

# GLENN-COLUSA IRRIGATION DISTRICT OVERVIEW

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## **Background**

The Glenn-Colusa Irrigation District (GCID) appropriative water rights began on the Sacramento River with an 1883 filing posted on a tree by Will S. Green, surveyor, newspaperman, public official, and pioneer irrigator. His first claim was for 500,000 miner's inches under 4 inches of pressure and was one of the earliest and largest water rights on the Sacramento River.

GCID was 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 disastrous rice crop failure of 1920–21 nearly destroyed the district at its inception, and the Great Depression took a further toll, making it necessary for the district to refinance in the 1930s. Additionally, the United States purchased lands within GCID during this period which would later become three federal refuges totaling approximately 20,000 acres.

Today, after surviving many challenges, GCID is the largest district in the Sacramento Valley. Located approximately eighty miles north of Sacramento, California, the district boundaries cover approximately 175,000 acres; of which 153,000 acres are deeded property and 138,800 are irrigable. There are 1,076 landowners in the District and an additional 300 tenant water users. There are an additional 5,000 acres of private habitat land, and winter water supplied by GCID to thousands of acres of rice land provides valuable habitat for migrating waterfowl during the winter months.

GCID's main pump station, its only diversion from the Sacramento River, is located near Hamilton City. The District's 65-mile long Main Canal conveys water into a complex system of nearly 1,000 miles of canals, laterals and drains, much of it constructed in the early 1900s. The District headquarters are located in Willows, the county seat of Glenn County, approximately 90 miles north of Sacramento on Interstate 5.

A five-member board of directors, who represent five subdivisions within the District, governs the District. The annual budget is \$15 million. GCID's mission is to provide reliable, affordable water supplies to its landowners and water users, while ensuring the environmental and economic viability of the region.

## **Water Supply**

From its first diversions until 1964, GCID relied upon its historic water rights and adequate water supply from the Sacramento River hydrologic system which receives rainfall and snowmelt from a 27,246 square mile watershed with average runoff of 22,389,000 acre-feet, providing nearly one-third of the state's total natural runoff. In 1964, after nearly two decades of negotiations with the United States, GCID along with

other Sacramento River water rights diverters entered into "Settlement Water Contracts" with the Bureau of Reclamation (Bureau). These Settlement Contracts were necessary at that time to allow the Bureau to construct, operate, and divert water for the newly constructed Central Valley Project. The contract provided GCID with water supply for the months of April through October for 720,000 acre-feet of base supply, and 105,000 acre-feet of Central Valley Project water that is purchased during the months of July and August. During a designated critical year when natural inflow to Shasta Reservoir is less than 3.2 million acre-feet, GCID's total supply is reduced by 25%, to a total of 618,000 acre-feet.

Additionally, the District has rights under a State Water Resources Control Board (SWRCB) permit to "winter water" from November 1 through March 31 at a 1,200 cubic feet per second (cfs) diversion rate. This water supply is used for rice straw decomposition and waterfowl habitat. The permit provides 150,000 acre-feet for rice straw decomposition and 32,900 acre-feet for crop consumption.

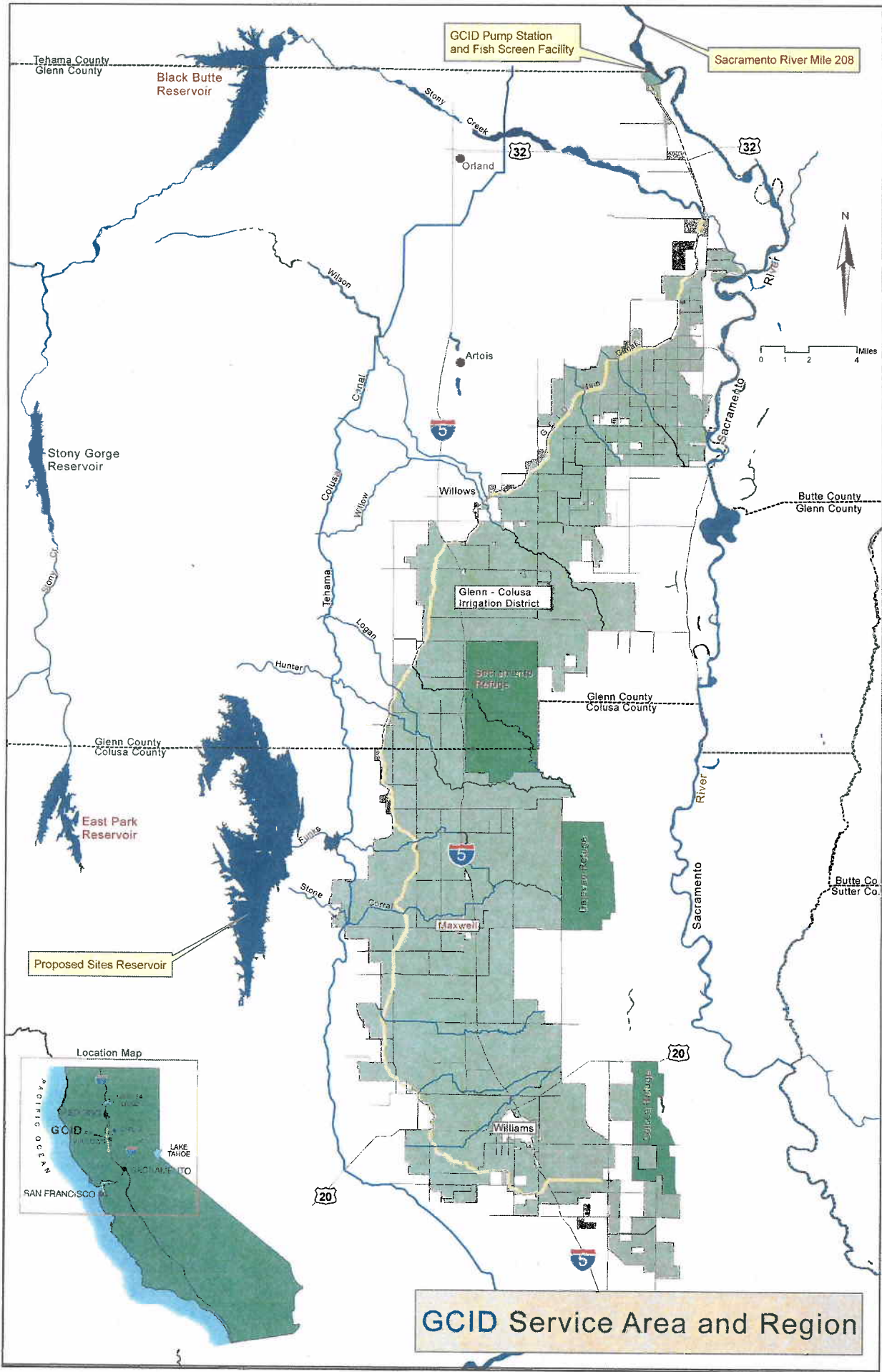
Groundwater can be used to supplement GCID's supplies, with 5,000 acre-feet available from District wells, and approximately 45,000 acre-feet from privately owned landowner wells.

### **Fish Screen Improvement Project**

A major challenge in sustaining this important agricultural area has been the completion of the Fish Screen Improvement Project to resolve the fish passage problems past GCID's main diversion facility on the Sacramento River near Hamilton City. Because GCID is one of the largest diverters of Sacramento River water, its pumping operations were previously identified as a significant impediment to downstream migration of juvenile salmon.

