selenastrum*) of greater than or equal to 50% compared to the control, then Toxicity Identification Evaluation (TIE) procedures will be initiated using the most sensitive species to investigate the cause of toxicity. The 50% mortality threshold is consistent with the approach recommended in guidance published by USEPA for conducting TIEs (USEPA 1996b), which recommends a minimum threshold of 50% mortality because the probability of completing a successful TIE decreases rapidly for samples with less than this level of toxicity. For samples that met these trigger criteria, Phase 1 TIEs to determine the general class of constituent (*e.g.*, metal, non-polar organics) causing toxicity or pesticide-focused TIEs are conducted. TIE methods generally adhere to the documented USEPA procedures referenced in the QAPP. TIE procedures are initiated as soon as possible after toxicity is observed to reduce the potential for loss of toxicity due to extended sample storage. Procedures for initiating and conducting TIEs are documented in the QAPP.

Detection and Quantitation Limits

The Method Detection Limit (MDL) is the minimum analyte concentration that can be measured and reported with a 99% confidence that the concentration is greater than zero. The Quantitation Limit (QL) represents the concentration of an analyte that can be routinely measured in the sampled matrix within stated limits and confidence in both identification and quantitation. For this program, QLs were established based on the verifiable levels and general measurement capabilities demonstrated by labs for each method. Note that samples required to be diluted for analysis (or corrected for percent moisture for sediment samples) may have sample-specific QLs that exceed the established QLs. This is unavoidable in some cases.

Project Quantitation Limits

Laboratories generally establish QLs that are reported with the analytical results—these may be called *reporting limits*, *detection limits*, *reporting detection limits*, or several other terms used by different laboratories. In most cases, these laboratory limits are less than or equal to the project QLs listed in **Table** 5 and **Table 6.** Wherever possible, project QLs are lower than the proposed or existing relevant numeric water quality objectives or toxicity thresholds, as required by the ILRP.

All analytical results between the MDL and QL are reported as numerical values and qualified as estimates (Detected, Not Quantified (DNQ); or sometimes, "J-flagged", which is a USEPA data qualifier indicating that the reported value is estimated).

Table 5. Laboratory Method Detection Limit (MDL) and Quantitation Limit (QL) Data Quality Objectives for Analyses of Surface Water

Method	Analyte	Fraction	Units	MDL	QL	Note
Physical and Conventional Parameters						
EPA 130.2	Hardness, total as $CaCO_3$	Unfiltered	mg/L	3	5	
EPA 180.1; SM2130B	Turbidity	Unfiltered	NTU	0.1	1.0	
SM20-2540 C	Total Dissolved Solids (TDS)	Particulate	mg/L	4	10	(a)
EPA 160.2; SM2540D	Total Suspended Solids (TSS)	Particulate	mg/L	2	3	
EPA 9060; SM5310B; SM5310C	Organic Carbon, Total (TOC)	Unfiltered	mg/L	0.1	0.5	
Pathogen Indicators						
SM 9223 B	*E. Coli* bacteria	NA	MPN/100mL	2	2	
Organophosphorus Pesticides						
EPA 625(m)	Azinphos-methyl	Unfiltered	µg/L	0.05	0.1	
EPA 625(m)	Chlorpyrifos	Unfiltered	µg/L	0.005	0.01	
EPA 625(m)	Diazinon	Unfiltered	µg/L	0.005	0.01	
EPA 625(m)	Dichlorvos	Unfiltered	µg/L	0.005	0.01	
EPA 625(m)	Dimethoate	Unfiltered	µg/L	0.005	0.01	
EPA 625(m)	Malathion	Unfiltered	µg/L	0.005	0.01	
EPA 625(m)	Methidathion	Unfiltered	µg/L	0.01	0.02	
EPA 625(m)	Naled	Unfiltered	µg/L	0.2	0.5	(a)
EPA 625(m)	Phorate	Unfiltered	µg/L	0.01	0.02	
Organochlorine Pesticides						
EPA 625(m)	4,4’-DDT (o,p’ and p,p’)	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	4,4’-DDE (o,p’ and p,p’)	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	4,4’-DDD (o,p’ and p,p’)	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Aldrin	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Chlordane	Unfiltered	µg/L	0.001	0.005	
EPA 8081A	Chlorothalonil	Unfiltered	µg/L	0.1	0.2	(a)
EPA 625(m)	Dacthal	Unfiltered	µg/L	0.008	0.05	
EPA 625(m)	Dicofol	Unfiltered	µg/L	0.05	0.1	
EPA 625(m)	Dieldrin	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Endosulfan I	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Endosulfan II	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Endosulfan sulfate	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Endrin	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Endrin Aldehyde	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Endrin Ketone	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	HCH	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Heptachlor	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Heptachlor epoxide	Unfiltered	µg/L	0.001	0.005	
EPA 625(m)	Methoxychlor	Unfiltered	µg/L	0.001	0.005	

Method	Analyte	Fraction	Units	MDL	QL	Note
Carbamate and Urea Pesticides						
EPA 8321	Carbaryl	Unfiltered	µg/L	0.05	0.07	
EPA 8321	Methiocarb	Unfiltered	µg/L	0.2	0.4	
EPA 8321	Methomyl	Unfiltered	µg/L	0.05	0.07	
Pyrethroid Pesticides						
GCMS-NCI	Allethrin	Unfiltered	µg/L	0.0001	0.0015	
GCMS-NCI	Bifenthrin	Unfiltered	µg/L	0.0001	0.0015	
GCMS-NCI	Cyfluthrin	Unfiltered	µg/L	0.0002	0.0015	
GCMS-NCI	Cypermethrin	Unfiltered	µg/L	0.0002	0.0015	
GCMS-NCI	Deltamethrin/Tralomethrin	Unfiltered	µg/L	0.0002	0.003	
GCMS-NCI	Esfenvalerate/Fenvalerate	Unfiltered	µg/L	0.0002	0.003	
GCMS-NCI	Fenpropathrin	Unfiltered	µg/L	0.0002	0.0015	
GCMS-NCI	Fluvalinate	Unfiltered	µg/L	0.0002	0.0015	
GCMS-NCI	Lambda-Cyhalothrin	Unfiltered	µg/L	0.0002	0.0015	
GCMS-NCI	Permethrin	Unfiltered	µg/L	0.002	0.015	
GCMS-NCI	Tetramethrin	Unfiltered	µg/L	0.0002	0.0015	
Insecticide						
EPA 625	Acetamiprid	Unfiltered	µg/L	0.01	0.02	
EPA 625	Clothianidin	Unfiltered	µg/L	0.01	0.02	
EPA 625	Imidacloprid	Unfiltered	µg/L	0.002	0.004	
EPA 625	Pyridaben	Unfiltered	µg/L	0.01	0.05	
Other Herbicides						
EPA 8081A	Dacthal	Unfiltered	µg/L	0.008	0.05	
EPA 615	2,4-Dichlorophenoxyacetic Acid	Unfiltered	µg/L	0.45	1	
EPA 8321	Diuron	Unfiltered	µg/L	0.2	0.4	
NCL ME 321	Ethalfluralin	Unfiltered	µg/L	0.0038	0.01	
NCL ME 340	Flumioxazin	Unfiltered	µg/L	0.017	0.02	
EPA 547M	Glyphosate	Unfiltered	µg/L	1.7	5	
EPA 8321	Linuron	Unfiltered	µg/L	0.2	0.4	
EPA 625	Metolachlor	Unfiltered	µg/L	0.26	0.5	(a)
EPA 8321	Oryzalin	Unfiltered	µg/L	0.2	0.4	
EPA 8081A	Oxyfluorfen	Unfiltered	µg/L	0.008	0.05	
EPA 549.2M	Paraquat	Unfiltered	µg/L	0.19	0.4	
EPA 8141AM	Pendimethalin	Unfiltered	µg/L	0.53	1	
EPA 8141A	Trifluralin	Unfiltered	µg/L	0.036	0.05	
Triazines						
EPA 8141A	Atrazine	Unfiltered	µg/L	0.1	0.5	
EPA 8141A	Hexazinone	Unfiltered	µg/L	0.1	0.5	(a)
EPA 633M	Metribuzin	Unfiltered	µg/L	0.32	1	
EPA 8141A	Prometryn	Unfiltered	µg/L	0.05	0.1	
EPA 625(m)	Simazine	Unfiltered	µg/L	0.005	0.01	

Method	Analyte	Fraction	Units	MDL	QL	Note
Fungicides						
EPA 8260BM	Chloropicrin	Unfiltered	µg/L	7.4	10	
NCL ME 340	Cyprodinil	Unfiltered	µg/L	0.0031	0.02	
EPA 625	Dodine	Unfiltered	µg/L	0.01	0.025	
EPA 630	Mancozeb (Ziram)	Unfiltered	µg/L	1	5	
NCL ME 340/ NCL ME 342	Propiconazole	Unfiltered	µg/L	0.0069	0.02	(a)
NCL ME 340/ NCL ME 342	Pyraclostrobin	Unfiltered	µg/L	0.0034	0.02	(a)
Trace Elements						
EPA 200.8	Arsenic	Filtered, Unfiltered	µg/L	0.08	0.5	
EPA 200.8	Boron	Filtered, Unfiltered	µg/L	0.04	0.1	
EPA 200.8	Copper	Filtered, Unfiltered	µg/L	0.2	0.5	
EPA 200.8	Zinc	Filtered, Unfiltered	µg/L	0.7	1	
Nutrients						
EPA 350.1; 350.2	Ammonia, Total as N	Unfiltered	mg/L	0.02	0.1	
EPA 353.2	Nitrate + Nitrite as N	Unfiltered	mg/L	0.02	0.05	
EPA 365.2; SM4500-P E	Orthophosphate, as P	Unfiltered	mg/L	0.01	0.05	
EPA 365.2; SM4500-P E	Phosphorus, Total	Unfiltered	mg/L	0.02	0.05	

Note:

a. No QL target has been established for this analyte.

Table 6. Laboratory Method Detection Limit (MDL) and Quantitation Limit (QL) Data Quality Objectives for Analyses of Sediments for the Coalition Monitoring and Reporting Program Plan

Method	Analyte	Fraction	Units	MDL	QL
Physical and Conventional Parameters					
EPA 160.3	Solids (TS)	Total	%	NA	0.1
EPA 9060	Organic Carbon, Total (TOC)	Total	mg/kg dry wt.	50	200
Pyrethroids					
EPA 8270C(m)	Allethrin	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Bifenthrin	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Cyfluthrin	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Cypermethrin	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Deltamethrin/Tralomethrin	Total	ng/g dry wt.	0.15	1
EPA 8270C(m)	Esfenvalerate/Fenvalerate	Total	ng/g dry wt.	0.15	1
EPA 8270C(m)	Fenpropathrin	Total	ng/g dry wt.	0.15	1
EPA 8270C(m)	Fluvalinate	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Lambda-Cyhalothrin	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Permethrin	Total	ng/g dry wt.	0.1	1
EPA 8270C(m)	Tetramethrin	Total	ng/g dry wt.	0.1	1
Organochlorine Pesticides					
EPA 8270C(m)	Chlorpyrifos	Total	ng/g dry wt.	0.1	3
EPA 8270C(m)	Diazinon	Total	ng/g dry wt.	5	40

Monitoring Results

The following sections summarize the monitoring conducted by the Coalition and its subwatershed partners in the 2019 Monitoring Year (October 2018 through September 2019).

SUMMARY OF SAMPLE EVENTS CONDUCTED

This report presents monitoring results from 12 Coalition sampling events (Events 152-163), as well as data for events conducted by coordinating subwatershed monitoring programs and other agencies between October 2018 and September 2019. Samples collected for all of these events are listed in **Table 7**.

The Coalition and subwatershed monitoring events were conducted throughout the year. Analyses included water chemistry and toxicity, with pesticides monitored during months when higher use is typical. Sediment toxicity testing and/or chemistry analyses were also conducted by the Coalition as part of the assessment. The sites and parameters for all events were monitored in accordance with the Coalition's current MRP and QAPP.

The field logs for all Coalition and subwatershed samples collected for the October 2018 through September 2019 events, as well as associated site photographs, are provided in **Appendix A**.

Completeness

The objectives for completeness are intended to apply to the monitoring program as a whole. As summarized in **Table 7**, 156 of the 168 initial water column and toxicity sample events planned by the Coalition and coordinating programs were conducted, for an overall sample event success rate of approximately 93%. Planned sample collection at one Coalition location did not occur because the monitoring site was dry or inaccessible. Planned sampling that differed from the 2019 Monitoring Plan Update is summarized below:

- DWR did not conduct all of the planned monitoring events at Middle Fork of the Feather River above Grizzly Creek (MFFGR), Pit River at Pittville Bridge (PRPIT), Fall River Bridge (FRRRB), and Pit River at Canby Road (PRCAN), due to a suspension of funding.
- Samples for one event at MFFGR were not collected, due to unsafe sampling conditions. A make-up event was performed in April.

Table 7. Sampling for the 2019 Coalition Monitoring Year

Subwatershed (Agency)	Site ID	Sample Count Planned	Sample Count Collected	152 OCT	153 NOV	154 DEC	155 JAN	156 FEB	157 MAR	158 APR	159 MAY	160 JUN	161 JUL	162 AUG	163 SEP
Butte-Yuba-Sutter (SVWQC)	GILSL	5	5	-	-	-	W	W	-	-	W	-	W	W	-
	LHNCT	10	10	-	-	W	W	W	W	W,S	W	W	W	W,S	W
	LSNKR	11	11	W	W	W	W	W	W	W,S	W	W	W	W,S	-
	PNCHY	11	11	W	-	W	W	W	W	W,S	W	W	W	W,S	W
	SSKNK	4	4	-	W	-	W	-	-	-	W,S	-	-	W,S	-
Colusa Glenn (SVWQC)	COLDR	4	4	-	W	-	W	-	-	-	W,S	-	-	W,S	-
	FRSHC	11	11	-	W	W	W	W	W	W,S	W	W	W	W,S	W
	RARPP	2	2	-	-	-	W	-	-	-	-	-	-	W	-
	WLKCH	12	12	W	W	W	W	W	W	W,S	W	W	W	W,S	W
El Dorado (SVWQC)	COONH	3	3	-	-	-	W	-	-	W	-	-	-	W	-
Goose Lake	LOWLC	3	3	-	-	-	-	-	-	W	W	-	W	-	-
Lake (SVWQC)	MDLCR	4	4	-	W	-	-	W	-	W	-	-	-	W	-
	MGSLU	4	4	-	W	-	-	W	-	W	-	-	-	W	-
Pit River (NECWA)	FRRRB	0	4	-	[1]	-	-	[1]	-	-	[1]	-	-	[1]	-
	PRCAN	0	4	-	[1]	-	-	[1]	-	-	[1]	-	-	[1]	-
	PRPIT	2	2	-	[1]	-	-	W	-	-	W	-	-	-	-
PNSSNS	CCBRW	9	9	-	-	W	W	-	W	W,S	W	W	W	W,S	W
Sac/Amador (SVWQC)	CRTWN	9	10	D	W	-	-	W	W	W,S	W	W	W	W,S	W
	GIDLR	12	12	W	W	W	W	W	W	W,S	W	W	W	W,S	W
Shasta/Tehama (SVWQC)	ACACR	10	10	-	W	W	-	W	W	W,S	W	W	W	W,S	W
Solano (SVWQC)	UCBRD	12	12	W	W	W	W	W	W	W,S	W	W	W	W,S	W
	SSLIB	4	4	-	W	-	W	-	-	-	W,S	-	-	W,S	-
Yolo (SVWQC)	WLSPL	11	11	W	W	-	W	W	W	W,S	W	W	W	W,S	W
Upper Feather River (UFRW)	MFFGR	3	6	-	[1]	-	-	[1]	[2]	W	-	W	W	[1]	-
	Totals	**156**	**168**												

Notes:

NECWA = Northeastern California Watershed Association
PNSSNS = Placer-Nevada-South Sutter-North Sacramento
SVWQC = Sacramento Valley Water Quality Coalition
UFRW = Upper Feather River Watershed Group

W = Water sample collected
S = Sediment sample collected
D = Site was dry; no samples collected.
NS = Planned, but not sampled
"-" = no samples planned

[1] = Department of Water Resources monitoring suspended due to lack of funding.
[2] = Monitoring site was not safely accessible due to high flows. Event moved to April.

SUMMARY OF SAMPLING CONDITIONS

Samples were collected throughout the year for the Coalition (see **Table 2**, Sampling for the 2019 Coalition Monitoring Year). The October 1, 2018, through September 30, 2019, monitoring year was characterized by above-average precipitation during the months of November, January, March, and April, and at or below-average precipitation during all other months. The water year was classified as "Wet" for the Sacramento Valley by the California Department of Water Resources, with an estimated 138% of average total runoff (based on 1966-2015 mean).[5,6] At the end of the 2019 water year, statewide precipitation was 131% of average.[7]

The Coalition's two sample collection periods include the wet season monitoring period from November 2018 to March 2019, and the irrigation season monitoring period from April 2019 through September 2019. October 2018 is classified as belonging to the irrigation season, but is attributed to the previous year's period. The wet season monitoring period had below-average precipitation in December and above-average amounts in the remaining months. The irrigation season had above-average precipitation in March and May, average precipitation in July, and below-average precipitation in all other months.

Regional precipitation patterns for October 2018 through September 2019 are illustrated in **Figure 2-a** through **Figure 2-f**. Compared to the prior water year, more frequent precipitation events occurred throughout the year from October to June, resulting in relatively higher flows (**Figure 3-a** through **Figure 3-f**). Water samples were collected during high- and low-flow hydrologic conditions.

Based on climate data available from the Sacramento Executive Airport weather station, rainfall during the April – September 2019 irrigation season was greater than average during May, below average in April and at or below-average from June through September (**Table 8**). No precipitation occurred from June through September. Precipitation was normal in July, above normal in November, January, February, March and May, and below normal in the remaining six months. The maximum temperature exceeded 90° on 13 days in June, 19 days in July, 21 days in August, and 5 days in September.

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[5] http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST and http://cdec.water.ca.gov/cgi-progs/previous/WSI

[6] Sacramento River Region unimpaired runoff, for water year 2019, was about 24.7 million acre-feet (MAF), approximately 138% of average. During water year 2018, the observed Sacramento River Region unimpaired runoff was about 12.4 MAF, or 71% of average.