A cooperative effort, involving GCID, the California Department of Fish and Game, the U.S. Bureau of Reclamation, the U.S. Army Corps of Engineers (COE), the California Department of Water Resources, the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service resulted in the identification of a preferred alternative that received extensive environmental review. The selection of the preferred alternative led to the construction of a state-of-the-art fish screening facility at GCID's Hamilton City pump station.

The GCID Fish Screen Improvement Project is comprised of two major elements, the fish screen extension and the gradient facility in the Sacramento River. Construction began in 1998 and was essentially completed in 2001. GCID has been working with the COE for nearly a decade to resolve construction and design issues connected with the gradient facility. The approximately \$75 million project was 75% federally funded and the remaining 25% local cost-share was split equally between GCID and the State of California. The final solution to the fish passage problem constituted a major element in the restoration plans for the anadromous fisheries in the Central Valley by both the U.S. Fish and Wildlife Service and the California Department of Fish and Game.



GCID Pump Station and Fish Screen Facility

Sacramento River Mile 208

Tehama County  
Glenn County

Black Butte Reservoir

Stony Gorge Reservoir

Glenn County  
Colusa County

East Park Reservoir

Proposed Sites Reservoir



GCID Service Area and Region



# SACRAMENTO RIVER SETTLEMENT CONTRACTORS OVERVIEW

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## **Background**

The Sacramento River Settlement (SRS) Contractors are various irrigation districts, reclamation districts, mutual water companies, partnerships, corporations, and individuals situated in the Sacramento Valley, and formed under the provisions of California law. Among the Bureau's hundreds of Central Valley Project (CVP) water supply contracts, the SRS Contracts have a unique history and nature. The SRS Contractors divert water from the Sacramento River, miles upstream from the Bay-Delta and the boundaries of the delta habitat. They divert water under water rights that were vested under California law well before the construction of the CVP began.

Cumulatively, the senior water rights held by all of the SRS Contractors entitle them to a significant portion of the water (approximately 2.2 million acre-feet per year) available for appropriation in the Sacramento River, particularly during the irrigation season (April through October).

The SRS Contractors own and operate their own diversion facilities, and their water rights are not dependent in any way upon the operations or facilities of the CVP. The SRS Contractors originally entered into 40-year water rights settlement contracts with the Bureau in 1964, and their contracts are unlike any other contractor's. The purpose of the original SRS Contracts was to recognize the SRS Contractors' pre-existing rights, and to facilitate the Bureau's operation of the CVP by specifying the timing of the SRS Contractors' diversions. This facilitated the Bureau's ability to schedule its releases and deliveries of CVP water. In exchange, the SRS Contractors received greater certainty as to their water supplies during the summer months in certain year types. Without the original SRS Contracts, and the renewals which were completed in 2005, the SRS Contractors would revert to diverting water under their pre-existing water rights, and the Bureau's ability to operate the CVP would be severely compromised. In addition, this would likely lead to a decades-long water rights adjudication of the Sacramento River Basin.

The Sacramento River is a critical source of water for California, and the increasing needs of a growing state are placing increased demands on the river. Since 1944, the flow of the river has been managed to a significant degree using the facilities of the CVP, a system of reservoirs and conveyance facilities that helps to deliver the river's water to users both within and outside the Sacramento River Basin. Much has changed since the original SRS Contracts were executed in 1964, and proper future management of the Sacramento River Basin's water requires a thorough understanding of the system's condition; the needs of the users, including environmental resources; and the management options available.



## **Historical and Institutional Context**

Irrigation in California began during the time of Spanish expansion, when ditches were built to irrigate small crop areas near the missions. In the mid-1800s, settlers from the East also realized the importance of irrigation, and the practice slowly increased through the remainder of the 19th century. Ditches used for hydraulic mining were tapped for irrigating small farm plots, primarily in the foothills and mountain valleys. Larger scale irrigation in the Sacramento Valley began to increase significantly around 1910. With the dramatic increase in the demand for foodstuffs associated with World War I, a substantial increase in rice production caused a corresponding and rapid increase in Sacramento Valley irrigation beginning around 1916. According to state engineer reports, approximately 80,000 acres were irrigated in the Sacramento Valley in 1879. By 1910, this had nearly tripled to 220,000 acres. During the following 10 years, acreage more than doubled again, rising to just over 500,000 acres in 1920. Although irrigation slowed somewhat during the years immediately following the war, the practice of irrigation continued to grow in the Sacramento Valley during the following years; and in 1930, approximately 540,000 acres were irrigated. With additional water made available by the CVP (described below), irrigation in the Sacramento Valley has continued to expand.

## **Central Valley Project**

Concurrent with the rise in irrigation in the Sacramento Valley, the need for water in the less water-rich San Joaquin Valley to the south increased in the early 1900s. In response, water managers in the state began to look for projects that would allow surplus water from the Sacramento River to be exported to the San Joaquin Valley. They hoped to reduce groundwater overdraft and provide additional water during the critical summer months for irrigation in the Sacramento Valley. In 1933, the state legislature adopted the Central Valley Project Act to accomplish these objectives. In addition to providing water for expanded irrigation, the CVP was to provide flood protection, provide water for municipal and industrial (M&I) use, generate power, protect against saltwater intrusion, and provide recreation. At the state's urging, the federal government undertook the construction and operation of the CVP under the reclamation program. Construction of Shasta Dam, the first major unit of the CVP, began in 1938 on the upper Sacramento River north of Redding. It was completed and operating by the 1944 irrigation season.

## **SRS Contracts Negotiation**

Prior to construction of the CVP, water right holders along the Sacramento River included pre-1914 holders, riparian holders, and holders of post-1914 State Water Resources Control Board (SWRCB) appropriative rights. Construction of Shasta Dam required that California, Reclamation, and the Sacramento Water Users negotiate the rights to water in the Sacramento River, both its natural summer flows and the additional flows made available by the CVP. These efforts included a series of congressional hearings and cooperative studies, and culminated in the eventual signing and "settlement" of contracts with many of the more than 250 Sacramento River water

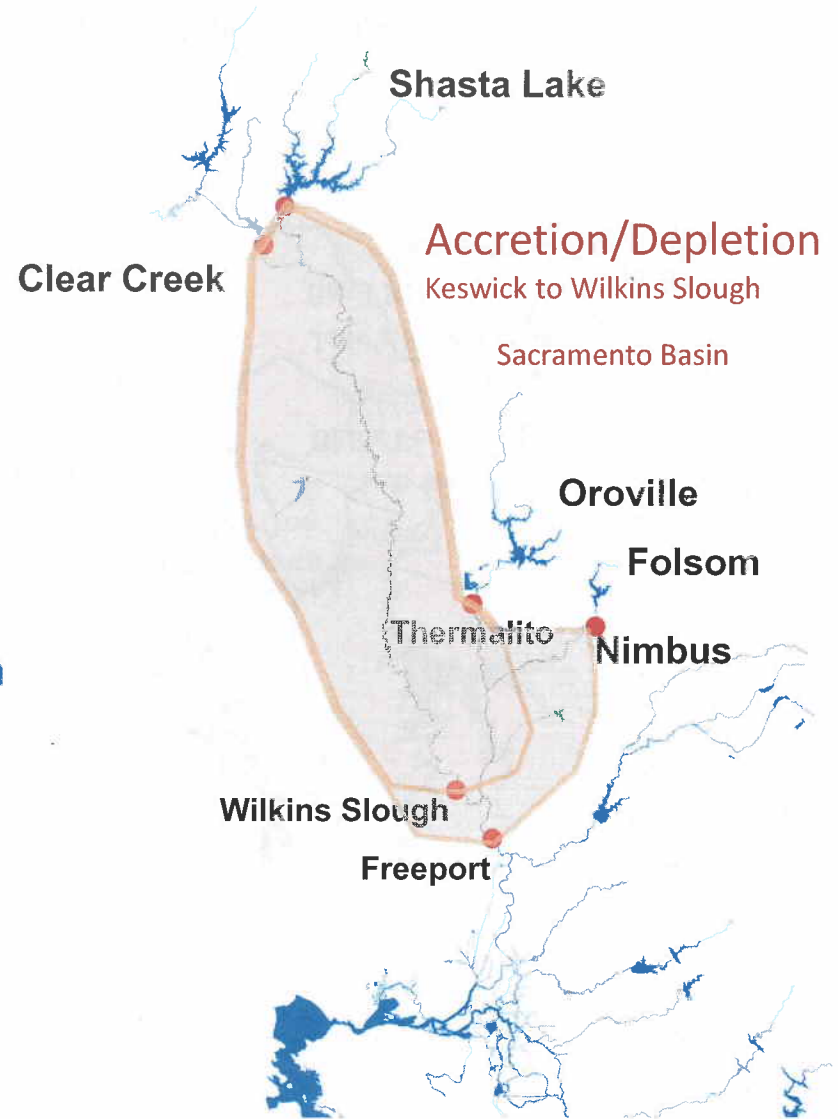
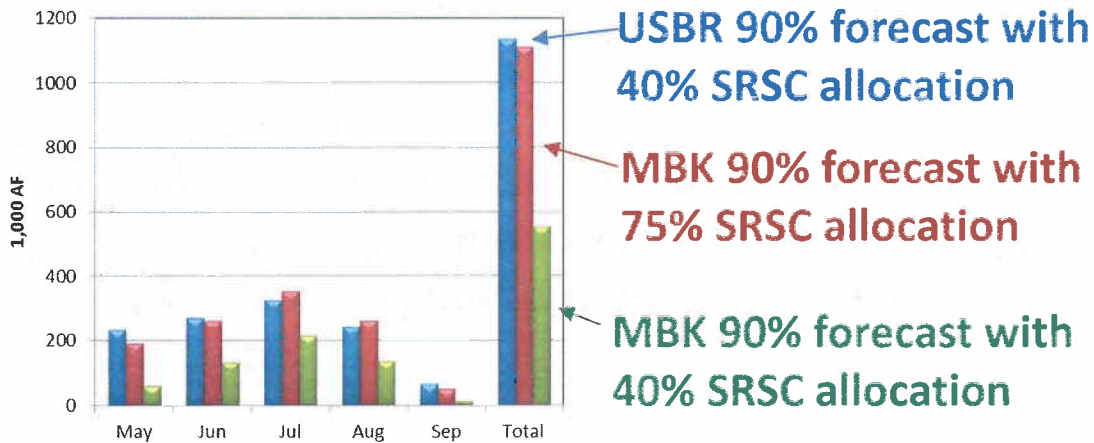
users, including SRS Contractors, beginning in 1964. The SRS Contractors renewed their contracts, in 2005, for another 40-year term. The SRS Contracts specify the amount of water that users agreed to divert each year during the 7-month period from April through October. Diversions include both a "Base Supply," which is delivered without charge, and "Project Water," for which the users are assessed a fee per unit volume identified in the contracts. Since 1989, when the actual operation and maintenance (O&M) costs exceeded the contract rate, contractors have either paid the excess or accrued a deficit. The Central Valley Project Improvement Act (CVPIA) in 1992 required an additional restoration charge on delivered Project Water. Other users such as CVP water service contractors hold contracts that contain different provisions. These contractors generally do not have their own independent water rights, and are dependent upon Reclamation's water rights for the deliveries of surface water.

# 2014 Issues with USBR Forecast

## Key Points

- USBR forecast model assumed historical diversions for SRSC, TCC, and others
- USBR initially allocated 40% and 0%

**Sacramento River Depletion  
Keswick to Wilkins Slough**

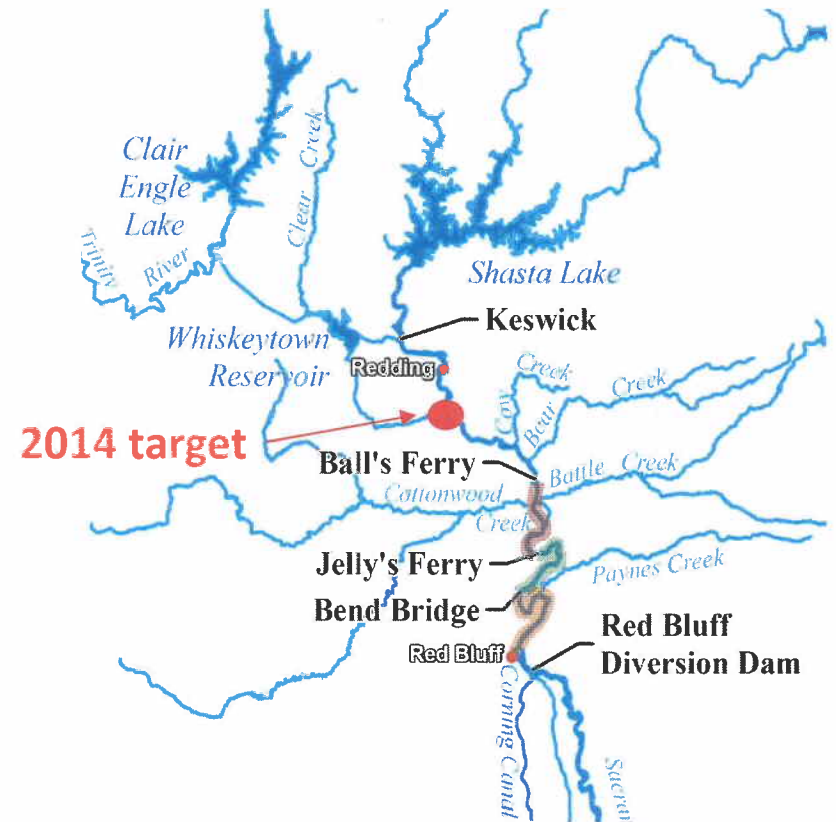
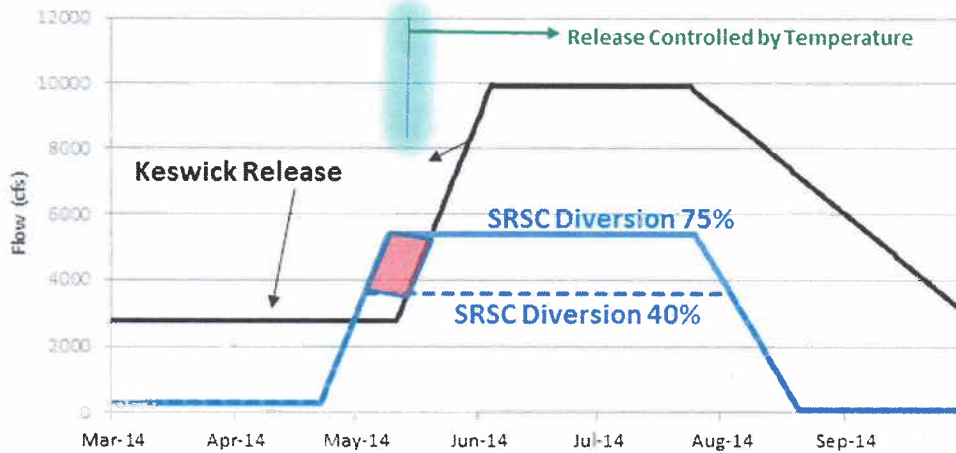