[7] California Department of Water Resources 2019 WY Precipitation Summary available at: http://cdec.water.ca.gov/reportapp/javareports?name=PRECIPSUM.201909

Table 8. Summary of Climate Data[8] at Sacramento Executive Airport, October 2018 – September 2019

Month	Departure from Normal Mean Temperature	Days with Maximum Temperature ≥ 90°F	Precipitation Total (Inches)	Departure from Normal Precipitation
October 2018	1.3	0	0.04	-0.91
November 2018	0.7	0	2.47	0.39
December 2018	2.6	0	2.37	-0.88
January 2019	3.9	0	4.22	0.58
February 2019	-3.4	0	7.45	3.98
March 2019	-0.9	0	3.76	1.01
April 2019	3.7	0	0.77	-0.38
May 2019	-2.6	0	3.17	2.49
June 2019	2.4	13	0.00	-0.21
July 2019	1.0	19	0.00	0.00
August 2019	3.3	21	0.00	-0.05
September 2019	2.9	5	0.00	-0.05

[8] Preliminary monthly climate data (temperature and precipitation) for Sacramento Executive Airport weather station available at: http://www.weather.gov/climate/index.php?wfo=sto

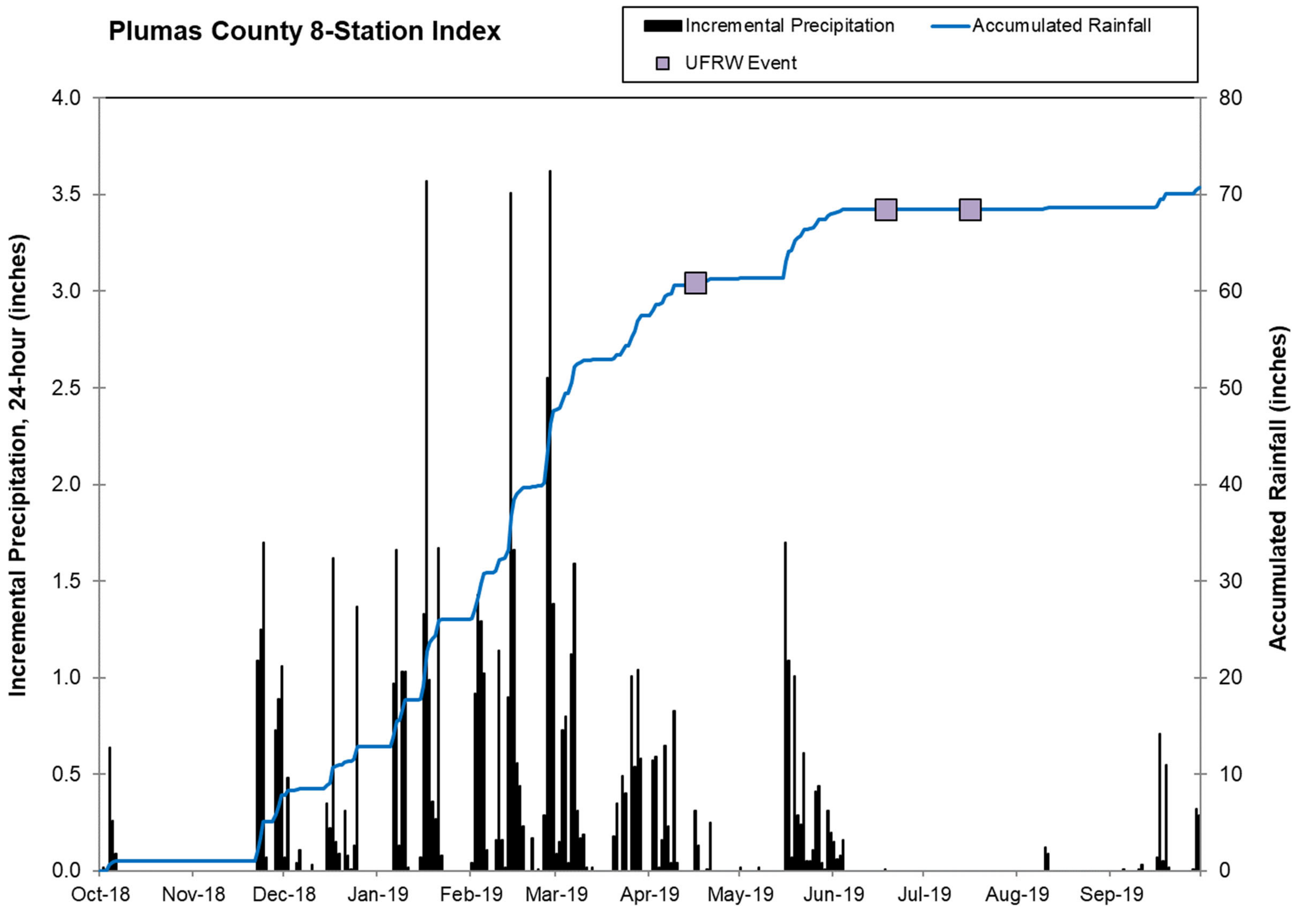

Figure 2-a. Precipitation during 2019 Coalition Monitoring: Plumas County

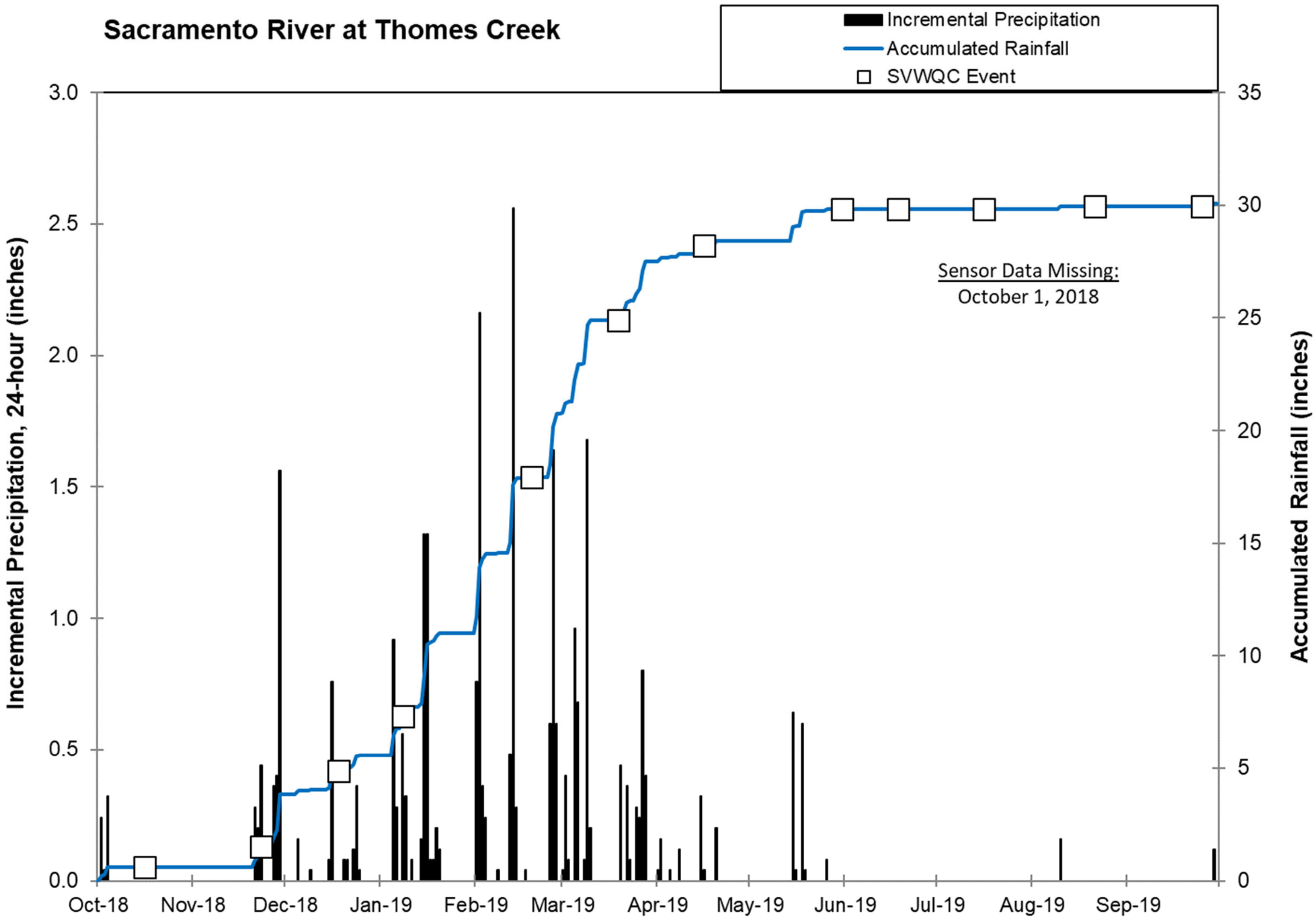

Figure 2-b. Precipitation during 2019 Coalition Monitoring: Upper Sacramento Valley

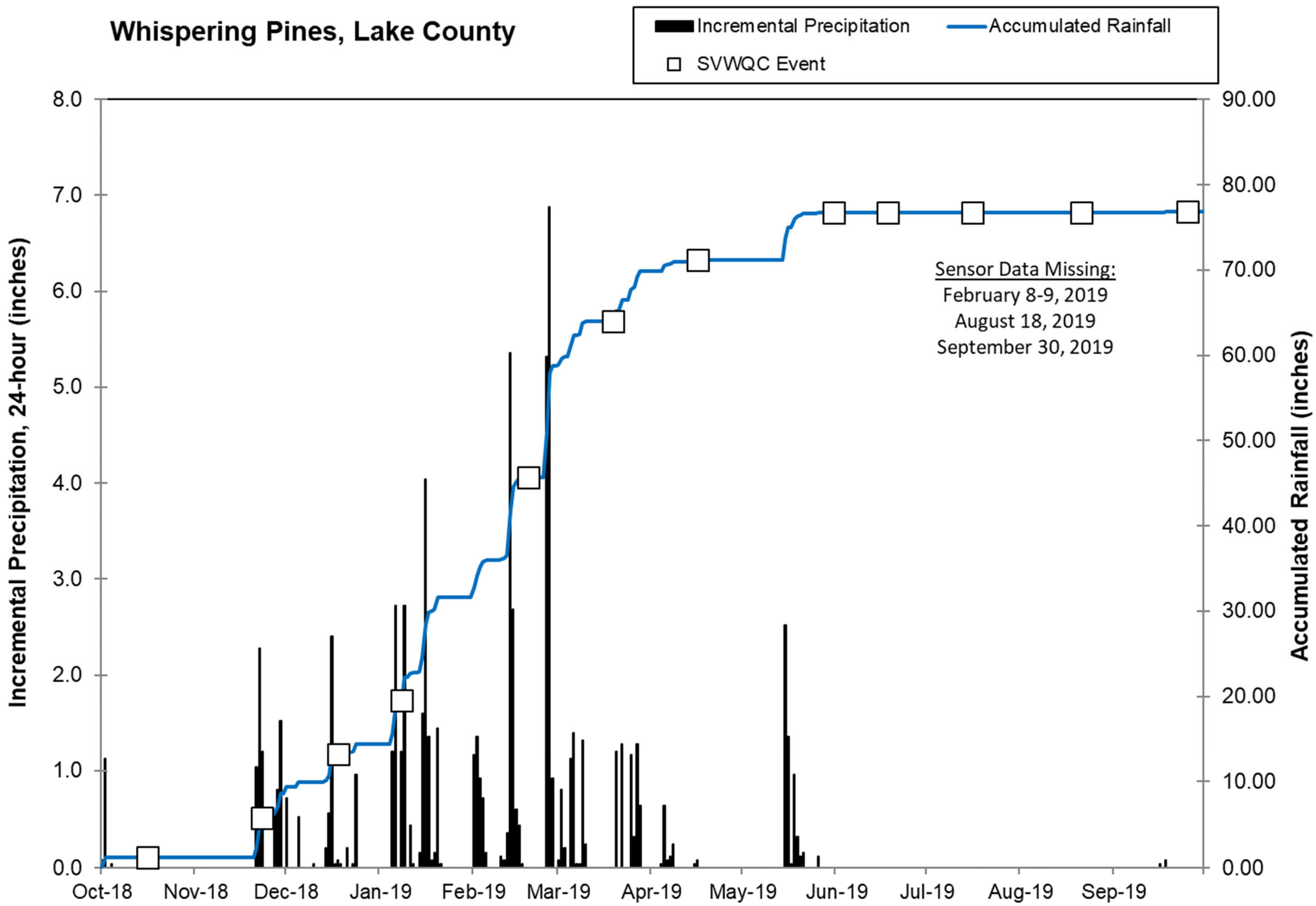

Figure 2-c. Precipitation during 2019 Coalition Monitoring: Lake County

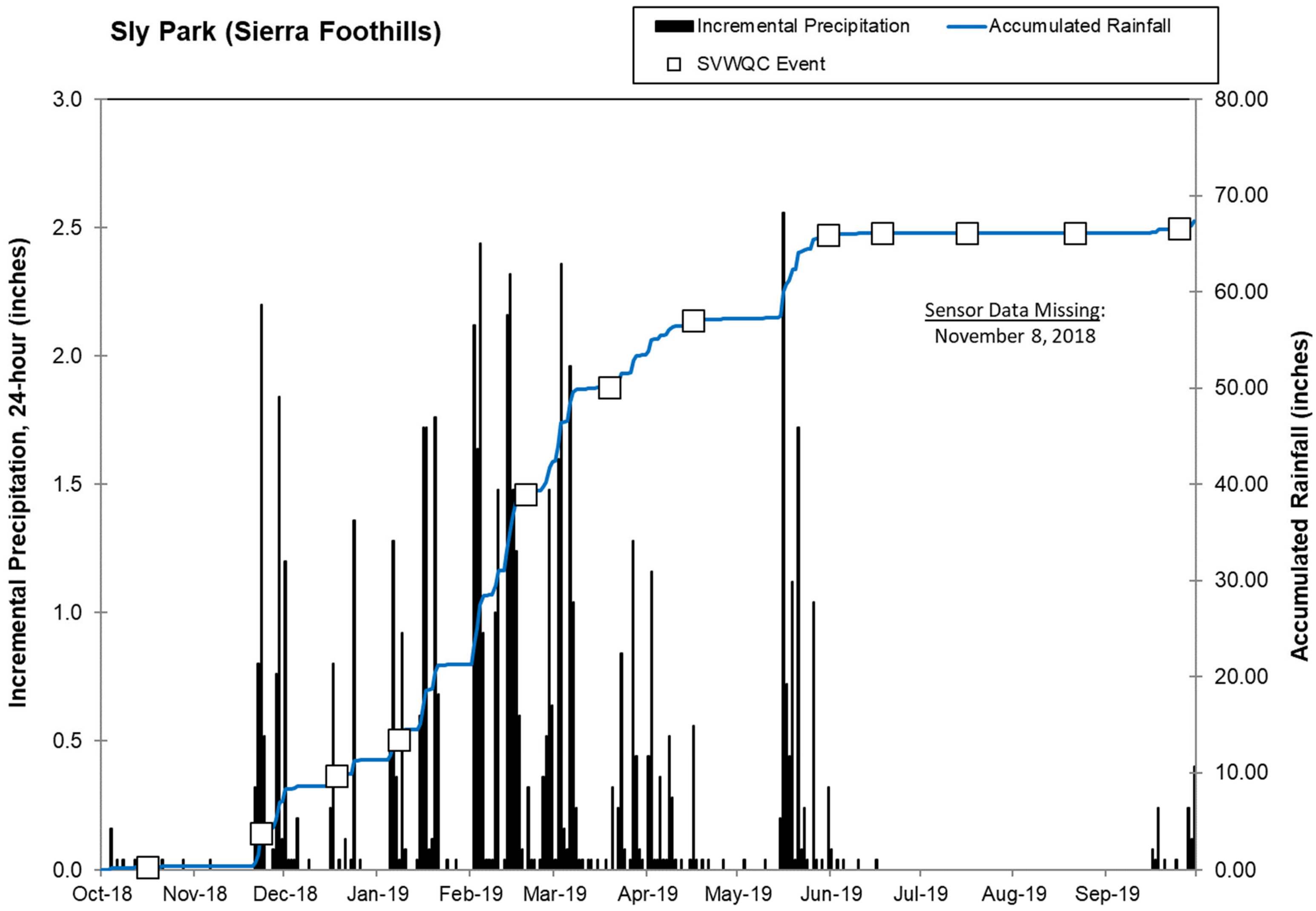

Figure 2-d. Precipitation during 2019 Coalition Monitoring: Sierra Foothills

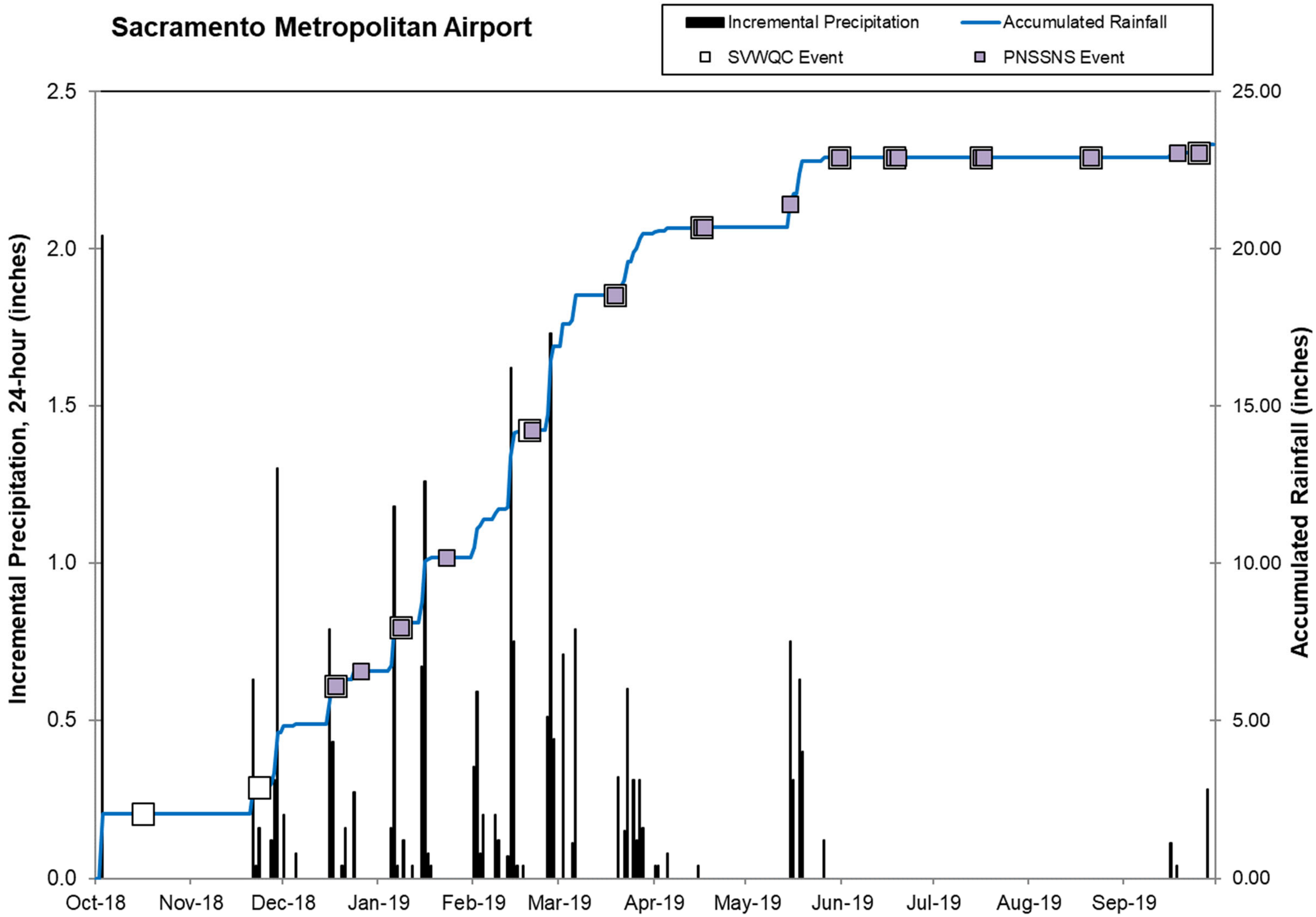

Figure 2-e. Precipitation during 2019 Coalition Monitoring: Lower Sacramento Valley