# Upper Sacramento River System Water Temperature Operations

## Key Points

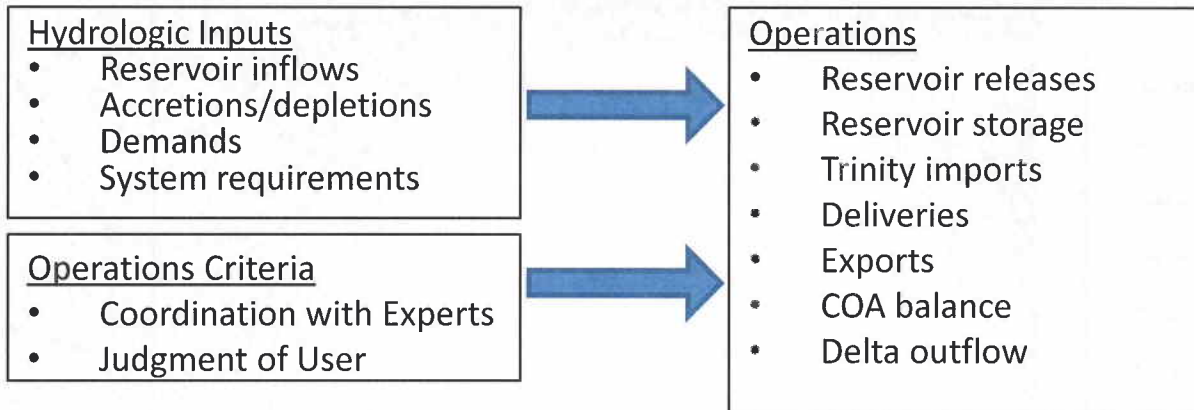
- SRSC worked hard shifting diversions to preserve cold water in Shasta in spring of 2014
- Significant effort toward agency outreach and coordination



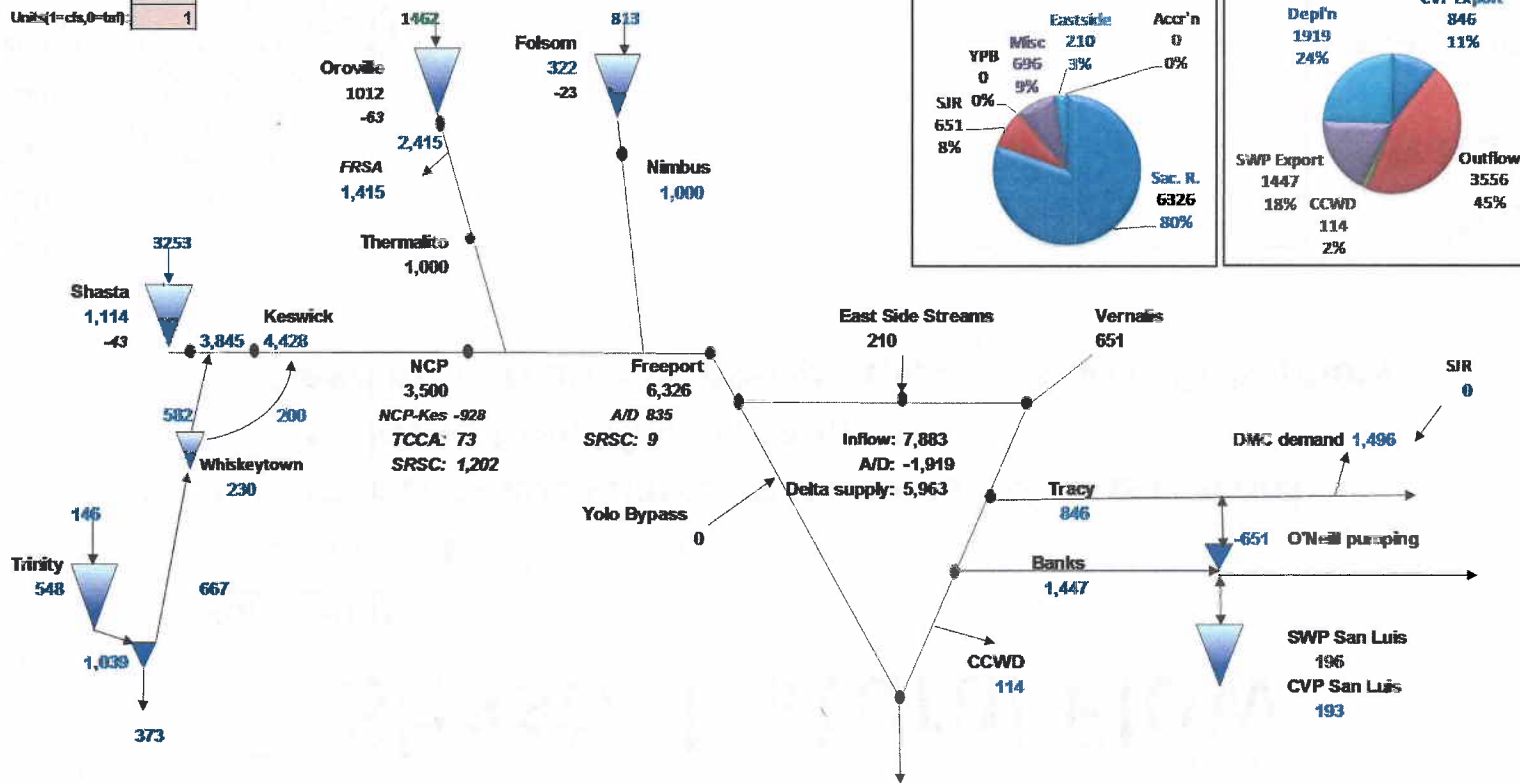
## Temperature Targets established annually by SRTTG

- Ball's Ferry Bridge, RM 274.85 (**25** miles downstream)
- Jelly's Ferry Bridge, RM 265.9 (**35** miles downstream)
- Bend Bridge, RM 256.33 (**44** miles downstream)
- Red Bluff Diversion Dam, RM 241.92 (**58** miles downstream)

# Forecasting "Tool"



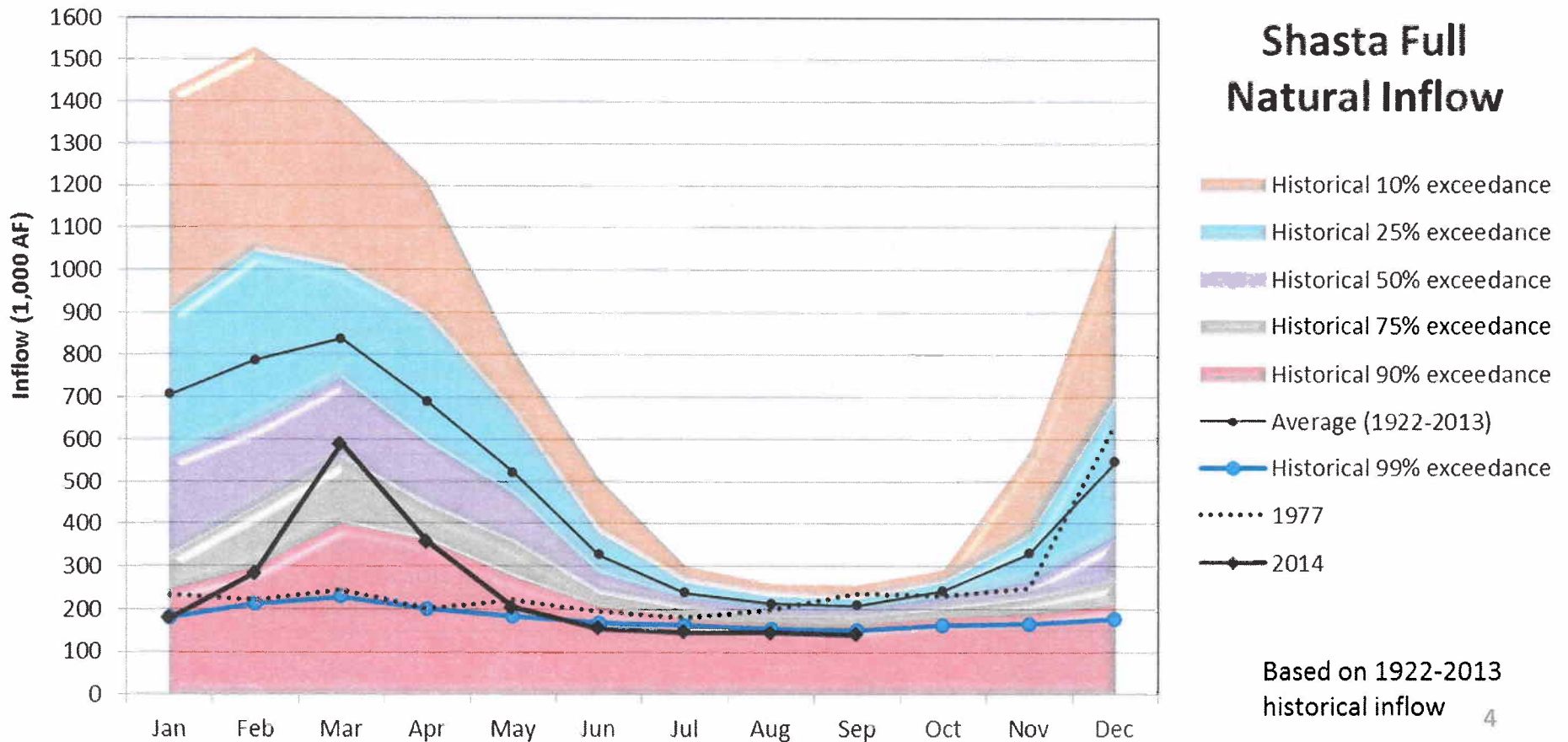
Month: 10  
 Year: 2014  
 Units (1= cfs, 0=traf)



# Shasta Natural Flow

## Key points

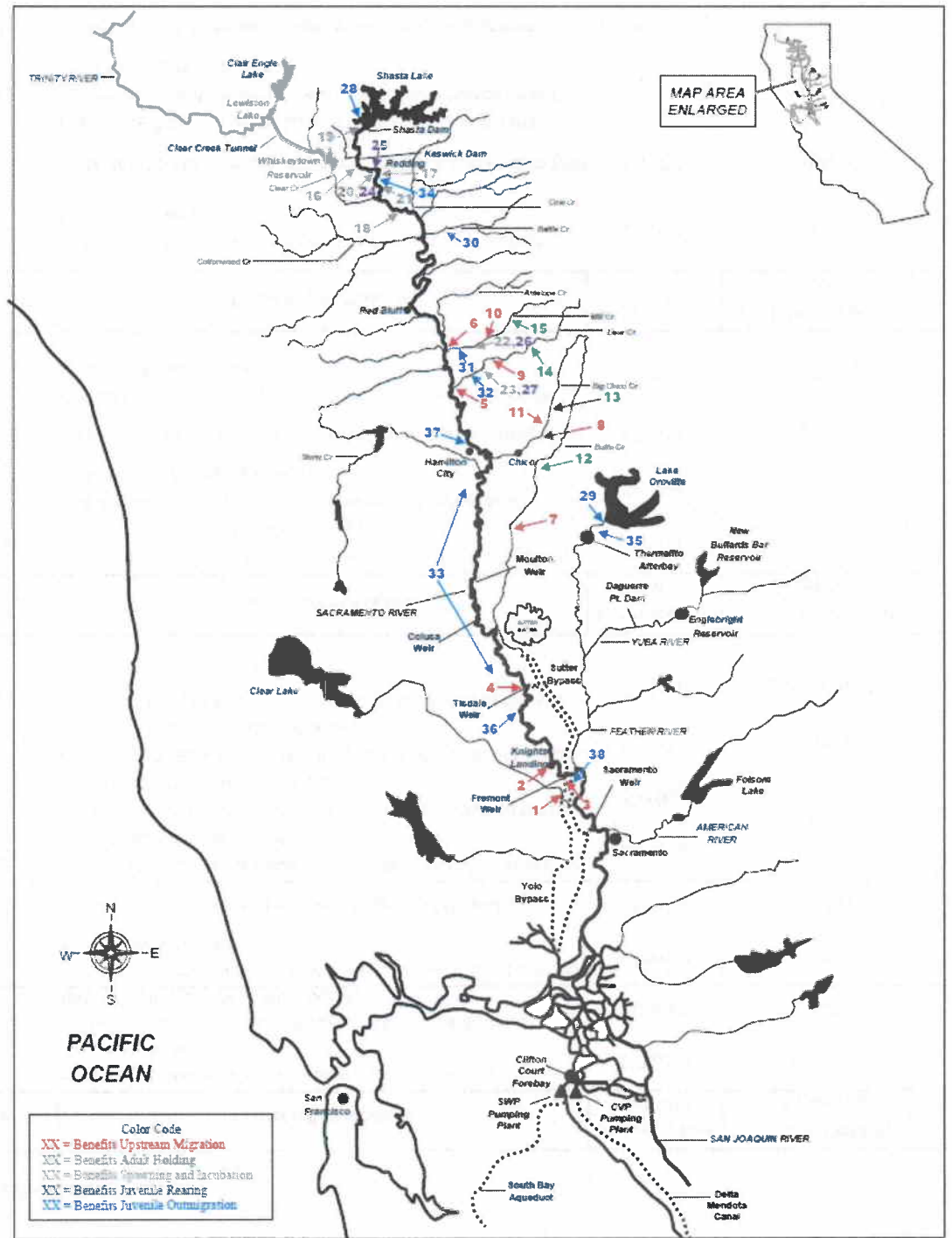
- Upper Basin is very dry
- Summer of 2014 has lowest Shasta inflow on record
  - lower than 99% exceedance
- Need more than 50% precipitation to receive 50% inflow