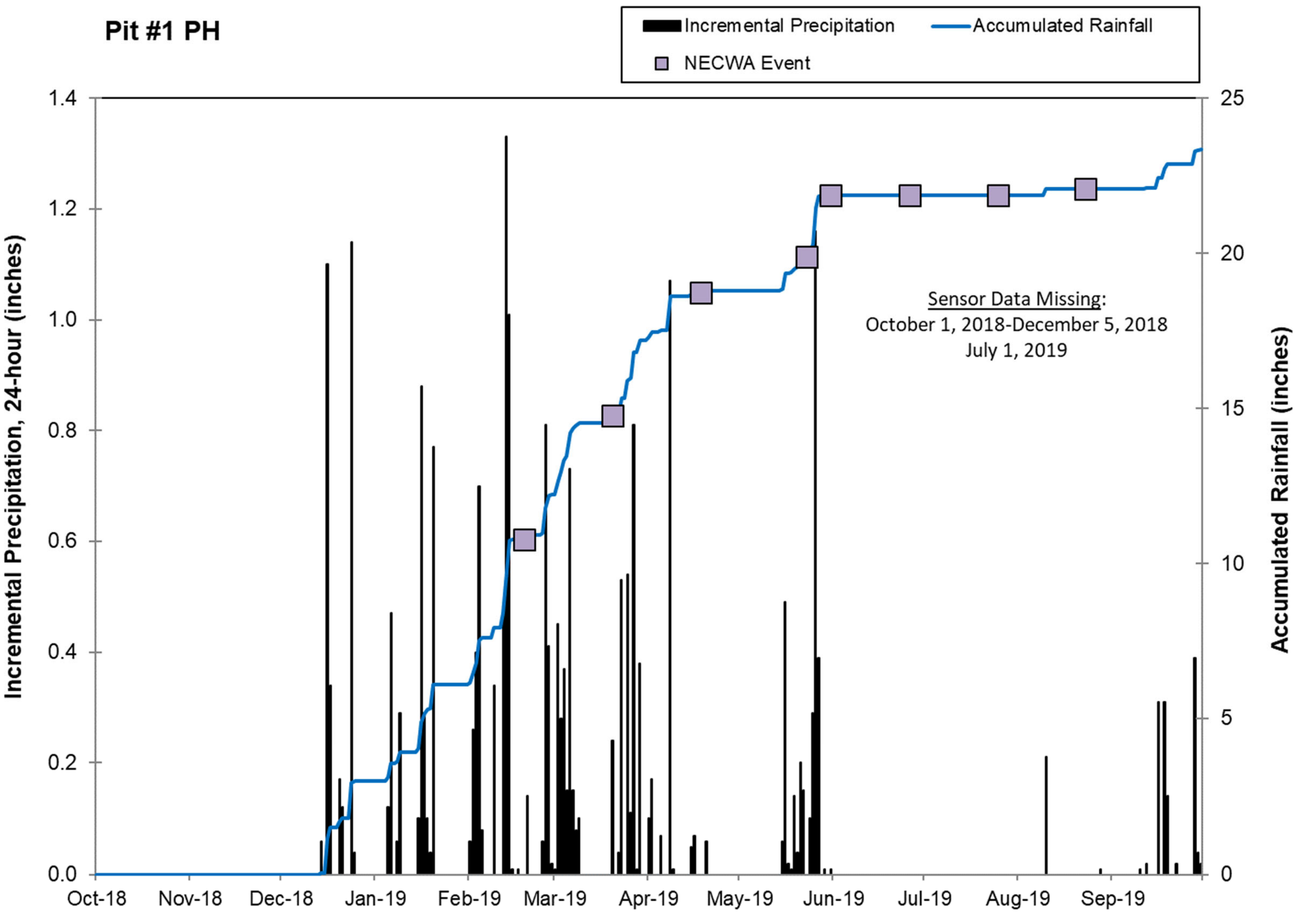

Figure 2-f. Precipitation during 2019 Coalition Monitoring: Pit River

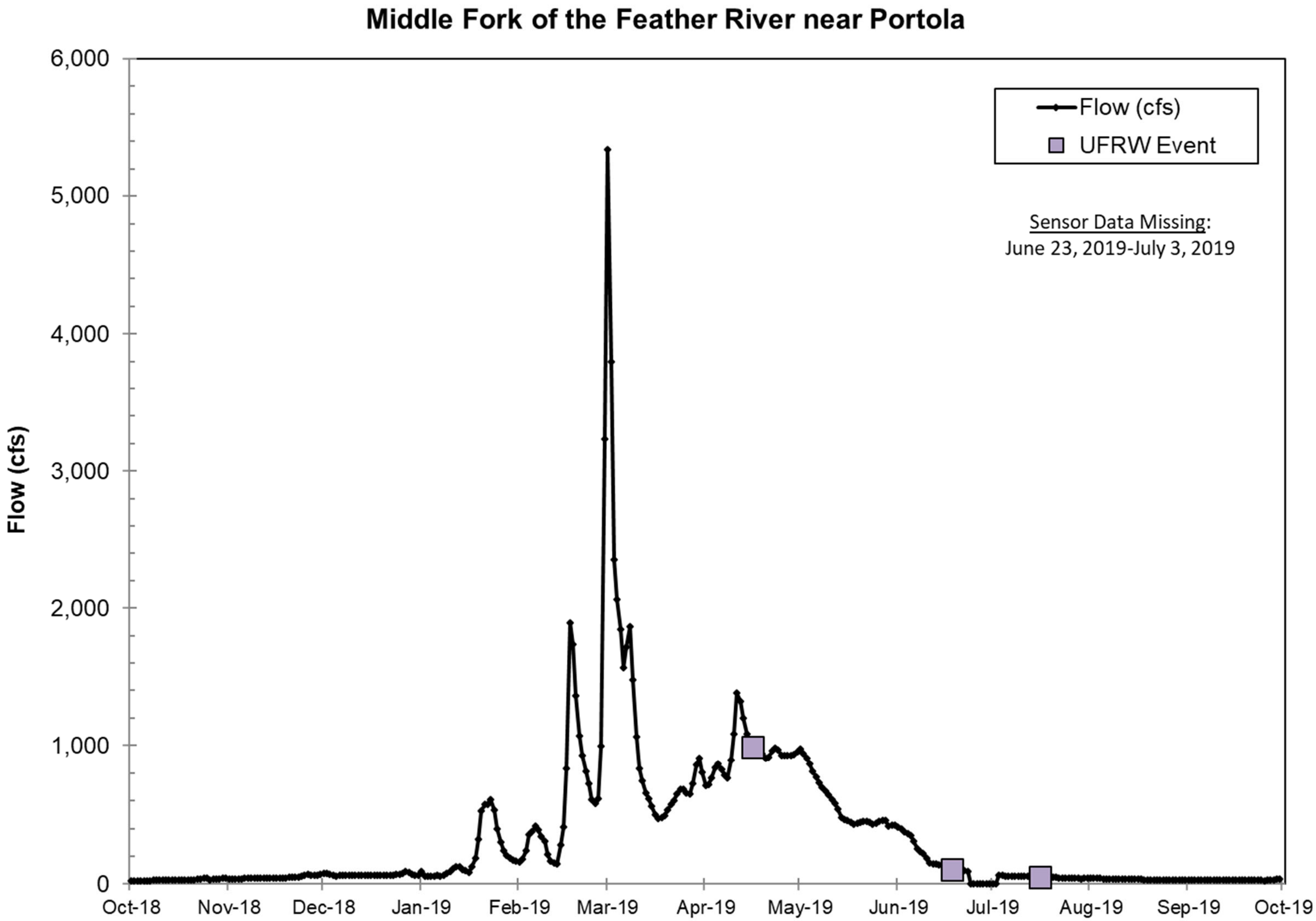

Figure 3-a. Flows during 2019 Coalition Monitoring: Plumas County

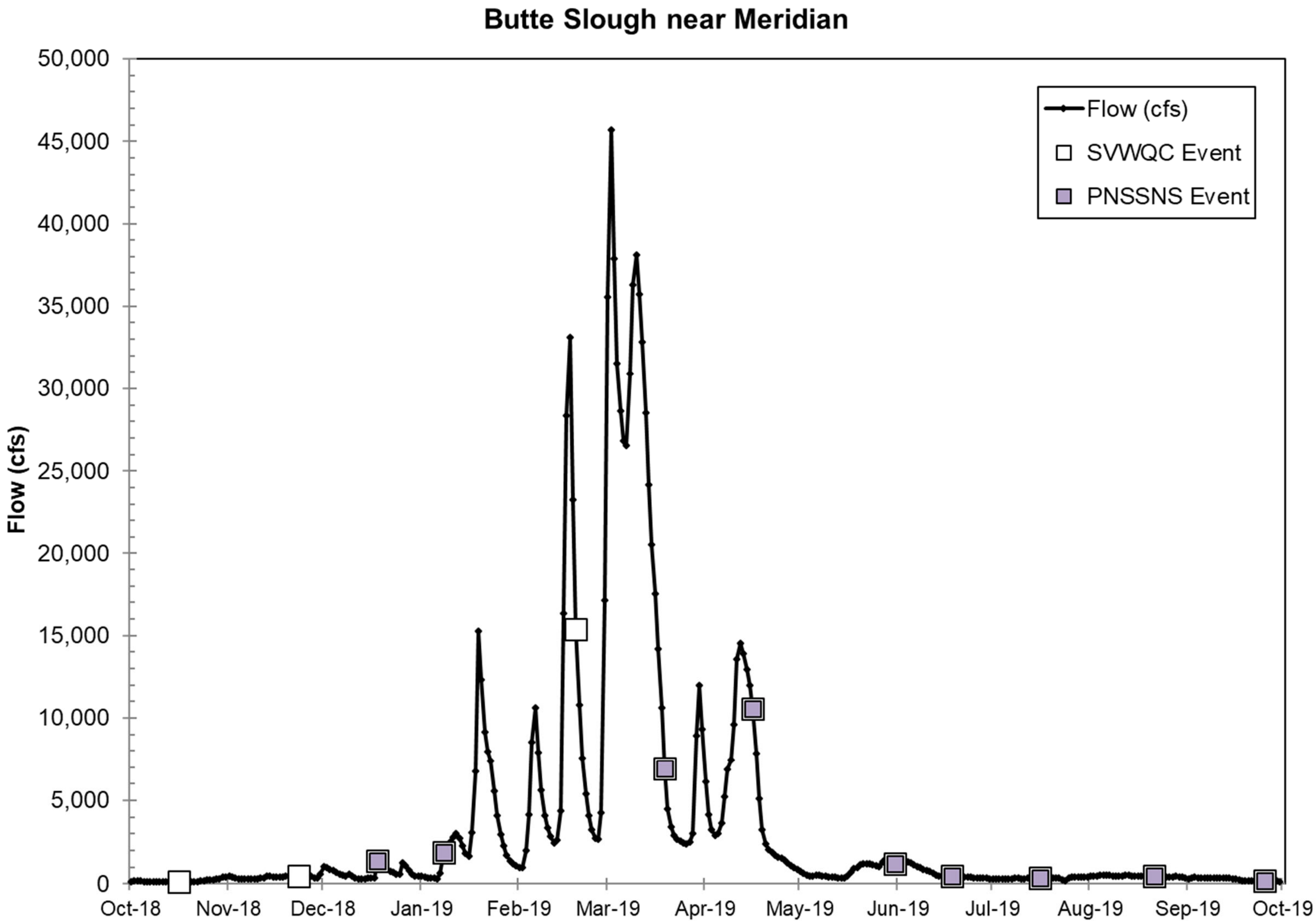

Figure 3-b. Flows during 2019 Coalition Monitoring: East Sacramento Valley

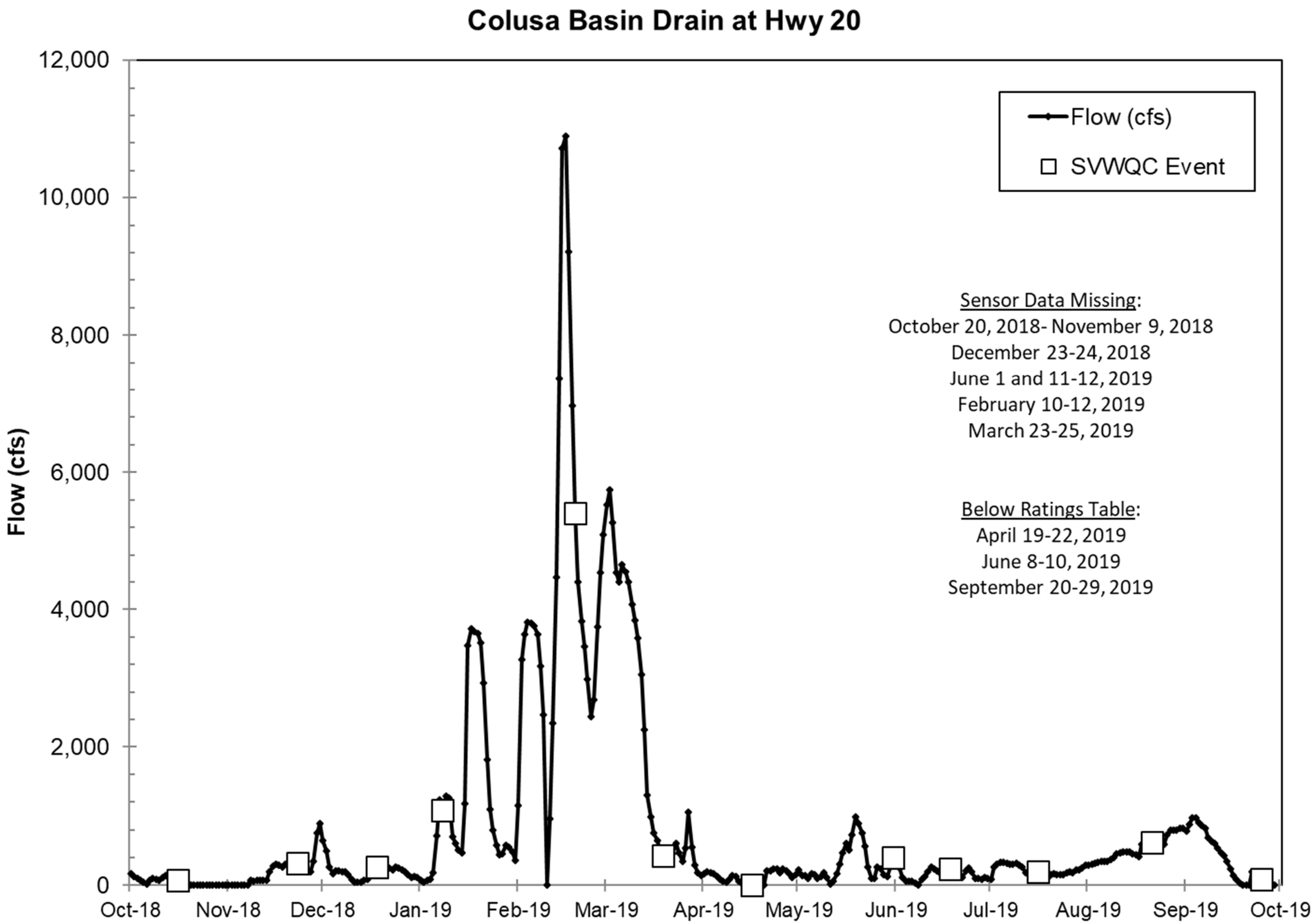

Figure 3-c. Flows during 2019 Coalition Monitoring: West Sacramento Valley

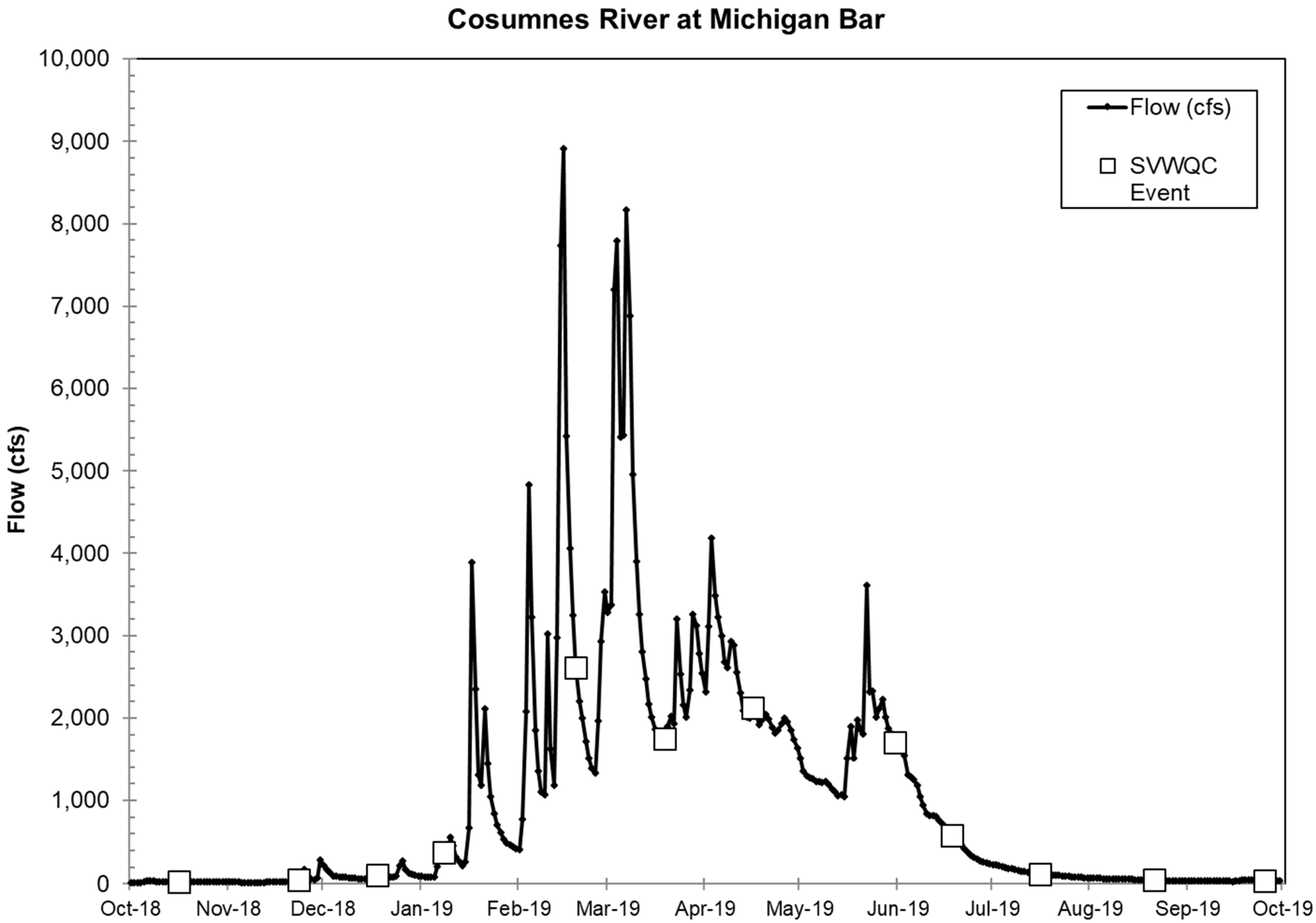

Figure 3-d. Flows during 2019 Coalition Monitoring: Lower Sacramento Valley

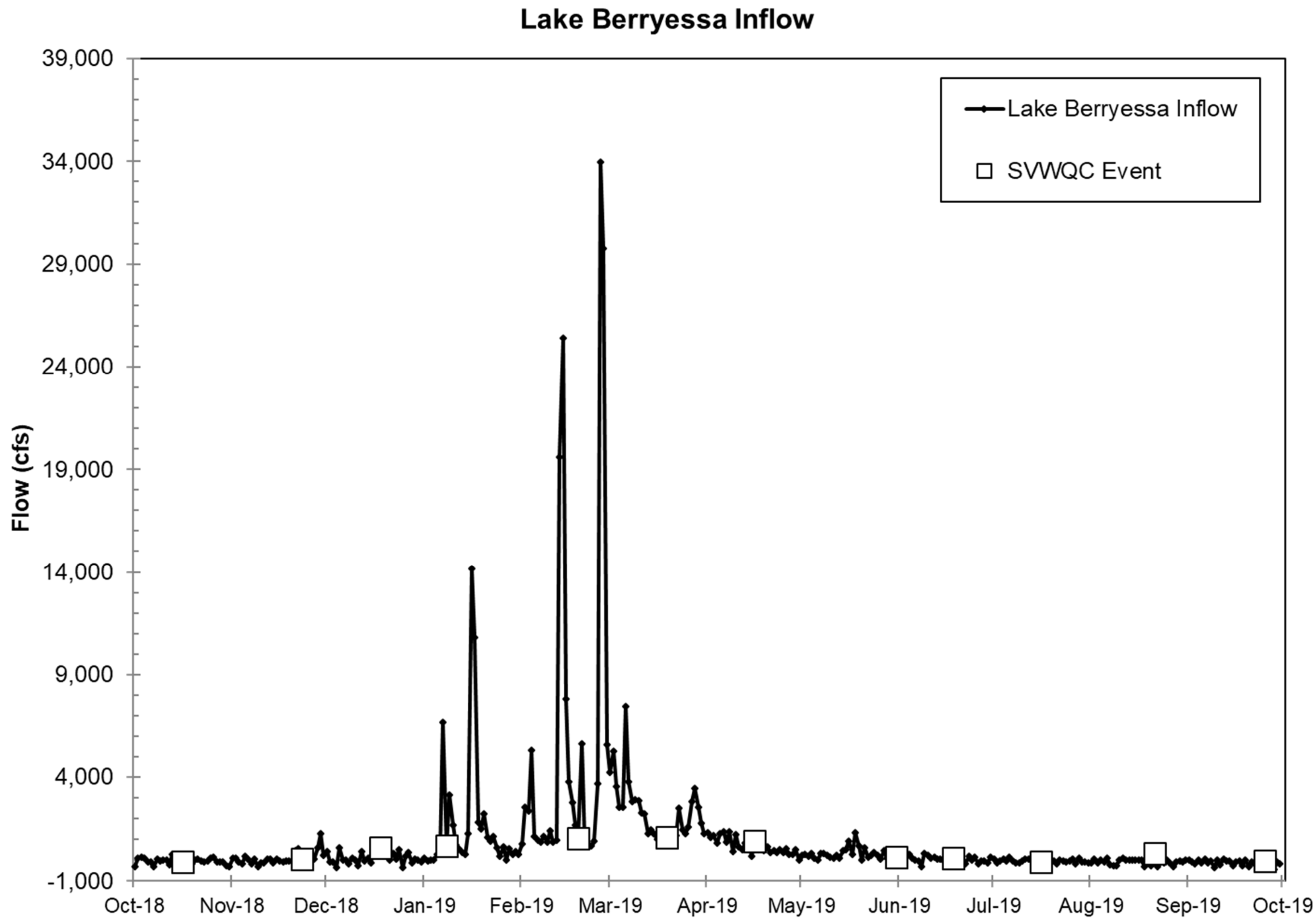

Figure 3-e. Flows during 2019 Coalition Monitoring: Lake Berryessa (Reservoir Inflow)

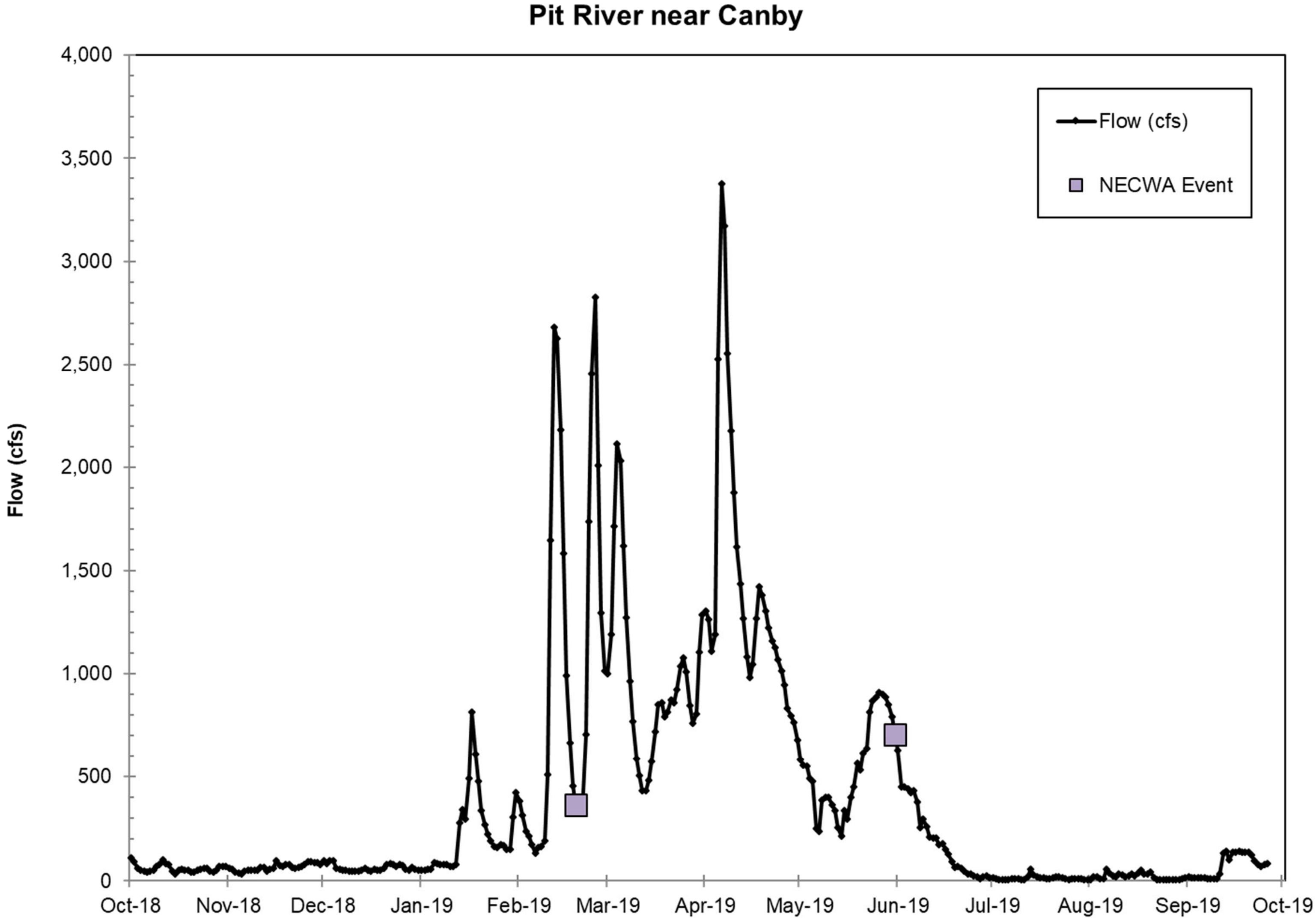

Figure 3-f. Flows during 2019 Coalition Monitoring: Pit River near Canby

SAMPLE HANDLING AND CUSTODY

All samples that were collected for the Coalition monitoring effort met the requirements for sample custody. Sample custody must be traceable from the time of sample collection until results are reported. A sample is considered under custody if:

- It is in actual possession;
- It is in view after in physical possession; and
- It is placed in a secure area (i.e., accessible by or under the scrutiny of authorized personnel only after in possession).

The chain-of-custody forms (COCs) for all samples collected by Coalition contractors for the monitoring events conducted from October 2018 through September 2019 are included with the related lab reports and are provided in **Appendix B**. All COCs for *ILRP* monitoring conducted by Coalition partners during this same period are also provided in **Appendix B** with their associated lab reports.

Sample containers are occasionally lost or broken in transit due to shipping and handling factors beyond the Coalition's control. Broken containers are relevant to program completeness if the incident prevents the Coalition from completing the required sample analyses or if they are analyzed and may potentially affect analytical quality. In general, broken bottles do not impact completeness of analyses. In most cases, sufficient remaining sample volume is available to complete the planned environmental and quality assurance analyses. If program completeness was affected, the issue of broken bottles is discussed in this report. The protocol that is followed if a broken bottle is reported is to contact the sampling crew and let them know of the issue so that they may review their packing and shipping procedures. Any known shipping and handling deficiencies are also noted. If samples lost or broken in shipping affect overall completeness for specific analyses at a specific location and the analyses are relevant to synoptically collected toxicity samples, additional sample volume is preferentially aliquoted from the sample collected for toxicity. If additional sample volume from another appropriately collected and preserved sample container is not available, the analyses are rescheduled for a future event to ensure program completeness objectives are met. Sample containers that were received broken are summarized below:

- Sample shipments for October 2018 through September 2019 monitoring were all received with no broken or damaged bottles.

In addition, sample containers occasionally arrive at the analytical laboratory at a temperature that is above the recommended maximum (6˚C) for Coalition samples. This may occur when samples do not have sufficient time to cool down to the target temperature or when extended shipping times and higher external temperatures cause sample temperatures to increase above 6˚C. This has proven to be a challenge for toxicity samples because the sample volumes are large (1-gallon containers), require additional shipping protection (bubble wrap), and take longer to cool, particularly when ambient water temperatures exceed 25˚C. However, because toxicity tests are typically conducted at ~20˚C over four days, sample temperatures slightly elevated above 6˚C on receipt are not expected to have a significant impact on the toxicity test results. However, all samples received above recommended temperatures are qualified as required (i.e., through the use of the appropriate CEDEN QA Code: *BY = Sample received at improper* *temperature*). In each case, the sampling crews are notified and the sample collection conditions and shipping procedures are reviewed to attempt to determine the cause of the elevated temperatures.

- Sample shipments for October 2018 through September 2019 monitoring were all received at temperatures below 6˚C.

QUALITY ASSURANCE RESULTS

The Data Quality Objectives (DQOs) used to evaluate the results of the Coalition monitoring efforts are detailed in the Coalition's QAPP. These DQOs are the detailed quality control specifications for precision, accuracy, representativeness, comparability, and completeness. These DQOs are used as comparison criteria during data quality review to determine if the minimum requirements have been met and the data may be used as planned.

Results of Field and Laboratory QA/QC Analyses

Quality Assurance/Quality Control (QA/QC) data are summarized in **Table 9**. All program QA/QC results are included with the lab reports in **Appendix B** of this document, and any qualifications of the data are presented with the tabulated monitoring data.

Table 9. Summary of QA/QC Results for 2019 Monitoring Year

Field Blank	Field Duplicate	Method or Lab Blank	Lab Control Spike	Lab Control Spike Duplicate	Matrix Spike	Matrix Spike Duplicate	Lab Duplicate	Surrogate Recovery