# SWRCB – Phase 2

## Fishery Restoration Efforts



**Goal: Double the population of native anadromous fish in the Sacramento River basin**

**Sub-Goals:**

<b>A. Increase adult fish upstream migration success and survival</b>	<b>Biological Objective</b>	<b>Location<sup>2</sup></b>	<b>Conservation Measure</b>	<b>Preliminary Cost Estimate</b>	<b>Implementing Agency(ies)<sup>3</sup></b>	
	1. Reduce straying in Colusa Basin Drain	1	a. Redesign Wallace Weir; temporary trap and haul; re-direct flow to Tule Canal	\$350,000	DWR, DFW	
		2	b. Eliminate attraction into Colusa Basin Drain outfall gates through behavioral or physical barrier	\$500,000	DWR	
	2. Reduce stranding behind Fremont and Tisdale Weirs	3	a. Cut earthen channel from Tule Canal to Fremont Weir; redesign Fremont Weir fishway	\$3,000,000	DWR	
		4	b. Notch Tisdale Weir; install operable gate and false weir	\$900,000	DWR	
	3. Improve upstream migration in tributaries	5, 6	a. Increase late spring flows in lower Deer and Mill Creeks for access from the Sacramento River	\$1,200,000	DWR, DFW	
		7, 8, 9, 10	b. More-frequent maintenance of existing fishways on Butte, Big Chico, Deer, and Mill Creeks	\$80,000	DFW	
		7, 8, 9, 10	c. Increased security of existing fishways on Butte, Big Chico, Deer, and Mill Creeks to reduce poaching	\$120,000	DFW	
		11	d. New fishways for Big Chico Creek for access to upstream habitats	\$700,000	DFW, DWR	
	<b>B. Increase holding survival of adult fish</b>	<b>Biological Objective</b>	<b>Location<sup>2</sup></b>	<b>Conservation Measure</b>	<b>Preliminary Cost Estimate</b>	<b>Implementing Agency(ies)<sup>3</sup></b>
	1. Protect adult fish in holding areas		12, 13, 14, 15	a. Installation of digital infrared cameras on Butte, Big Chico, Deer, and Mill Creeks to deter illegal harvest	\$150,000	DFW
			12, 13, 14, 15	b. Enhance protection for over-summering holding areas (i.e., limitation on recreational uses)	\$80,000	DFW
12, 13, 14, 15			c. Enhance riparian and structural cover for over-summering areas	\$800,000	DFW	
12, 13, 14, 15			d. Establish seasonal refuges for spring run (akin to bald eagle refuges for nesting areas)	\$400,000	DFW	
<b>C. Increase spawning and egg incubation success</b>	<b>Biological Objective</b>	<b>Location<sup>2</sup></b>	<b>Conservation Measure</b>	<b>Preliminary Cost Estimate</b>	<b>Implementing Agency(ies)<sup>3</sup></b>	
1. Increase the quantity and quality of spawning habitats in the mainstem		16	a. Transport Tehama-Colusa Spawning Channels gravels to the upper Sacramento River	\$4,000,000	USBR	
		17	b. Restoration of Painter's Riffle on the Upper Sacramento Rive	\$50,000	USBR, GCID	
		18	c. Improve flow and water temperature conditions on the Upper Sacramento River by means of the new management committee (See WRO 90-5)	\$0	USBR, SWRCB	
		19	d. Reduce redd stranding through water project reoperations	\$50,000	USBR, GCID, RD 108	

		20	e. Creation of 2- 3 new side-channel spawning/rearing areas in the upper Sacramento River	\$600,000	USBR
		21	f. Mechanically redistribute spawning gravel from high-elevation benches to lower elevations	\$250,000	USBR
	2. Increase the quantity and quality of spawning habitats in the tributaries	22, 23	g. Gravel additions and increased channel complexity in Mill and Deer Creeks	\$2,500,000	USBR, DWR, DFW

C. Increase fry and juvenile rearing survival	Biological Objective	Location <sup>2</sup>	Conservation Measure	Preliminary Cost Estimate	Implementing Agency(ies) <sup>3</sup>
	1. Increase the quantity and quality of rearing habitats	24	a. Add salmon rearing habitat structures in the upper Sacramento River (pilot projects)	\$400,000	USBR, DFW
		25	b. Creation of 2- 3 new side-channel spawning/rearing areas in the upper Sacramento River	\$600,000	USBR, DFW
		26, 27	c. Implement Mill and Deer Creeks floodplain restoration projects to improve channel complexity and rearing habitats	\$1,500,000	USBR, DWR, DFW

D. Increase juvenile fish outmigration survival	Biological Objective	Location <sup>2</sup>	Conservation Measure	Preliminary Cost Estimate	Implementing Agency(ies) <sup>3</sup>
	1. Reduce sources of juvenile fish mortality	28, 29	a. Short-duration pulse flows for wild fish (timed with and without accretion events)	Unknown	USBR, DWR, SWRCB
		28, 29	b. Short-duration pulse flows, linked with release of hatchery fish	Unknown	USBR, DWR, SWRCB, USFWS
		30, 31, 32	c. Improve fish screens on tributaries (e.g., bypass systems)	\$500,000	USBR, DFW
			d. Retrofit irrigation pumps with variable-speed motors	\$350,000	Water Districts
		33	e. Reduced lighting at Sacramento River fish screens	\$500,000	USBR
		34, 35	f. Reduced lighting at Sacramento and Feather River bridges	\$750,000	USBR, DWR
		36	g. Modification of fish screen hydraulics to reduce predation (pilot project)	\$800,000	USBR, RD 108
		37	h. Modification of fish screen wiper blades to reduce predation (pilot project)	\$250,000	USBR, GCID
		38	i. Install 3 operable gates in the Tule Canal of the Yolo Bypass to prevent fish stranding	\$200,000	DWR, USBR
		Basin Wide	j. Program to identify predation hot spots	\$500,000	USBR, DFW

TOTAL COSTS \$21,480,000





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GENERAL MANAGER  
Thaddeus L. Bettner, P.E.

## Restoring the Salmon Runs

Glenn-Colusa Irrigation District, the Northern California Water Association (NCWA) and water resources managers in the Sacramento Valley, as part of ongoing efforts to foster regional sustainability with respect to water resources, have developed significant partnerships with federal and state agencies and conservation organizations that have improved migratory corridors and habitat for anadromous fish (salmon and steelhead) within the region. However, there is still more work ahead to restore the salmon runs.

In 2011, fisheries biologist Dave Vogel prepared a scientific report titled, *Insights into the Problems, Progress and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration* (<http://www.norcalwater.org/efficient-water-management/fisheries-enhancements/>). The water resources managers continue to work with Biologist Vogel to develop and implement a series of actions, summarized below, that will improve fish habitat in the region and help achieve a better understanding of the actions necessary to help advance the recovery efforts for anadromous fish.

- A. Fish Passage Improvements.** Over the past several decades there has been tremendous effort to build fish screens and siphons on major diversions in the Sacramento Valley to protect fisheries while assuring water supply reliability for farms, refuges, cities and rural communities. There is an ongoing effort to finalize fish screens on the few remaining major diversions in the Sacramento Valley.
- B. Instream Flows.** The Sacramento Valley has instream flow agreements or requirements on every major part of the Sacramento River hydrologic region, which is summarized in "Instream Flow Requirements in the Sacramento River Hydrologic Region" (<http://www.norcalwater.org/efficient-water-management/instream-flows/>). These various arrangements will continuously be evaluated over time to assure they provide water supply reliability and benefit fisheries.
- C. Spawning Habitat.** A gravel recruitment program in key reaches of the river system would help provide spawning habitat for salmon.
- D. Salmon Smolt Escapement Plan.** Water resources managers, working with various partners, have developed a "Salmon Smolt Escapement Plan" to maximize the escapement of natural and hatchery salmon smolts through a coordinated program of water storage releases, additional strategic pulse flows,

and the timing of diversions. This will help avoid the primary problem with predation, the principal source of mortality.

- E. **High Priority Streams.** In 2009, the California Legislature required the State Water Resources Control Board to develop a prioritized schedule to complete instream flow studies for high priority streams by 2018 (Water Code §85087). To help jumpstart this process, there is an interest in accelerating programs on two high-priority tributaries to the Sacramento River, both of which contain important habitat for spring run salmon: Mill Creek and Deer Creek.



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## **Painter's Riffle Anadromous Fish Habitat Enhancement Project**

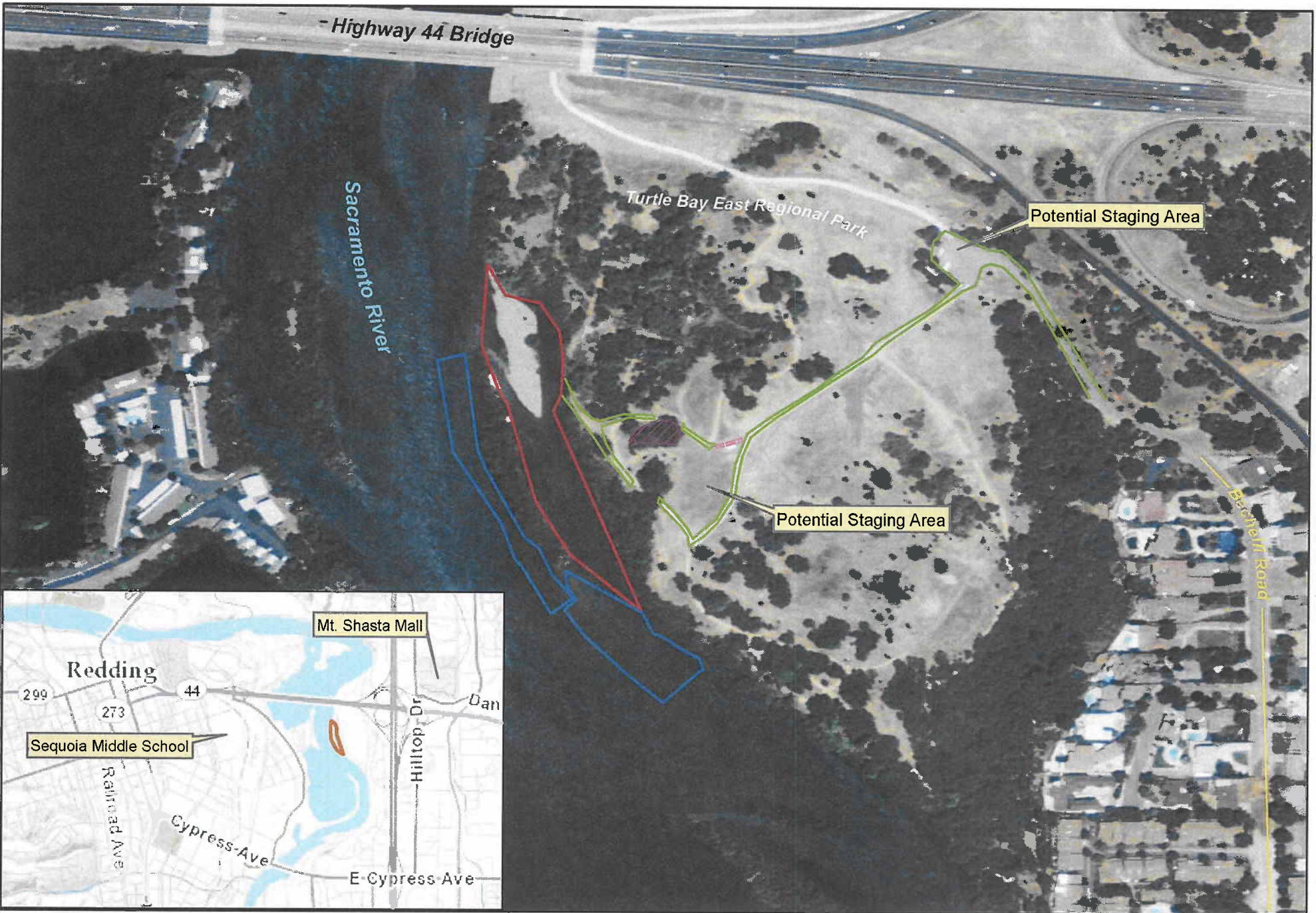
A unique partnership of GCID, Bureau of Reclamation, U.S. Fish and Wildlife Service, Golden Gate Salmon Association, Northern California Water Association, the City of Redding, and the California Department of Fish and Wildlife (CDFW) developed and designed the Painter's Riffle restoration project. With that technical assistance and support from the Central Valley Project Improvement Act, GCID proposes to utilize its own staff and assets to obtain final permits and construct the proposed Painter's Riffle project in November of 2014.







Painter's Riffle was initially constructed in 1986 by CDFW Biologist Dick Painter, and was successful in producing 100 to 200 additional redds (fish nests), each of which contain an average of 5,000 eggs resulting in up to 750,000 salmon smolt in the Sacramento River system on an annual basis. For 25 years, Painter's Riffle assisted the survival of winter-run and spring-run Chinook salmon, as well as fall-run Chinook salmon, which are important to the commercial fishing industry. In 2011, it was blocked and filled by approximately 11,000 cubic yards of gravel during a large storm event. The unstable gravel that filled the channel was originally placed in the Sacramento River as a construction work pad beneath the Highway 44 Bridge. When the gravel moved in 2011, it essentially buried the Painter's Riffle spawning habitat.

Modeling indicates that spawning habitat in the side channel can be reestablished with the removal of between 6,600 and 8,000 cubic yards of gravel; however, due to uncertainties in the survey data and the longitudinal extent of the deposits, the estimated quantities could range up to 10,000 cubic yards. Most of the gravel would be redistributed in the side channel; in-river gravel placement areas include the main channel adjacent to the side channel inlet or within 200 feet downstream of the side channel along the steep bank of the east bend of the main river. The work is estimated to take two to three weeks to complete.

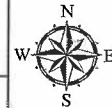
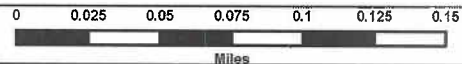
This project is consistent with GCID's ongoing efforts to protect fisheries and wildlife as demonstrated by the construction and utilization of fish screens at its Main Pump Station, the commitment to continue the collection and dissemination of Sacramento River rotary fish trap data, contributing to the habitat for the Pacific Flyway, and preservation of habitat for terrestrial species including the Giant Garter Snake.