98.9%	92.3%	99.9%	98.8%	99.6%	93.4%	97.6%	96.3%	97.6%

TABULATED RESULTS OF LABORATORY ANALYSES

Copies of final laboratory reports and all reported QA/QC data for Coalition monitoring results are provided in **Appendix B**. The tabulated results for all validated and Quality Assurance-evaluated (QA) data are provided in **Appendix C**. These data were previously submitted as part of the Coalition's quarterly data submittals to ILRP.

Assessment of Water Quality Objectives

Coalition and subwatershed monitoring data were compared to ILRP Trigger Limits. Generally, these trigger limits are based on applicable narrative and numeric water quality objectives in the Central Valley Basin Plan (CVRWQCB, 2018), subsequent adopted amendments, the California Toxics Rule (USEPA 2000), and numeric interpretations of the Basin Plan narrative objectives. Observed exceedances of the ILRP Trigger Limits are the focus of this discussion.

Other relevant non-regulatory toxicity thresholds were also considered for the purpose of identifying potential causes of observed toxicity. It should be noted that these unadopted non-regulatory toxicity thresholds are not appropriate criteria for determining exceedances for the purpose of the Coalition's monitoring program and evaluating compliance with the ILRP. The additional toxicity thresholds were acquired from USEPA's Office of Pesticide Programs (OPP) Ecotoxicity database (USEPA 2019; online database updated regularly) and the International Union of Pure and Applied Chemistry Pesticide Properties Database (IUPAC PPDB; online database updated regularly).

Water quality objectives and other relevant water quality thresholds discussed in this section are summarized in **Table 10** and **Table 11**. Monitored analytes without relevant water quality objectives or *ILRP* Trigger Limits are listed in **Table 12**.

The data evaluated for exceedances as described in this document include all Coalition collected results, as well as the compiled results from the subwatershed monitoring programs presented in this report where relevant water quality objectives exist. The results of these evaluations are discussed below.

Table 10. Adopted Basin Plan and California Toxics Rule Objectives for Analytes Monitored for 2019 Coalition Monitoring

Analyte	Most Stringent Objective[(1)]	Units	Objective Source[(2)]
Ammonia, Total as N	narrative	mg/L	Basin Plan
Arsenic, total	50	µg/L	CA 1˚ MCL
Atrazine	1	µg/L	CA 1˚ MCL
Cadmium, dissolved	Hardness-dependent[(3)]	µg/L	CTR
Chlorpyrifos	0.015	µg/L	Basin Plan
Copper, dissolved	Hardness-dependent[(3)]	µg/L	CTR
DDE (o,p' and p,p')	0.00059	µg/L	CTR
Diazinon	0.10	µg/L	Basin Plan
Dissolved Oxygen	5	mg/L	Basin Plan
Glyphosate	700	µg/L	CA 1˚ MCL
Malathion	0.1[(4)]	µg/L	Basin Plan
Nitrate, as N	10	mg/L	CA 1˚ MCL
pH	6.5-8.5	-log[H+]	Basin Plan
Pyrethroid Pesticides[5]	1 CGU	----	Basin Plan
Simazine	4	µg/L	CA 1˚ MCL
Temperature	narrative	µg/L	Basin Plan
Toxicity, Algae (*Hyalella*) Survival	narrative	µg/L	Basin Plan
Toxicity, Algae (*Selenastrum*) Cell Density	narrative	µg/L	Basin Plan
Toxicity, Water Flea (*Ceriodaphnia*) Survival	narrative	µg/L	Basin Plan
Turbidity	narrative	µg/L	Basin Plan

Notes:

1. For analytes with more than one limit, the most limiting applicable adopted water quality objective is listed.
2. *CA 1º MCLs* are California's Maximum Contaminant Levels for treated drinking water; *CTR* = California Toxics Rule criteria.
3. Objective varies with the hardness of the water.
4. These values are Basin Plan performance goals. The Basin Plan states: "…discharge is prohibited unless the discharger is following a management practice approved by the Board." This has been interpreted as an ILRP Trigger Limit of ND (Not Detected).
5. Pyrethroid pesticides considered in the 2017 Central Valley Pyrethroid Pesticides Total Maximum Daily Load and Basin Plan Amendment (Pyrethroid Pesticide BPA) include the following: Bifenthrin, Cyfluthrin, Cypermethrin, Esfenvalerate, Lambda-Cyhalothrin, and Permethrin. The ILRP Trigger Limit for the additive concentration of these six pyrethroid pesticides was compared to Coalition water quality results beginning in April 2019.

Table 11. Unadopted Water Quality Limits Used to Interpret Narrative Water Quality Objectives for Analytes Monitored for 2019 Coalition Monitoring

Analyte	Unadopted Limit(1)	Units	Limit Source
Boron, total	700	µg/L	Ayers and Westcott 1988
Specific Conductivity	700	µS/cm	Ayers and Westcott 1988
Specific Conductivity	900	µS/cm	CA Recommended 2˚ MCL
E. coli (1)	235	MPN/100mL	Basin Plan Amendment
Total Dissolved Solids	500	mg/L	CA Recommended 2˚ MCL
Total Dissolved Solids	450	mg/L	Ayers and Westcott 1988
Azinphos methyl	0.01	µg/L	USEPA NAWQC(2)
Carbaryl	2.53	µg/L	USEPA NAWQC
Dichlorvos	0.085	µg/L	Cal/EPA Cancer Potency Factor
Dimethoate	1	µg/L	CDPH Notification Level(3)
Diuron	2	µg/L	USEPA Health Advisory
Linuron	1.4	µg/L	USEPA IRIS Reference Dose
Methidathion	0.7	µg/L	USEPA IRIS Reference Dose
Methiocarb	0.5	µg/L	USFW Acute Toxicity
Methomyl	0.52	µg/L	USEPA NAWQC
Paraquat	3.2	µg/L	USEPA IRIS Reference Dose
Phorate	0.7	µg/L	NAS Health Advisory
Trifluralin	5	µg/L	USEPA IRIS Cancer Risk Level
Zinc	1000	µg/L	CA Recommended 2˚ MCL

Note:

1. Adopted by the Regional Water Board but not approved by the State Water Resources Control Board.
2. USEPA National Ambient Water Quality Criteria.
3. Notification levels (formerly called "action levels") are published by the California Department of Public Health (CDPH) for chemicals for which there is no drinking water MCL.

Table 12. Analytes Monitored for 2019 Coalition Monitoring without Applicable Adopted or Unadopted Limits

Analytes		
% Solids	Dissolved Organic Carbon	Phosphorus as P, Total
Acetamiprid	Dodine	Prometryn
Allethrin	Ethalfluralin	Propiconazole
Chloropicrin	Fenpropathrin	Pyraclostrobin
Chlorothalonil	Hardness as CaCO3	Pyrethroid Pesticides[1]
Clothianidin	Hexazinone	Pyridaben
Cyprodinil	Imidacloprid	Tau-Fluvalinate
Deltamethrin	Orthophosphate, as P	Tetramethrin
Dichlorophenoxyacetic Acid, 2,4-	Oryzalin	Total Organic Carbon
Discharge (flow)	Oxyfluorfen	Total Suspended Solids
Dissolved Organic Carbon	Pendimethalin	

1. Pyrethroid pesticides considered in the 2017 Central Valley Pyrethroid Pesticides Total Maximum Daily Load and Basin Plan Amendment (Pyrethroid Pesticide BPA) include the following: Bifenthrin, Cyfluthrin, Cypermethrin, Esfenvalerate, Lambda-Cyhalothrin, and Permethrin. The ILRP did not require comparison to the Trigger Limit prior to April 2019.

TOXICITY AND PESTICIDE RESULTS

A summary of the toxicity and pesticide results from 2019 Coalition monitoring is provided in this section.

Toxicity Exceedances in Coalition Monitoring

There were 281individual toxicity results (including 27 field duplicates) analyzed in water column and sediment samples collected from 15 different sites during 2019 Coalition monitoring. Analyses were conducted for *Selenastrum capricornutum, Ceriodaphnia dubia,* and *Hyalella azteca*. Statistically significant toxicity to *Selenastrum capricornutum* was observed in one water column sample collected from the Willow Slough Bypass site, analyzed by Pacific EcoRisk (PER). Two sediment samples exhibited statistically significant toxicity to *Hyalella azteca*. Significant toxicity to *Hyalella azteca* was observed in samples from Ulatis Creek in April 2019 and Walker Creek in August 2019. Both of the samples exhibited toxicity that exceeded the 20% effect threshold recommended by SWAMP to evaluate toxicity in sediment[9]. Samples exhibiting statistically significant sediment and water column toxicity are summarized in **Table 13**.

Table 13. Toxicity Exceedances in 2019 Coalition Monitoring

Matrix	Site ID	Water Body	Sample Date	Analyte	% of Control
Water Column Toxicity	WLSPL	Willow Slough Bypass	1/9/2019	*Selenastrum capricornutum cell growth*	50.5
Sediment Toxicity	UCBRD	Ulatis Creek	4/18/2019	*Hyalella azteca* survival	64.6
Sediment Toxicity	WLKCH	Walker Creek	8/22/2019	*Hyalella azteca* survival	62.3

Significantly toxic results and any follow-up evaluations or testing conducted on these samples are summarized below by event.

Event 155, January 9, 2019 – Willow Slough Bypass at Pole Line, *Selenastrum capricornutum* toxicity

In a water column toxicity test conducted with *Selenastrum*, the Coalition observed reductions in cell density of 53% compared to the control used for the Willow Slough Bypass sample. In the water column sample, oxyfluorfen was detected at a concentration of 0.36 µg/L, which is above the United States EPA (2017) Aquatic Life Benchmark and Ecological Risk Assessments for Registered Pesticides of 0.29 µg/L.

Event 158, April 18, 2019 – Ulatis Creek at Brown Road, Hyalella toxicity

In a sediment toxicity test conducted with *Hyalella*, the Coalition observed survival of 64.6% compared to the control used for the Ulatis Creek sample. The toxicity observed in the sample

[9] Regional Water Board approval letter for completion of the Cosumnes River Hyalella toxicity Management Plan (January 22, 2015).

(≥20% reduction compared to the control) triggered follow-up sediment analyses for pyrethroid and organophosphate (chlorpyrifos) pesticides. Two pesticides were detected in the sample: bifenthrin (2.5 ng/g dry weight (dw)) and lambda-cyhalothrin (3.6 ng/g dw). A total of 1.164 toxic units (TU) of agricultural use pyrethroids were estimated to likely have contributed to the toxicity observed at the Ulatis Creek monitoring site, with bifenthrin and lambda-cyhalothrin concentrations contributing approximately 38% and 62%, respectively, to the estimated TU. The TU was estimated based on published LC50 values for pyrethroids and chlorpyrifos in sediment[10], normalized for organic carbon concentrations. A TU of 1 or greater suggests that the pesticide concentrations detected in the sediment sample are sufficient to cause toxicity to *Hyalella*.

Event 162, August 22, 2019 – Walker Creek near 99W and CR33, Hyalella toxicity

In a sediment toxicity test conducted with *Hyalella*, the Coalition observed survival of 62.3% compared to the control used for the Walker Creek sample. The toxicity observed in the sample (≥20% reduction compared to the control) triggered follow-up sediment analyses for pyrethroid and organophosphate (chlorpyrifos) pesticides. All pesticides analyzed in the sediment were found to be non-detect.

Pesticides Detected in Coalition Monitoring

There were 1,772 individual pesticide results (including 237 field duplicates) analyzed in 202 water column samples collected from 18 different sites, including both Representative and Management Plan or Special Study sites during 2019 Coalition monitoring. Analyses were conducted for organophosphates, carbamates, organochlorines, insecticides, fungicides, pyrethroids, triazines, pyrethroids, and a variety of herbicides. Within these monitored pesticide categories, 20 different pesticides were detected out of a total of 159 total detected results (including 20 field duplicates). Overall, greater than 91% of all pesticide results were below detection for the 2019 Monitoring Year.

It should be noted that detections of pesticides are not equivalent to exceedances (with the exceptions of carbofuran, malathion, and methyl parathion which have prohibitions of discharge in the Basin Plan).

All pesticides detected in water column samples for 2019 Coalition monitoring are listed in **Table 14**. Pesticides were compared to relevant numeric and narrative water quality objectives, and to toxicity threshold concentrations published in USEPA's *ECOTOX* Database (USEPA 2019; online database updated regularly) and International Union of Pure and Applied Chemistry Pesticide Properties Database (IUPAC PPDB; online database updated regularly). One registered pesticide, malathion (one sample) and 12 pyrethroid pesticide samples exceeded applicable water quality objectives or ILRP Trigger Limits.

A discussion of these detections and exceedances follows below.

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[10] Weston, D.P., Jackson, C.J., 2009. Use of engineered enzymes to identify organo-phosphate and pyrethroid-related toxicity in toxicity identification evaluations. *Environ Sci Technol* 43, 5514-5520.

- The insecticide acetamiprid was detected in one sample collected at Freshwater Creek. There is currently no ILRP Trigger Limit or adopted water quality objective for acetamiprid.
- The insecticide clothianidin was detected in two environmental samples and one field duplicate at Willow Slough Bypass. There is currently no ILRP Trigger Limit or adopted water quality objective for clothianidin.
- The insecticide cyprodinil was detected in three environmental samples. There is currently no ILRP Trigger Limit or adopted water quality objective for cyprodinil.
- The herbicide diuron was detected in three samples collected at three sites: Grand Island Drain, Lower Snake River, and Walker Creek. No samples exceed the USEPA Health Advisory limit of 2 µg/L.
- The herbicide 2,4-dichlorophenoxyacetic acid was detected once at Willow Slough Bypass. There is currently no ILRP Trigger Limit or adopted water quality objective for herbicide 2,4-dichlorophenoxyacetic acid.
- The herbicide ethalfluralin was detected in one sample each collected at Pine Creek, Sacramento Slough, and Shag Slough, and one field duplicate collected at Willow Slough Bypass. There is currently no ILRP Trigger Limit or adopted water quality objective for ethalfluralin.
- The insecticide fenpropathrin was detected in one sample at Grand Island Drain and one sample at Ulatis Creek. There is currently no ILRP Trigger Limit or adopted water quality objective for fenpropathrin
- The herbicide glyphosate was detected in three samples: one at Lower Snake River and two at Pine Creek. None of the samples exceeded the California Maximum Contaminant Level of 700 µg/L.
- The insecticide imidacloprid was detected in 24 samples (and four field duplicates) collected at eight sites, including three samples collected at Lower Snake River. There is currently no ILRP Trigger Limit or adopted water quality objective for imidacloprid.
- The insecticide malathion was detected with a concentration of 0.04 µg/L at Pit River. Detection of malathion is an exceedance of the Basin Plan discharge prohibition. There were six reported applications of malathion in the month prior to the exceedance. Malathion was applied to approximately 170 acres of alfalfa, 103 acres of wild rice, 100 acres of timothy grass, and 32 acres of strawberries in the Pit River drainage during that time. All of the wild rice applications were made aerially, while the other crops were applied by ground methods. Toxicity tests were not performed during this event.
- The herbicide oxyfluorfen was detected in 12 samples (and one field duplicate), including three samples each collected at Ulatis Creek and Willow Slough Bypass. There is currently no *ILRP* Trigger Limit or adopted water quality objective for oxyfluorfen.
- The fungicide propiconazole was detected in two samples: one collected at Lower Snake River and one at Walker Creek. There is currently no ILRP Trigger Limit or adopted water quality objective for propiconazole.

- The fungicide pyraclostrobin was detected in one sample at Walker Creek. There is currently no ILRP Trigger Limit or adopted water quality objective for pyraclostrobin
- The insecticide tetramethrin was detected in two samples: one collected at Grand Island Drain and one at Willow Slough Bypass. There is currently no ILRP Trigger Limit or adopted water quality objective for tetramethrin.

The Central Valley Regional Water Quality Control Board's *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Pyrethroid Pesticide Discharges* in Resolution R5-2017-0057[11] (Pyrethroid Pesticide Basin Plan Amendment (BPA)) establishes measurable pyrethroid concentration goals. The pyrethroid pesticide numeric trigger is evaluated through calculation of additive acute and chronic concentration goal units (CGUs). Both calculations consider measured concentrations of six individual pyrethroid pesticides: bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, lambda-cyhalothrin, and permethrin. While the additive concentration calculations for the acute and chronic analyses differ, both have ILRP Trigger Limits of 1 CGU; more specifically, 1 CGUa for the acute Trigger Limit and 1 CGUc for chronic Trigger Limit). Pyrethroid concentrations measured between the MDL and QL, and assigned a DNQ (Detected, Not Quantified) qualification by the Coalition, are not considered in the additive concentration calculations. All six of the pyrethroid pesticides that were detected in water column samples for 2019 Coalition monitoring are listed in **Table 14** and discussed below.

- Bifenthrin was detected in 49 environmental samples and six field duplicate samples at a total of 13 different monitoring sites.
- Cyfluthrin was detected in two environmental samples at two sites.
- Cypermethrin was detected in three environmental samples and one field duplicate at three monitoring sites.
- Esfenvalerate was detected in 11 environmental samples at a total of six monitoring sites.
- Lambda-cyhalothrin was detected in 24 environmental samples and four field duplicates samples at a total of 11 monitoring sites.
- Permethrin was detected in one environmental sample.

The Pyrethroid Pesticide BPA came into effect following its approval by the Office of Administrative Law (OAL) on February 19, 2019. The total maximum daily loads (TMDLs), established in the Pyrethroid Pesticide BPA, became effective as of April 22, 2019, with approval from the United States Environmental Protection Agency (USEPA). ILRP staff notified the Coalition that is must report exceedances of the acute and chronic pyrethroid pesticide numeric triggers beginning in April 2019. All exceedances observed from April 2019 through September 2019 are listed in **Table 15** and discussed below.

[11] Central Valley Regional Water Quality Control Board. *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Pyrethroid Pesticide Discharges.* Resolution R5-2017-0057. Adopted on June 2017. https://www.waterboards.ca.gov/rwqcb5/board_decisions/adopted_orders/resolutions/r5-2017-0057_res.pdf

- On May 21, 2019, the calculated chronic additive concentration (4 CGUc) of the detected pyrethroids measured in the sample collected from the Cosumnes River site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU. Bifenthrin was the only pyrethroid whose concentration (2 ng/L) was detected above the reporting limit and thus, contributed to this exceedance. There were six reported applications of bifenthrin in the month prior to the exceedance. Applications were made to almond (185 acres), walnut (60 acres), and outdoor plants (6 acres). The single walnut application was an aerial application of bifenthrin-containing product that occurred less than one week before the observed exceedance. Approximately 1.3" of rain fell on May 18-19.
- The Freshwater Creek site had a total of two exceedances of the Basin Plan Trigger Limit for pyrethroid pesticides:
    - On May 21, 2019, the calculated chronic additive concentration (10 CGUc) and acute additive concentration (5 CGUa) both exceeded the Basin Plan Chronic and Acute Trigger Limits of 1 CGU. Concentrations of cypermethrin (1.5 ng/L) and lambda-cyhalothrin (13 ng/L) were detected above the reporting limit and thus, contributed to this exceedance. There were no agriculture or non-agricultural applications of cypermethrin made during the six weeks prior to the observed exceedance. Lambda-cyhalothrin was applied in April and May 2019 on six occasions to sunflower on a total of 267 acres. Additionally, there were 70 aerial applications of lambda-cyhalothrin made to rice in the six weeks prior to the observed exceedance. One application occurred six hours prior to the monitoring event and six other applications were made within 24 hours preceding the event. Approximately 0.9" of rain fell on May 15 followed by over 1" on May 18-19.
    - On July 16, 2019, the calculated chronic additive concentration (2 CGUc) of the detected pyrethroids measured in the sample collected from the Freshwater Creek at Gibson Road site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU. Concentrations of bifenthrin and lambda-cyhalothrin (13 ng/L) were detected above the reporting limit and thus, contributed to this exceedance. There were 26 bifenthrin applications leading up to the July 16, 2019, exceedance. These applications were made to tomato (586 acres), almond (442 acres), cucumber (88 acres), and dried bean (20 acres). There were also nine lambda-cyhalothrin applications collectively made to sunflower (267 acres), almond (79 acres), and walnut (7 acres), and six applications made to rice (228 acres) leading up to the observed exceedance. There was no precipitation in the two weeks prior to the event.
- On May 22, 2019, the calculated chronic additive concentration (8 CGUc) of detected pyrethroids measured in the sample collected from the Coon Creek site exceeded the Basin Plan Chronic Trigger Limit of 1 GCU. Bifenthrin was the only pyrethroid whose concentration (7 ng/L) was detected above the reporting limit and thus, contributed to this exceedance. There were no reported agricultural applications of bifenthrin within the Middle Coon Creek Drainage in the month prior to the observed exceedance. Both Sutter and Placer counties reported many non-agricultural applications of bifenthrin in April and May.

- On May 22, 2019, the calculated chronic additive concentration (3 CGUc) of the detected pyrethroids measured in the sample collected from the Lower Snake River site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU. Lambda-cyhalothrin was the only pyrethroid whose concentration (3.8 ng/L) was detected above the reporting limit and thus, contributed to this exceedance. There were only three reported applications of lambda-cyhalothrin leading up to the May 21, 2019 exceedance. In mid-April, lambda-cyhalothrin was applied to 28 acres of alfalfa and in May there were two small applications to onion seed (2 acres) and prune (1.5 acres). Less than a gallon of total product was applied during these three applications. Additionally, there were 46 applications to rice (2,225 acres) in May leading up to the monitoring event. A total of approximately 65 gallons of lambda-cyhalothrin-containing product was used in these applications to rice. Approximately 2" of rain fell during May 15 – 19.
- The Walker Creek site had a total of two exceedances of the Basin Plan Trigger Limit for pyrethroid pesticides:
    - On May 22, 2019, the calculated chronic additive concentration (3 CGUc) of the detected pyrethroids measured in the sample collected from the Walker Creek site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU). Concentrations of bifenthrin (3.7 ng/L) and esfenvalerate (9.5 ng/L) were detected above the reporting limit and thus, contributed to this exceedance. There were four reported applications of bifenthrin in the month prior to the May 22, 2019, exceedance. All of these applications were made to pistachio, which totaled 234 acres. All of these applications were made greater than ten days prior to the monitoring event. There were no documented agricultural or non-agricultural applications of esfenvalerate in the month prior to the monitoring event. Approximately 0.9" of rain fell on May 15 followed by over 1" on May 18-19.
    - On July 17, 2019, the calculated chronic additive concentration (5 CGUc) and acute additive concentration (2 CGUa) both exceeded the Basin Plan Chronic and Acute Trigger Limits of 1 CGU. Concentrations of bifenthrin (1.5 ng/L) and lambda-cyhalothrin (10 ng/L) were detected above the reporting limit and thus, contributed to this exceedance. There were six reported applications of bifenthrin and nine applications of lambda-cyhalothrin in the month prior to the July 17, 2019, observed exceedance. The bifenthrin applications were made to almond (248 acres) and pistachio (110 acres), while lambda-cyhalothrin was applied to almond (815 acres). Additionally, there were 14 applications to rice (423 acres), with one of the applications (72 acres) occurring on the day of the observed exceedance. There was no precipitation measured in the two weeks prior to the event.
- On May 23, 2019, the calculated chronic additive concentration (8 CGUc) and acute additive concentration (3 CGUa) of detected pyrethroids in the sample collected from the Colusa Basin Drain site both exceeded the Basin Plan Chronic and Acute Basin Plan Trigger Limits of 1 CGU. Concentrations of bifenthrin (0.7 ng/L), cypermethrin (0.7 ng/L), and lambda-cyhalothrin (12 ng/L) were detected above their respective reporting limits and thus, contributed to this exceedance. There were only five bifenthrin applications leading up to the exceedance. With the exception of 75 acres of almonds

treated on May 13, 2109, all other applications were made on April 16 to parcels of 2.5-acres or less. Lambda-cyhalothrin was applied in April and May 2019 on six occasions to sunflower on a total of 267 acres. Additionally, there were 70 aerial applications of lambda-cyhalothrin made to rice in the six weeks prior to the monitoring event. One application to rice occurred in the six hours prior to the event and six other applications were made within 24 hours preceding the event. There were no agricultural or non-agricultural applications of cypermethrin in the six weeks prior to the observed exceedance. Approximately 0.9" of rain fell on May 15 followed by over 1" on May 18-19.

- The Pine Creek site had a total of three exceedances of the Basin Plan Trigger Limit for pyrethroid pesticides:
    - On July 17, 2019, the calculated chronic additive concentration (10 CGUc) and acute additive concentration (2 CGUa) of detected pyrethroids in the sample collected from the Pine Creek site both exceeded the Basin Plan Chronic and Acute Trigger Limits of 1 CGU. Concentrations of bifenthrin (2.6 ng/L) and cyfluthrin (15 ng/L) were detected above the reporting limit and thus, contributed to this exceedance. Bifenthrin applications we made to almond (949 acres) and walnut (772 acres). No cyfluthrin was reported as being applied to irrigated crops during this time period. There were non-agricultural applications of cyfluthrin for structural pest control made in both June and July 2017. There was no precipitation in the two weeks prior to the event.
    - On August 21, 2019, the calculated chronic additive concentration (3 CGUc) of the detected pyrethroids measured in the sample collected from the Pine Creek site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU. Bifenthrin was the only pyrethroid whose concentration (1.6 ng/L) was detected above the reporting limit and thus, contributed to this exceedance. Bifenthrin applications we made to almond (5051 acres), pistachio (227), and tomato (212 acres). There was no precipitation in the two weeks prior to the event.
    - On September 26, 2019, the calculated chronic additive concentration (2 CGUc) of the detected pyrethroids measured in the sample collected from the Pine Creek site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU. Bifenthrin was the only pyrethroid whose concentration (1.3 ng/L) was detected above the reporting limit and thus, contributed to this exceedance. Bifenthrin applications we made to almond (228 acres), pistachio (64), and walnut (1002 acres). Nine (9) aerial applications of bifenthrin were made to walnut the week prior to the exceedance. There was no precipitation in the two weeks prior to the event.
- On September 26, 2019, the calculated chronic additive concentration (2 CGUc) of the detected pyrethroids measured in the sample from collected from the Anderson Creek site exceeded the Basin Plan Chronic Trigger Limit of 1 CGU. Permethrin was the only pyrethroid whose concentration (110 ng/L) was detected above the reporting limit and thus, contributed to this exceedance. There were five reported permethrin applications to 170 acres of walnut within just over one week prior to the observed exceedance. The applications were made to parcels that were located upstream and adjacent to the

monitoring site, with four of the applications made within 48 hours of the observed exceedance. There was no precipitation in the two weeks prior to the event.

Table 14. Pesticides Detected in 2019 Coalition Monitoring

Site	Date	Analyte	Result(1) (ug/L)		Trigger Limit(2)	Basis for Limit(3)
FRSHC	7/16/2019	Acetamiprid	=	0.0622		
ACACR	9/26/2019	Bifenthrin	DNQ	0.1		
CCBRW	**5/22/2019**	**Bifenthrin**	**=**	**7**	**[5]**	
COLDR	1/8/2019	Bifenthrin	=	6.5		
COLDR	**5/23/2019**	**Bifenthrin**	**=**	**0.7**	**[5]**	
COLDR	**5/23/2019**	**Bifenthrin (4)**	**=**	**0.5**	**[5]**	
COLDR	8/22/2019	Bifenthrin	=	0.5		
CRTWN	**5/21/2019**	**Bifenthrin**	**=**	**2**	**[5]**	
CRTWN	7/16/2019	Bifenthrin	DNQ	0.1		
CRTWN	8/21/2019	Bifenthrin	DNQ	0.3		
FRSHC	1/9/2019	Bifenthrin	DNQ	0.3		
FRSHC	2/19/2019	Bifenthrin	=	0.6		
FRSHC	3/19/2019	Bifenthrin	DNQ	0.2		
FRSHC	4/18/2019	Bifenthrin	DNQ	0.3		
FRSHC	5/21/2019	Bifenthrin	DNQ	0.3		
FRSHC	**7/16/2019**	**Bifenthrin**	**=**	**1**	**[5]**	
FRSHC	8/21/2019	Bifenthrin	=	1		
FRSHC	8/21/2019	Bifenthrin (4)	=	0.5		
FRSHC	9/25/2019	Bifenthrin	DNQ	0.4		
GIDLR	3/19/2019	Bifenthrin	DNQ	0.2		
GIDLR	5/21/2019	Bifenthrin	DNQ	0.3		
GIDLR	7/16/2019	Bifenthrin	DNQ	0.3		
GIDLR	9/25/2019	Bifenthrin	DNQ	0.2		
LHNCT	12/18/2018	Bifenthrin	DNQ	0.2		
LHNCT	7/17/2019	Bifenthrin	DNQ	0.2		
LHNCT	9/26/2019	Bifenthrin	DNQ	0.2		
LSNKR	1/9/2019	Bifenthrin	=	2.1		
LSNKR	5/22/2019	Bifenthrin	DNQ	0.4		
LSNKR	7/17/2019	Bifenthrin	=	0.8		
LSNKR	8/22/2019	Bifenthrin	=	0.6		
PNCHY	1/9/2019	Bifenthrin	=	1		
PNCHY	4/17/2019	Bifenthrin	=	0.6		
PNCHY	4/17/2019	Bifenthrin (4)	DNQ	0.3		
PNCHY	5/22/2019	Bifenthrin	DNQ	0.3		
PNCHY	**7/17/2019**	**Bifenthrin**	**=**	**2.6**	**[5]**	
PNCHY	**8/21/2019**	**Bifenthrin**	**=**	**1.6**	**[5]**	

Site	Date	Analyte	Result(1) (ug/L)		Trigger Limit(2)	Basis for Limit(3)
PNCHY	**9/26/2019**	**Bifenthrin**	**=**	**1.3**	**[5]**	
PNCHY	**9/26/2019**	**Bifenthrin (4)**	**=**	**1.7**	**[5]**	
SSKNK	1/8/2019	Bifenthrin	DNQ	0.4		
SSKNK	5/23/2019	Bifenthrin	DNQ	0.2		
SSKNK	8/22/2019	Bifenthrin	=	0.7		
SSLIB	8/22/2019	Bifenthrin	DNQ	0.3		
UCBRD	10/16/2018	Bifenthrin (4)	DNQ	0.3		
UCBRD	2/19/2019	Bifenthrin	DNQ	0.2		
UCBRD	4/18/2019	Bifenthrin	=	2.5		
UCBRD	9/25/2019	Bifenthrin	DNQ	0.1		
WLKCH	3/20/2019	Bifenthrin	=	0.8		
WLKCH	4/17/2019	Bifenthrin	=	0.7		
WLKCH	**5/22/2019**	**Bifenthrin**	**=**	**3.7**	**[5]**	
WLKCH	**7/17/2019**	**Bifenthrin**	**=**	**3.4**	**[5]**	
WLKCH	8/22/2019	Bifenthrin	=	0.5		
WLKCH	9/26/2019	Bifenthrin	=	0.6		
WLSPL	6/18/2019	Bifenthrin	=	0.7		
WLSPL	6/18/2019	Bifenthrin (4)	=	0.6		
WLSPL	7/16/2019	Bifenthrin	DNQ	0.4		
WLSPL	8/22/2019	Bifenthrin	DNQ	0.4		
WLSPL	7/16/2019	Clothianidin	DNQ	0.0187		
WLSPL	7/16/2019	Clothianidin	DNQ	0.0107		
WLSPL	7/16/2019	Clothianidin (4)	=	0.037		
GIDLR	8/21/2019	Cyfluthrin	=	0.9		
PNCHY	**7/17/2019**	**Cyfluthrin**	**=**	**15**	**[5]**	
CCBRW	3/19/2019	Cypermethrin	DNQ	0.2		
COLDR	**5/23/2019**	**Cypermethrin**	**=**	**0.7**	**[5]**	
COLDR	**5/23/2019**	**Cypermethrin (4)**	**=**	**0.6**	**[5]**	
FRSHC	**5/21/2019**	**Cypermethrin**	**=**	**1.5**	**[5]**	
LSNKR	3/20/2019	Cyprodinil	DNQ	0.008		
WLKCH	2/20/2019	Cyprodinil	DNQ	0.017		
WLKCH	3/20/2019	Cyprodinil	=	0.06		
WLSPL	3/19/2019	Dichlorophenoxyacetic Acid, 2,4-	=	1.6		
GIDLR	2/19/2019	Diuron	DNQ	0.22	2	USEPA Health Advisory
LSNKR	1/9/2019	Diuron	DNQ	0.24	2	USEPA Health Advisory
WLKCH	2/20/2019	Diuron	DNQ	0.32	2	USEPA Health Advisory
COLDR	1/8/2019	Esfenvalerate/Fenvalerate	DNQ	0.7		
LHNCT	12/18/2018	Esfenvalerate/Fenvalerate	DNQ	0.2		
LHNCT	1/9/2019	Esfenvalerate/Fenvalerate	DNQ	0.4		
LHNCT	6/19/2019	Esfenvalerate/Fenvalerate	=	1.2		

Site	Date	Analyte	Result(1) (ug/L)		Trigger Limit(2)	Basis for Limit(3)
LSNKR	1/9/2019	Esfenvalerate/Fenvalerate	=	8		
PNCHY	1/9/2019	Esfenvalerate/Fenvalerate	DNQ	0.4		
PNCHY	5/22/2019	Esfenvalerate/Fenvalerate	DNQ	0.3		
PNCHY	7/17/2019	Esfenvalerate/Fenvalerate	DNQ	0.7		
SSKNK	1/8/2019	Esfenvalerate/Fenvalerate	DNQ	0.6		
WLKCH	5/22/2019	Esfenvalerate/Fenvalerate	=	9.5		
WLKCH	7/17/2019	Esfenvalerate/Fenvalerate	DNQ	0.3		
PNCHY	6/19/2019	Ethalfluralin	DNQ	0.0066		
SSKNK	1/8/2019	Ethalfluralin	DNQ	0.0083		
SSLIB	1/9/2019	Ethalfluralin	DNQ	0.0056		
WLSPL	4/16/2019	Ethalfluralin (4)	DNQ	0.0038		
GIDLR	5/21/2019	Fenpropathrin	DNQ	0.4		
UCBRD	2/19/2019	Fenpropathrin	DNQ	0.2		
UCBRD	2/19/2019	Fenpropathrin (4)	DNQ	0.2		
LSNKR	7/17/2019	Glyphosate	DNQ	4.1	700	1˚ MCL
PNCHY	7/17/2019	Glyphosate	=	27	700	1˚ MCL
PNCHY	7/17/2019	Glyphosate (4)	=	13	700	1˚ MCL
ACACR	4/17/2019	Imidacloprid	=	0.00698		
COLDR	1/8/2019	Imidacloprid	=	0.0457		
COLDR	1/8/2019	Imidacloprid (4)	=	0.0106		
FRSHC	1/9/2019	Imidacloprid	=	0.042		
GIDLR	11/23/2018	Imidacloprid	=	0.0141		
GIDLR	5/21/2019	Imidacloprid	DNQ	0.00377		
LHNCT	6/19/2019	Imidacloprid	=	0.0156		
LSNKR	4/17/2019	Imidacloprid	=	0.00569		
LSNKR	6/19/2019	Imidacloprid	=	0.0355		
LSNKR	6/19/2019	Imidacloprid	=	0.0294		
LSNKR	6/19/2019	Imidacloprid (4)	=	0.0256		
SSKNK	5/23/2019	Imidacloprid	=	0.00542		
SSKNK	5/23/2019	Imidacloprid	=	0.00581		
SSKNK	5/23/2019	Imidacloprid (4)	=	0.00606		
WLKCH	8/22/2019	Imidacloprid	=	0.141		
WLKCH	8/22/2019	Imidacloprid	=	0.126		
WLKCH	8/22/2019	Imidacloprid (4)	=	0.119		
CCBRW	5/22/2019	Lambda-Cyhalothrin	DNQ	0.2		
COLDR	1/8/2019	Lambda-Cyhalothrin	DNQ	0.3		
COLDR	**5/23/2019**	**Lambda-Cyhalothrin**	**=**	**12**	**[5]**	
COLDR	**5/23/2019**	**Lambda-Cyhalothrin (4)**	**=**	**8.8**	**[5]**	
FRSHC	5/21/2019	Lambda-Cyhalothrin	=	13		
FRSHC	6/18/2019	Lambda-Cyhalothrin	=	1.1		

Site	Date	Analyte	Result(1) (ug/L)		Trigger Limit(2)	Basis for Limit(3)
FRSHC	**7/16/2019**	**Lambda-Cyhalothrin**	**=**	**0.5**	**[5]**	
GIDLR	5/21/2019	Lambda-Cyhalothrin	DNQ	0.3		
GIDLR	8/21/2019	Lambda-Cyhalothrin	=	0.5		
LHNCT	5/22/2019	Lambda-Cyhalothrin	DNQ	0.3		
LHNCT	6/19/2019	Lambda-Cyhalothrin	DNQ	0.4		
LHNCT	7/17/2019	Lambda-Cyhalothrin	=	1.3		
LHNCT	7/17/2019	Lambda-Cyhalothrin (4)	=	1.4		
LHNCT	8/22/2019	Lambda-Cyhalothrin	DNQ	0.2		
LSNKR	1/9/2019	Lambda-Cyhalothrin	DNQ	0.3		
LSNKR	**5/22/2019**	**Lambda-Cyhalothrin**	**=**	**3.8**	**[5]**	
LSNKR	6/19/2019	Lambda-Cyhalothrin	DNQ	0.3		
LSNKR	7/17/2019	Lambda-Cyhalothrin	DNQ	0.2		
PNCHY	7/17/2019	Lambda-Cyhalothrin	DNQ	0.4		
SSKNK	1/8/2019	Lambda-Cyhalothrin	DNQ	0.3		
SSKNK	5/23/2019	Lambda-Cyhalothrin	=	1.4		
UCBRD	10/16/2018	Lambda-Cyhalothrin (4)	DNQ	0.2		
UCBRD	3/19/2019	Lambda-Cyhalothrin	=	2.7		
UCBRD	4/18/2019	Lambda-Cyhalothrin	=	3.6		
WLKCH	**5/22/2019**	**Lambda-Cyhalothrin**	**DNQ**	**0.3**	**[5]**	
WLKCH	**7/17/2019**	**Lambda-Cyhalothrin**	**=**	**10**	**[5]**	
WLSPL	6/18/2019	Lambda-Cyhalothrin	=	0.9		
WLSPL	6/18/2019	Lambda-Cyhalothrin (4)	=	0.9		
PRPIT	**5/22/2019**	**Malathion**	**DNQ**	**0.04**	**0.1**	**BPA**
COLDR	1/8/2019	Oxyfluorfen	=	0.059		
FRSHC	12/18/2018	Oxyfluorfen	DNQ	0.011		
LSNKR	1/9/2019	Oxyfluorfen	DNQ	0.029		
SSKNK	1/8/2019	Oxyfluorfen	DNQ	0.0098		
UCBRD	11/23/2018	Oxyfluorfen	DNQ	0.02		
UCBRD	1/8/2019	Oxyfluorfen	=	0.095		
UCBRD	1/8/2019	Oxyfluorfen (4)	=	0.12		
UCBRD	5/21/2019	Oxyfluorfen	DNQ	0.049		
WLKCH	12/19/2018	Oxyfluorfen	DNQ	0.043		
WLKCH	1/9/2019	Oxyfluorfen	=	0.92		
WLSPL	11/23/2018	Oxyfluorfen	=	0.16		
WLSPL	1/9/2019	Oxyfluorfen	=	0.36		
WLSPL	2/19/2019	Oxyfluorfen	=	0.082		
ACACR	**9/26/2019**	**Permethrin**	**=**	**110**	**[5]**	
LSNKR	3/20/2019	Propiconazole	=	0.03		
WLKCH	2/20/2019	Propiconazole	=	0.13		
WLKCH	6/19/2019	Propiconazole	=	0.35		

Site	Date	Analyte	Result[1] (ug/L)		Trigger Limit[2]	Basis for Limit[3]
WLKCH	3/20/2019	Pyraclostrobin	=	0.071		
GIDLR	3/19/2019	Tetramethrin	=	22		
WLSPL	8/22/2019	Tetramethrin	=	1		

BOLD = Exceedance

1. "DNQ" (Detected Not Quantified) indicates that the detected value was less than the quantitation or reporting limit (QL).
2. Water Quality Objective or Narrative Interpretation Limits for ILRP. "NA" if no ILRP limit established.
3. Water Quality Objective Basis: BP = Central Valley Basin Plan; BPA = Basin Plan Amendment; Cal/EPA = Cal/EPA Cancer Potency Factor; CDPH Notification Level = Notification levels (formerly called "action levels") are published by the California Department of Public Health (CDPH) for chemicals for which there is no drinking water MCL;
   CTR = California Toxics Rule; Narrative = unadopted limits used to interpret Basin Plan narrative objectives by the Central Valley Water Board; USEPA Health Advisory = Drinking water health advisory.
4. Sample was collected as a field duplicate.
5. This pyrethroid pesticide contributed to the exceedance of a chronic and/or acute trigger limit included in the Pyrethroid Pesticide BPA. The ILRP Trigger Limit for the additive concentration of six pyrethroid pesticides was compared to Coalition water quality results beginning in April 2019.

Table 15: Pyrethroid Pesticides Exceedances in 2019 Monitoring

Site	Date[1]	Detected Pyrethroids	Chronic Additive Concentration (CGUc)	Acute Additive Concentration (CGUa)	Chronic & Acute Trigger Limit (CGU)	Basis for Limit
CRTWN	5/21/2019	Bifenthrin	4	0	1	Basin Plan
FRSHC	5/21/2019	Cypermethrin, Lambda-Cyhalothrin	10	5	1	Basin Plan
CCBRW	5/22/2019	Bifenthrin	8	0	1	Basin Plan
LSNKR	5/22/2019	Lambda-Cyhalothrin	3	0	1	Basin Plan
WLKCH	5/22/2019	Bifenthrin, Esfenvalerate	3	0	1	Basin Plan
COLDR	5/23/2019	Bifenthrin, Cypermethrin, Lambda-Cyhalothrin	8	3	1	Basin Plan
FRSHC	7/16/2019	Bifenthrin, Lambda-Cyhalothrin	2	0	1	Basin Plan
PNCHY	7/17/2019	Bifenthrin, Cyfluthrin	10	2	1	Basin Plan
WLKCH	7/17/2019	Bifenthrin, Lambda-Cyhalothrin	5	2	1	Basin Plan
PNCHY	8/21/2019	Bifenthrin	3	0	1	Basin Plan
ACACR	9/26/2019	Permethrin	10	2	1	Basin Plan
PNCHY	9/26/2019	Bifenthrin	2	0	1	Basin Plan

1. Exceedances are assessed for the 2019 monitoring year beginning with the monitoring event in April 2019.

OTHER COALITION-MONITORED WATER QUALITY PARAMETERS

Exceedances of adopted Basin Plan objectives, CTR criteria, or ILRP Trigger Limits were observed for specific conductivity, dissolved oxygen, *E. coli*, pH, and trace metals during 2019 Coalition Monitoring (see **Table 16**).

Specific Conductivity

Specific conductivity was monitored in 153 samples from 22 Coalition sites. Specific conductivity exceeded the unadopted UN Agricultural Goal (700 µS/cm) in a total of 16 samples and also exceeded the California recommended 2˚ MCL (900 µS/cm) for drinking water in eight of the 16 samples. Exceedances were observed at five sites.

Dissolved Oxygen

During 2019 Coalition monitoring, dissolved oxygen was measured in 156 samples at 22 Coalition sites. A total of 12 samples exceeded the COLD Basin Plan limit with measured dissolved oxygen concentrations below 7.0 mg/L for waterbodies with a COLD designated beneficial use.

Dissolved oxygen exceedances are generally caused primarily by low flows, stagnant conditions, or extensive submerged aquatic vegetation in some cases. The low flows and stagnant conditions have the potential to increase diurnal variability or limit oxygen production by in-stream algae and also to trap organic particulates that contribute to in-stream oxygen consumption.

E. coli Bacteria

E. coli bacteria were analyzed in 140 environmental samples and 12 field duplicates from 18 Coalition sites. *E. coli* results exceeded the single sample maximum objective (235 MPN/100mL) in 45 samples (including three field duplicates) from 12 Coalition monitoring locations.

The Basin Plan objectives are intended to protect contact recreational uses where ingestion of water is probable (e.g., swimming). Agricultural lands commonly support a large variety (and very large numbers seasonally) of birds and other wildlife. These avian and wildlife resources are known to be significant sources of *E. coli* and other bacteria in agricultural runoff and irrigation return flows. Other potential sources of *E. coli* include, but are not limited to, cattle, horses, septic systems, treated wastewater, and urban runoff.

pH

During 2019 Coalition monitoring, pH was measured in 153 samples from 22 Coalition sites. pH exceeded the Basin Plan maximum of 8.5 standard pH units (-log[H+]) in 10 samples collected from six sites and fell below the Basin Plan minimum of 6.5 pH units (-log[H+]) in five samples from three sites.

The Basin Plan limit for pH is intended to be assessed based on "…*an appropriate averaging period that will support beneficial uses*" (CVRWQCB 2018). This parameter typically exhibits significant natural diurnal variation over 24 hours in natural waters, with daily fluctuations controlled principally by photosynthesis, rates of respiration, and buffering capacity of the water. These processes are controlled by light and nutrient availability, concentrations of organic matter, and temperature. These factors combine to cause increasing pH during daylight hours and decreasing pH at night. Diurnal variations in winter are typically smaller because less light is available and there are lower temperatures and higher flows. Irrigation return flows may influence this variation primarily by increasing or decreasing in-stream temperatures or by increasing available nutrients or organic matter.

The reason for these pH exceedances was not immediately obvious nor easily determined. In most cases, the marginal pH exceedances were likely due primarily to in-stream algal and/or vascular plant respiration, caused in part by low flows or ponded and stagnant conditions and temperatures sufficient to stimulate algal growth.

Trace Metals

Trace metals monitored during 2019 Coalition monitoring included the collection and analysis of both unfiltered metals (total arsenic, boron, copper, and zinc) and filtered metals (dissolved copper and dissolved zinc).

Total trace metals were monitored in 55 environmental samples and 14 field duplicate samples from 15 Coalition sites, and dissolved metals were monitored in 40 environmental samples and seven field duplicate samples from 15 Coalition sites.

Arsenic

Eleven total arsenic environmental samples and nine field duplicate samples were collected from two Coalition sites. Three environmental samples and three field duplicate samples from the monitoring site at Grand Island Drain exceeded the California 1° MCL of 10 µg/L.

There are both legacy and a few current sources of arsenic in the Sacramento River Watershed. There is very little remaining agricultural use of arsenic-based pesticide products (based on a review of DPR's PUR data), and arsenic has only a few potentially significant sources: (1) natural background from arsenic in the soils, (2) arsenic remaining from legacy lead arsenate use in orchards, (3) arsenic used in various landscape maintenance and structural pest control applications (non-agriculture), and (4) arsenic used in wood preservatives. One possible source is the wooden bridge structure located just upstream of the Grand Island Drain sampling site, if arsenic-based preservatives were used on the wood. A final, but somewhat unlikely source is an arsenic-based additive that may still be used for chicken feed[12] and which can potentially make its way through the chicken and into agricultural fields and runoff if the poultry litter is used on the field.

Boron

Four total boron environmental samples and four field duplicate samples were collected from one Coalition site, Willow Slough Bypass at Pole Line. Four of the eight total boron samples, two environmental samples and two field duplicate samples, exceeded the ILRP Trigger Limit of 700 µg/L, based on Ayers and Westcott (1985).

Boron is a naturally-occurring mineral that is not applied by agriculture, but it is elevated in some irrigation supplies (especially those sourced in part or entirely from groundwater) and soils,

[12] http://water.usgs.gov/owq/AFO/proceedings/afo/pdf/Wershaw.pdf

and concentrations may be elevated through consumptive use of irrigation water. It is known to be naturally elevated in the groundwater and major tributaries supplying irrigation water in the Willow Slough drainage.

Table 16. Other Physical, Chemical, and Microbiological Parameters Observed to Exceed Numeric Objectives in 2019 Coalition Monitoring

Sample Date	Analyte	Unit	Result	Trigger Limit[1]	Basis for Limit[2]	Management Plan [3]
10/16/2018	Arsenic	µg/L	11	10	1˚ MCL [5]	Active
10/16/2018	Arsenic	µg/L	11	10	1˚ MCL [5]	Active
12/18/2018	Arsenic	µg/L	13	10	1˚ MCL [5]	Active
12/18/2018	Arsenic	µg/L	13	10	1˚ MCL [5]	Active
4/16/2019	Arsenic	µg/L	11	10	1˚ MCL [5]	Active
4/16/2019	Arsenic	µg/L	11	10	1˚ MCL [5]	Active
3/19/2019	Boron	µg/L	1500	700	Narrative	Active
3/19/2019	Boron	µg/L	1500	700	Narrative	Active
4/16/2019	Boron	µg/L	1600	700	Narrative	Active
4/16/2019	Boron	µg/L	1600	700	Narrative	Active
10/17/2018	Dissolved Oxygen	mg/L	5.1	7	BP [SSO COLD]	Active
7/17/2019	Dissolved Oxygen	mg/L	6.5	7	BP [SSO COLD]	Active
7/16/2019	Dissolved Oxygen	mg/L	4.5	7	BP [SSO COLD]	Active
8/21/2019	Dissolved Oxygen	mg/L	5.21	7	BP [SSO COLD]	Active
8/22/2019	Dissolved Oxygen	mg/L	5.09	7	BP [SSO COLD]	Active
8/21/2019	Dissolved Oxygen	mg/L	3.9	7	BP [SSO COLD]	Active
8/22/2019	Dissolved Oxygen	mg/L	4.11	7	BP [SSO COLD]	Active
8/22/2019	Dissolved Oxygen	mg/L	3.02	7	BP [SSO COLD]	Active
8/22/2019	Dissolved Oxygen	mg/L	5.51	7	BP [SSO COLD]	Active
9/25/2019	Dissolved Oxygen	mg/L	3.97	7	BP [SSO COLD]	Active
9/25/2019	Dissolved Oxygen	mg/L	4.7	7	BP [SSO COLD]	Active
9/26/2019	Dissolved Oxygen	mg/L	6.51	7	BP [SSO COLD]	Active
11/24/2018	E. coli	MPN/100mL	260.3	235	BP	Suspended
11/23/2018	E. coli	MPN/100mL	980.4	235	BP	Suspended
11/23/2018	E. coli	MPN/100mL	2419.6	235	BP	Suspended
11/24/2018	E. coli	MPN/100mL	920.8	235	BP	Suspended
12/18/2018	E. coli	MPN/100mL	1011.2	235	BP	Suspended
12/18/2018	E. coli	MPN/100mL	691	235	BP	Suspended
12/19/2018	E. coli	MPN/100mL	1046.2	235	BP	Suspended
12/19/2018	E. coli	MPN/100mL	1299.7	235	BP	Suspended
12/18/2018	E. coli	MPN/100mL	437.4	235	BP	Suspended
12/19/2018	E. coli	MPN/100mL	866.4	235	BP	Suspended
1/8/2019	E. coli	MPN/100mL	1299.7	235	BP	Suspended

Sample Date	Analyte	Unit	Result	Trigger Limit(1)	Basis for Limit(2)	Management Plan (3)
1/8/2019	E. coli	MPN/100mL	1986.3	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	307.6	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	866.4	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	2419.6	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	1553.1	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	727	235	BP	Suspended
1/8/2019	E. coli	MPN/100mL	2419.6	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	524.7	235	BP	Suspended
1/9/2019	E. coli	MPN/100mL	2419.6	235	BP	Suspended
2/19/2019	E. coli	MPN/100mL	517.2	235	BP	Suspended
3/20/2019	E. coli	MPN/100mL	365.4	235	BP	Suspended
4/18/2019	E. coli	MPN/100mL	285.1	235	BP	Suspended
4/16/2019	E. coli	MPN/100mL	272.3	235	BP	Suspended
5/22/2019	E. coli	MPN/100mL	579.4	235	BP	Suspended
5/22/2019	E. coli	MPN/100mL	272.3	235	BP	Suspended
5/21/2019	E. coli	MPN/100mL	686.7	235	BP	Suspended
5/22/2019	E. coli	MPN/100mL	410.6	235	BP	Suspended
5/22/2019	E. coli	MPN/100mL	547.5	235	BP	Suspended
5/22/2019	E. coli	MPN/100mL	816.4	235	BP	Suspended
5/21/2019	E. coli	MPN/100mL	387.3	235	BP	Suspended
6/19/2019	E. coli	MPN/100mL	727	235	BP	Suspended
6/18/2019	E. coli	MPN/100mL	866.4	235	BP	Suspended
6/18/2019	E. coli	MPN/100mL	2419.6	235	BP	Suspended
6/19/2019	E. coli	MPN/100mL	2419.6	235	BP	Suspended
7/17/2019	E. coli	MPN/100mL	770.1	235	BP	Suspended
7/16/2019	E. coli	MPN/100mL	344.8	235	BP	Suspended
7/31/2019	E. coli	MPN/100mL	326	235	BP	Suspended
7/17/2019	E. coli	MPN/100mL	261.3	235	BP	Suspended
8/21/2019	E. coli	MPN/100mL	1046.2	235	BP	Suspended
8/22/2019	E. coli	MPN/100mL	365.4	235	BP	Suspended
8/22/2019	E. coli	MPN/100mL	248.9	235	BP	Suspended
9/25/2019	E. coli	MPN/100mL	313	235	BP	Suspended
9/26/2019	E. coli	MPN/100mL	285.1	235	BP	Suspended
9/25/2019	E. coli	MPN/100mL	435.2	235	BP	Suspended
12/18/2018	pH	-log[H+]	6.44	6.5-8.5	BP	Active

Sample Date	Analyte	Unit	Result	Trigger Limit[1]	Basis for Limit[2]	Management Plan [3]
1/8/2019	pH	-log[H+]	6.43	6.5-8.5	BP	Active
2/19/2019	pH	-log[H+]	6.39	6.5-8.5	BP	Active
4/30/2019	pH	-log[H+]	6.15	6.5-8.5	BP	Active
4/23/2019	pH	-log[H+]	8.7	6.5-8.5	BP	Active
4/18/2019	pH	-log[H+]	8.54	6.5-8.5	BP	Active
5/22/2019	pH	-log[H+]	5.8	6.5-8.5	BP	Active
6/28/2019	pH	-log[H+]	9.17	6.5-8.5	BP	Active
7/23/2019	pH	-log[H+]	9.69	6.5-8.5	BP	Active
8/22/2019	pH	-log[H+]	8.89	6.5-8.5	BP	Active
10/16/2018	Specific Conductivity	µS/cm	992	700, 900 [4]	Narrative	Active
1/8/2019	Specific Conductivity	µS/cm	862	700, 900 [4]	Narrative	Active
2/19/2019	Specific Conductivity	µS/cm	838	700, 900 [4]	Narrative	Active
2/19/2019	Specific Conductivity	µS/cm	1508	700, 900 [4]	Narrative	Active
3/19/2019	Specific Conductivity	µS/cm	869	700, 900 [4]	Narrative	Active
3/19/2019	Specific Conductivity	µS/cm	1048	700, 900 [4]	Narrative	Active
3/19/2019	Specific Conductivity	µS/cm	829	700, 900 [4]	Narrative	Active
3/19/2019	Specific Conductivity	µS/cm	905	700, 900 [4]	Narrative	Active
4/16/2019	Specific Conductivity	µS/cm	1001	700, 900 [4]	Narrative	Active
4/18/2019	Specific Conductivity	µS/cm	713	700, 900 [4]	Narrative	Active
4/18/2019	Specific Conductivity	µS/cm	720	700, 900 [4]	Narrative	Active
4/18/2019	Specific Conductivity	µS/cm	767	700, 900 [4]	Narrative	Active
6/18/2019	Specific Conductivity	µS/cm	1186	700, 900 [4]	Narrative	Active
7/16/2019	Specific Conductivity	µS/cm	1071	700, 900 [4]	Narrative	Active
8/21/2019	Specific Conductivity	µS/cm	869	700, 900 [4]	Narrative	Active
9/25/2019	Specific Conductivity	µS/cm	941	700, 900 [4]	Narrative	Active

Notes:

1. Water Quality Objective or Narrative Interpretation Limits for ILRP.
2. Water Quality Objective Basis: BP = Central Valley Basin Plan; BPA = Basin Plan Amendment; CTR = California Toxics Rule; Narrative = unadopted limits used to interpret Basin Plan narrative objectives by the Central Valley Water Board.
3. Indicates whether sites and parameter are currently being addressed by an ongoing Management Plan, study, or TMDL.
4. Specific conductivity exceeded the unadopted United Nations Agricultural Goal (700 µS/cm), the California recommend 2º MCL (900 µS/cm) for drinking water, and/or the Site-Specific Objective 90th percentile limit (150 µS/cm).

Trend Analysis

As part of the evaluation of monitoring results, the WDR requires the Coalition to conduct trend analyses to…

"… identify potential trends[13] and patterns in surface and groundwater quality that may be associated with waste discharge from irrigated lands. As part of this evaluation, the third-party must analyze all readily available monitoring data that meet program quality assurance requirements to determine deficiencies in monitoring for discharges from irrigated agricultural lands and whether additional sampling locations or sampling events are needed or if additional constituents should be monitored. If deficiencies are identified, the third-party must propose a schedule for additional monitoring or source studies. … The third-party should incorporate pesticide use information, as needed, to assist in its data evaluation."

As part of the 2018 AMR, the Coalition conducted the trend analysis for all representative monitoring sites, as well as all pesticides that were detected with ≥5% detection[14]. From this dataset, it was determined that the sites and constituents shown in **Table 17** had potential to degrade water quality.

Table 17. Significant Trends from 2018 Trend Analysis

Category	Analyte	Site Name
Physical	Conductivity	Anderson Creek at Ash Creek Road
		Colusa Basin Drain above KL
		Pit River at Pittville
		Sacramento Slough bridge near Karnak
		Ulatis Creek at Brown Road
		Willow Slough Bypass at Pole Line
	Dissolved Oxygen	Middle Creek u/s from Highway 20
		Coon Creek at Brewer Road
	pH	Anderson Creek at Ash Creek Road
		Colusa Basin Drain above KL
		Lower Snake R. at Nuestro Rd
		Pine Creek at Highway 32
		Willow Slough Bypass at Pole Line
	Total Organic Carbon	Walker Creek near 99W and CR33
Nutrients	Ammonia, Total as N	Cosumnes River at Twin Cities Rd
		Sacramento Slough near Karnak
	Orthophosphate, as P	Ulatis Creek at Brown Road

13 "All results (regardless of whether exceedances are observed) must be included to determine whether there are trends in degradation that may threaten applicable beneficial uses."

14 Pesticides with lower than 5% detection rates were considered to have insufficient detected data to reliably identify trends.

Category	Analyte	Site Name
Pesticides	Simazine	Grand Island Drain
Trace Metals	Arsenic	Lower Snake River at Nuestro Road
	Boron	Willow Slough Bypass at Pole Line
Toxicity	Selenastrum growth	Anderson Creek at Ash Creek Road

Beginning in 2015, the Coalition proposed a prioritized approach that would focus on reanalyzing the higher priority trends from the most recent trend analysis. This approach was approved by the Regional Water Board for the second year of an Assessment Monitoring period and for non-Assessment years. 2019 was the second year of an Assessment period, so the trend analysis included here followed the prioritized approach. The modified trend assessment for 2019 reanalyzed the following:

- High priority pesticides with historically high detection rates
    - Chlorpyrifos
    - Diazinon
    - Diuron
- Sites with active Management Plans for *Ceriodaphnia* and *Selenastrum*
- Nutrient data for the 2018 sites that were listed in the "potential degradation subsection"

Pyrethroid pesticides were excluded from the current trend analysis due to their small dataset relative to those of other pesticides that have been monitored by the Coalition for years. Pyrethroids will be included in the Coalition's trend analysis after it completes the Pyrethroid Control Program's Baseline Monitoring during the 2021 Monitoring Year that is required under the Pyrethroid Pesticide BPA.

The methods used to analyze and evaluate the data for the trend analysis were as follows:

- Data were initially evaluated using Spearman's non-parametric test for trends (concentrations vs. sample date). A table of the initial Spearman's test results are provided in **Appendix G**.
    - Data below detection were coded as "0" for initial non-parametric Spearman's evaluation
    - Data were analyzed separately for each site for all parameters
    - The threshold for statistical significance was set at $p<0.05$
- Significant preliminary results ($p<0.05$) were screened for potential degradation impacts
    - Increasing trends in pesticides, metals, nutrients, pathogen indicators
    - Decreasing trends in toxicity survival or growth results
    - The subset of the initial Spearman's test results with potential degradation impacts are provided in **Appendix G**.
- Parameters with potential degradation trend indicators were plotted (concentration vs. date) for further evaluation (plots are provided in **Appendix G**.)

  - Data below detection were plotted at the detection limit
  - Data were reviewed for potential outliers
  - Linear, log-linear, or robust trend lines were plotted to illustrate trends (the selected method was based on visual inspection and best professional judgment)
  - Plots were evaluated for other (non-trend) patterns

A determination of the significance of a potential water quality degradation trend was based on the likelihood of a continuing trend and the likelihood of adverse impacts on beneficial uses. Evaluations of beneficial use impacts were based on a continued increasing probability of exceedances of trigger limits. These determinations are provided in **Appendix G**, and significant findings are discussed below.

Pesticide use data were evaluated during the process used to develop the 2019 Monitoring Plan Update, as required by the WDR, MRP, and PEP, and no additional evaluations of pesticide use data were conducted for this AMR. The results of the PEP analysis conducted in summer 2018 were incorporated into the 2019 Monitoring Plan Update that was approved by the Regional Water Board.

DISCUSSION OF RESULTS

The Coalition's 2019 Monitoring Plan Update was approved by Regional Water Board staff as meeting the requirements of the WDR, MRP, and PEP. The WDR provides no additional guidance or criteria for making a determination if there are "deficiencies in monitoring" or if additional locations or events need to be included in an annual monitoring schedule, and no deficiencies were identified as a result of the trend analysis conducted for this report.

Summary of initial Spearman's test results

- 63 site-parameter combinations were evaluated
- 33 results were not significant ($p \geq 0.05$)
- 17 results were not significant due to insufficient detected data
- 13 results were initially determined to have potentially significant trends ($p<0.05$)
  - 10 significant results were identified for trends with no potential negative impacts (i.e., they indicated potentially improving water quality)
  - Three initially significant results were identified as suggesting potential water quality degradation with potential negative impacts on beneficial uses and were further evaluated
- The three results (5% of the beginning number of evaluations) were evaluated as trend plots and were determined to have significant increasing or decreasing trends suggesting potential water quality degradation (**Table 18**) and were evaluated further.

Table 18. Significant Trends Further Evaluated for Potential Water Quality Degradation

Category	Analyte	Site Name
Nutrients	Ammonia, Total as N	Cosumnes River at Twin Cities Rd
		Sacramento Slough near Karnak
Pesticides	Chlorpyrifos	Gilsizer Slough

Total ammonia as nitrogen (N) exhibited a significant increasing trend in samples from Cosumnes River (**Figure 4-a**) and Sacramento Slough (**Figure 4-b**). Neither trend appears to indicate a continuing long-term trend in ammonia as N concentrations and there were no exceedances of the ILRP Trigger Limit for the nutrient[15]. Additional monitoring events or locations are not necessary.

Chlorpyrifos concentrations at Gilsizer Slough were elevated above the average for the site between 2014 and 2015 due to four exceedances of the WQO for chlorpyrifos (**Figure 4-c**), which triggered a Management Plan in 2015. An additional exceedance occurred in August 2018, but all samples analyzed in the 2019 Monitoring Year were below detection for the pesticide. Risk of degradation and need for tracking are addressed by the Management Plan and ongoing monitoring.

In summary, the results of trend analyses conducted for this AMR did not indicate a need for the monitoring of any additional locations, events, or parameters. We continue to recommend that the trend analysis evaluation be performed no more than once per Assessment Monitoring period, with the next evaluation occurring in the 2022 Monitoring Year. By that monitoring year, two to three years of additional assessment monitoring will have been conducted under the Pesticides Evaluation Protocol, which will increase the amount of data evaluated and the robustness of the analysis.

[15] Ammonia as N concentrations measured in Coalition water quality samples are compared to criteria promulgated in the 2013 USEPA final Aquatic Life Ambient Water Quality Criteria for Ammonia – Freshwater.

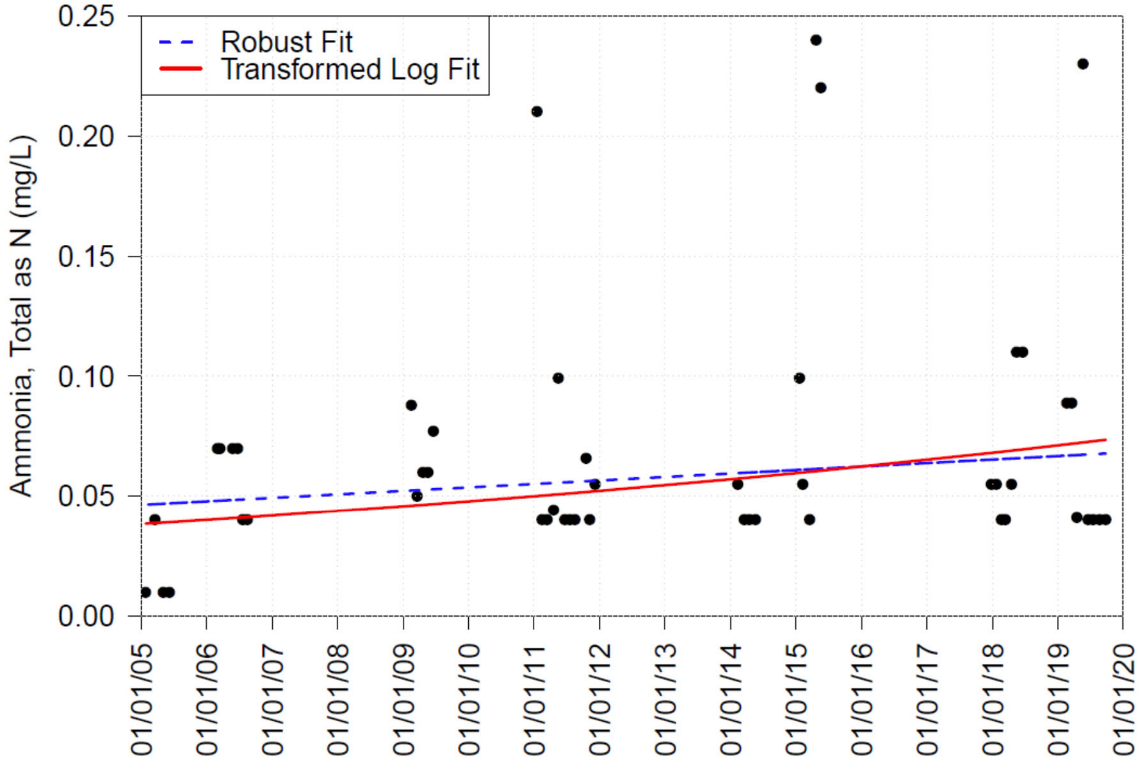

Figure 4-a. Ammonia, Total as N, Cosumnes River at Twin Cities Road

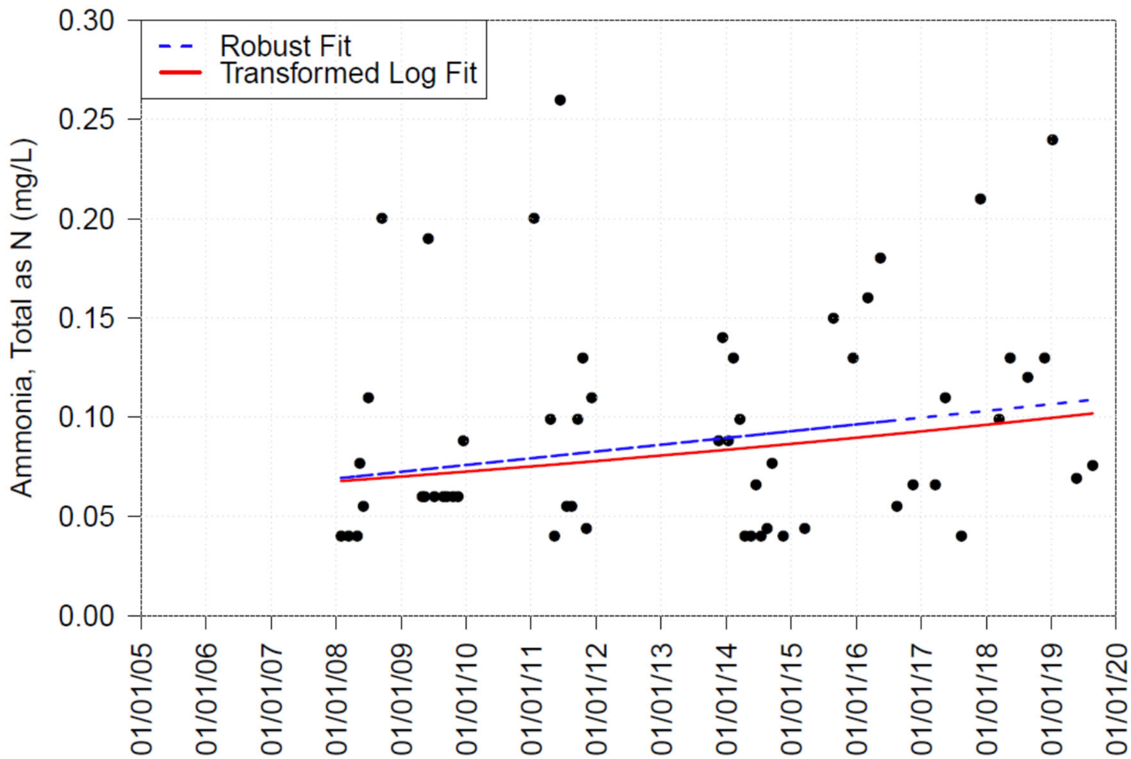

Figure 4-b. Ammonia, Total as N, Sacramento Slough Bridge near Karnak

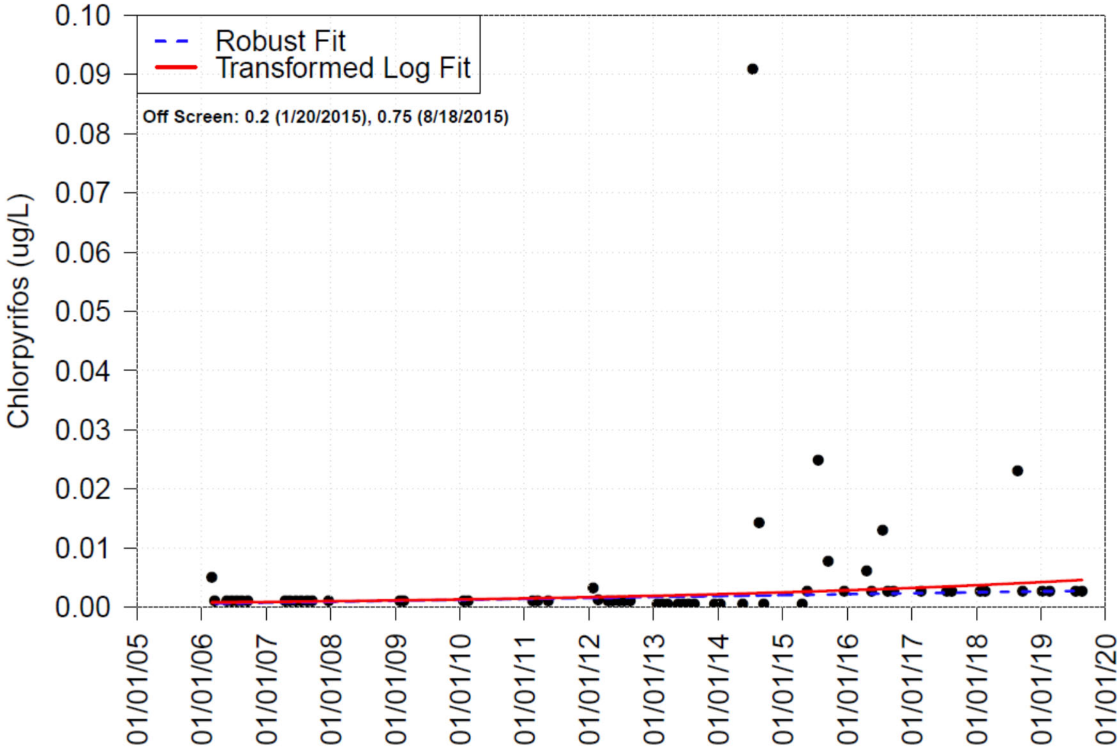

Figure 4-c. Chlorpyrifos at Gilsizer Slough

Management Practices and Actions Taken

RESPONSE TO EXCEEDANCES

To address specific water quality exceedances, the Coalition and its partners initially developed a Management Plan in 2009, subsequently approved by the Regional Water Board. The Coalition also previously developed a *Landowner Outreach and Management Practices Implementation Communications Process for Monitoring Results (Management Practices Process)* to address exceedances. The 2009 Management Plan was reorganized into the Comprehensive Surface Water Quality Management Plan (CSQMP) in 2015. The CSQMP was last updated in September 2016 and approved by the Regional Water Board in November 2016. Implementation of the CSQMP[16] is the primary mechanism for addressing exceedances observed in the Coalition's surface water monitoring.

Management Plan Status Update

The Management Plan Progress Report (MPPR), documenting the status and progress toward meeting individual Management Plan element requirements for 2019, is provided to the Regional Water Board with this AMR. Activities conducted in 2019 to implement the Coalition's CSQMP included addressing exceedances of objectives for registered pesticides, development of a new Management Plan, evaluation of existing Management Plan elements that could be deemed complete, and monitoring required for toxicity and pesticide Management Plans and TMDLs.

Implementation completed specifically for registered pesticides and toxicity included review and evaluation of pesticide application data, identification of potential sources, and determination of likely agricultural sources. Prior to 2015, surveys of Coalition members operating on high priority parcels were conducted to determine the degree of implementation of relevant management practices related to individual Management Plan elements for registered pesticides and identified causes of toxicity. Beginning in 2015, these surveys were replaced with data compiled from Coalition Member Farm Evaluations. Farm Evaluation data have been used to establish goals for additional management practice implementation needed to address exceedances of Basin Plan water quality objectives and ILRP Trigger Limits.

LANDOWNER OUTREACH EFFORTS

The Coalition and its subwatersheds, working with the Coalition for Urban/Rural Environmental Stewardship (CURES), stand committed to working with the Regional Water Board and its staff to implement the *Management Practices Process* and the Coalition's CSQMP to address water quality problems identified in the Sacramento Valley. The primary strategic approach taken by the Coalition is to notify and educate the subwatershed landowners, farm operators, and/or wetland managers about the cause(s) of toxicity and/or exceedance(s) of water quality objectives. Notifications are focused on (but not limited to) growers who operate directly adjacent to or within close proximity to a receiving water. The broader outreach program, which includes both grower meetings and notifications distributed through direct mailings, encourages the adoption

[16] *SVWQC Comprehensive Surface Water Quality Management Plan. Prepared for the Sacramento Valley Water Quality Coalition (SVWQC) by Larry Walker Associates, Davis, California. November 2016.*

of best management practices (BMPs) and modification of the uses of specific farm and wetland inputs to prevent movement of constituents of concern into Sacramento Valley surface waters.

Targeted Outreach Efforts

The Coalition's targeted outreach approach is to focus on the growers with fields directly adjacent to or near the actual waterway of concern where statistically significant toxicity and/or exceedances of applicable numeric water quality objectives and ILRP Trigger Limits have been observed. To identify those landowners operating in high priority lands, the Coalition identifies the assessor parcels and subsequently, the owners of agricultural operations nearest the water bodies of interest. From the list of assessor parcel numbers, a subwatershed identifies its members and provides them an advisory notice along with information on how to address a specific exceedance using BMPs. This same approach was also used to conduct management practice surveys in areas targeted by individual Management Plan elements.

General Outreach Efforts

Outreach efforts conducted by the Coalition and its partners for specific subwatersheds during the monitoring period are summarized in an Excel table for each subwatershed in **Appendix F**. Available outreach materials are also included as attachments in **Appendix F**.

Summary of Farm Evaluation Data

Starting in 2014, the WDR required that the Coalition to collect and aggregate summarized information from Farm Evaluations. In 2018, the Regional Water Board revised the reporting schedule and the Coalition was not required to conduct a Farm Evaluation for the 2018 or 2019 crop years. Farm Evaluations will now be submitted on a five-year cycle beginning with the 2020 Crop Year.

Conclusions and Recommendations

The Coalition submits this 2019 Annual Monitoring Report (AMR) as required under the Regional Water Board's Irrigated Lands Regulatory Program (ILRP). The AMR provides a detailed description of the Coalition's monitoring results as part of its ongoing efforts to characterize irrigated agricultural and wetlands related water quality in the Sacramento River Basin.

To summarize, the results from the Coalition monitoring conducted in 2019 continue to indicate that with few exceptions, there are no major water quality problems with agricultural and managed wetlands discharges in the Sacramento River Basin.

This AMR characterizes potential water quality impacts of agricultural drainage from a broad geographic area in the Sacramento Valley from October 2018 through September 2019. To date, a total of 163 Coalition storm and irrigation season events have been completed since the beginning of Coalition monitoring in January 2005, with additional events collected by coordinating programs and for follow-up evaluations. For the period of record considered in this AMR (October 2018 through September 2019), samples were collected for ten scheduled monthly events and 2 wet weather ("storm") events.

Pesticides were infrequently detected (~10% of all pesticide results for 2019 were detected), and when detected, rarely exceeded applicable water quality objectives. One sample for the registered pesticide malathion and twelve pyrethroid pesticide samples exceeded applicable water quality objectives or ILRP Trigger Limits during the 2019 Monitoring Year.

Many of the pesticides specifically required to be monitored in the past by the ILRP have rarely been detected in Coalition water samples, including glyphosate and paraquat. Over 98.2% of all pesticide analyses performed to date for the Coalition have been below detection. Coalition monitoring of pesticides for the 2019 Monitoring Year was conducted based on the 2016 Pesticides Evaluation Protocol (PEP) and active Management Plan element requirements. The Regional Water Board's PEP requires the Coalition to monitor specific registered pesticides based on (1) their rate of application in a given drainage (lbs. applied per drainage) and (2) a pesticide-specific relative risk (the ratio of the amount of chemical applied to a reference value with a specific averaging period). The Coalition also conducted monitoring of the ILRP-required trace elements (arsenic, boron, copper, and zinc) informed by the Coalition's past monitoring results, which have demonstrated that most of these metals rarely approach or exceed objectives and are not likely to cause adverse impacts to aquatic life or human health in waters receiving agricultural runoff in the Sacramento River Watershed. This strategy for monitoring trace metals was implemented in 2010 in accordance with the Coalition's 2009 MRP (*Order No. R5-2009-0875*, CVRWQCB 2009), and this same strategy is consistent with the requirements of the current WDR and MRP (*Order No. R5-2014-0030*).

The majority of exceedances of adopted numeric objectives continue to consist of specific conductivity, dissolved oxygen, pH, and *E. coli*. Agricultural runoff and irrigation return flows may contribute to exceedances of these objectives, but these parameters are primarily controlled or significantly affected by natural processes and sources that are not controllable by agricultural management practices.

The Coalition has implemented the requirements of the ILRP since 2004. The Coalition developed a Watershed Evaluation Report (WER) that set the priorities for development and implementation of the initial Monitoring and Reporting Program Plan (MRPP). The Coalition successfully developed the MRPP, QAPP, and Management Plan as required by the ILRP*,* and all were approved by the Regional Water Board. Subsequent revisions requested by the Regional Water Board and the Coalition were incorporated into the Coalition's program and implemented through the Coalition's ongoing ILRP monitoring efforts. The Coalition also continues to adapt and improve elements of its monitoring program based on the knowledge gained through its monitoring efforts.

The Coalition's 2019 monitoring program, as specified in the 2019 Monitoring Plan Update, was developed to be consistent with the requirements of the WDR and MRP (*Order No. R5-2014-0030*) and 2016 PEP, and was approved by the Regional Water Board for this purpose with the understanding that it would serve as an "Assessment" monitoring period for the Coalition. The Coalition has implemented the approved monitoring program in coordination with its subwatershed partners, has initiated follow-up activities required to address observed exceedances, and continued to implement the approved 2016 CSQMP and approved individual Management Plan elements. Throughout this process, the Coalition has kept an open line of communication with the Regional Water Board and has made every effort to fulfill the requirements of the ILRP in a cost-effective, scientifically defensible, and management-focused manner. This AMR is documentation of the success and continued progress of the Coalition in achieving these objectives.

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Appendices

The following appendices are available in electronic form on the CD provided.

Appendix A: Field Log Copies

Appendix B: Lab Reports and Chains-of-Custody

Appendix C: Tabulated Monitoring Results

Appendix D: Exceedance Reports

Appendix E: Site-Specific Drainage Maps

Appendix F: SVWQC Outreach Materials

Appendix G: Trend Analysis Results

Appendix H: Reduced Monitoring Verification Reports