- Legend**
-  Lateral Berm/Excess Relocation Sites
  -  Gravel Excavation/Redistribution Area
  -  Potential Reopened Trail/Access Route
  -  Access Route
  -  Elderberry Shrubs
  -  Painter's Riffle

Painter's Riffle Anadromous Fish Habitat Enhancement Project  
**Project Action Area**



## **SUPERVISORY CONTROL AND DATA ACQUISITION MEETS PUBLIC POLICY – A GLENN-COLUSA IRRIGATION DISTRICT CASE STUDY**

Pat Kennedy <sup>1</sup>  
Thaddeus Bettner, PE <sup>2</sup>

### **ABSTRACT**

Looking into the future, water agency managers, consultants, board members and other decision makers will need to assess and consider using today's available technology to make more informed decisions to balance competing needs for water, to demonstrate improved water management, and to implement and manage water conservation programs. The initial investment and "growing pains" of using technology to install or update a system can streamline operations and serve multiple functions to improve efficiency and data acquisition. With this foundation, Glenn-Colusa Irrigation District (GCID) elected to proceed with installing and utilizing a Supervisory Control and Data Acquisition (SCADA) system to improve operations and assist in addressing the myriad challenges associated with operating a large irrigation district in California.

Internal to GCID, the SCADA system is part of a long-term strategic plan to enable improvements to control the distribution and delivery of irrigation water through GCID's extensive canal network. One of the most important components of GCID's SCADA system is the communication system, which is a high-speed endlessly expandable communication network capable of adding an unlimited amount of SCADA sites.

External to GCID, California's policy makers continue to enact new legislation requiring water agencies to prove that they are accurately measuring water, to demonstrate that water is being efficiently managed and beneficially used, and to establish linkages between surface water and groundwater. GCID is in the process of expanding its SCADA system to meet these new public objectives.

### **INTRODUCTION**

Glenn-Colusa Irrigation District's water rights begin on the Sacramento River with an 1883 filing posted on a tree by Will S. Green, surveyor, newspaperman, public official, and pioneer irrigator. His first claim was for 500,000 miner's inches under 4 inches of pressure and was one of the earliest and largest water rights on the Sacramento River.

GCID was 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 disastrous rice crop failure of 1920-21 nearly destroyed

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the District at its inception and the Great Depression took a further toll, making it necessary for the district to refinance in the 1930s. Additionally, the United States purchased lands within GCID during this period that would later become three federal wildlife refuges totaling over 21,000 acres.

Today, after surviving many challenges, GCID is the largest irrigation district in the Sacramento Valley. Located approximately 80 miles north of Sacramento, California, the District boundaries encompass approximately 175,000 acres, with 141,000 planted acres and over 21,000 acres within three federal wildlife refuges that provide critical wildlife habitat. There are an additional 5,000 acres of private habitat land, and water supplied by GCID to thousands of acres of rice land provides valuable habitat for migrating waterfowl during the winter months.

GCID's main pump station, its only diversion from the Sacramento River, is located near Hamilton City. Prior to water entering the pump station, river water passes through an 1,100-foot long fish screen, built in the late 1990s (Figure 1). Water is then lifted an average of 4 feet before entering the conveyance system (Figure 2). The District's 65-mile long main canal conveys water into a complex system of nearly 1,000 miles of canals, laterals and drains, much of it constructed in the early 1900s.



Figure 1. SCADA allows GCID to monitor the activities of its 1,100-foot long fish screen. The pump station is located directly behind the fish screens.

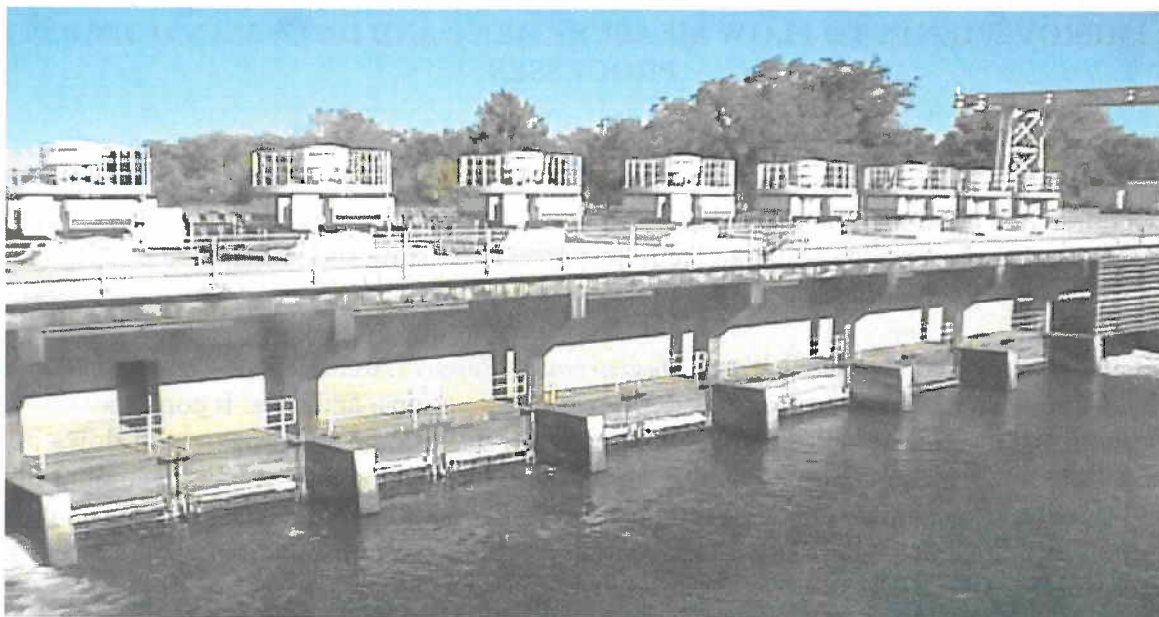


Figure 2. GCID's main pump station, located on the Sacramento River, has the capability of pumping 3,000 cubic feet per second (cfs). SCADA allows canal operators to make pump changes remotely, monitor water elevations, and measure the water quality entering the District's main canal.

## WATER SUPPLY

From the time of its first diversions until 1964, GCID relied upon historic water rights and adequate water supply from the Sacramento River system. This system receives rainfall and snowmelt from a 27,246 square mile watershed with average runoff of 22,389,000 acre-feet, providing nearly one-third of the state's total natural runoff. In 1964, after nearly a decade of negotiations with the United States, GCID along with other Sacramento River water rights diverters entered into "Settlement Water Contracts" with the Bureau of Reclamation (Bureau). These Settlement Contracts were necessary at that time to allow the Bureau to construct, operate, and divert water for the newly constructed Central Valley Project (CVP). The contract provided GCID with water supply for the months of April through October consisting of 720,000 acre-feet of base supply, and 105,000 acre-feet of CVP water that is purchased during the months of July and August. During a designated critical year when natural inflow to Shasta Reservoir is less than 3.2 million acre-feet, GCID's total supply is reduced by 25%, to a total of 618,750 acre-feet.

Additionally, the District has rights under a State Water Resources Control Board (SWRCB) permit for "winter water" from November 1 through March 31 at a 1,200 cubic feet per second (cfs) diversion rate. This water supply is used for rice straw decomposition and waterfowl habitat. The permit provides 150,000 acre-feet for rice straw decomposition and 32,900 acre-feet for crop consumption. Groundwater can also be used to supplement GCID's supplies, with 5,000 acre-feet available from District wells, and approximately 45,000 acre-feet from privately owned wells.



## IMPROVEMENTS TO FLOW MEASUREMENT AND DATA MANAGEMENT PROCESSES

GCID continues to improve its flow measurement and related data management processes. Existing processes have evolved in a manner that adequately supported water operation and administration, but do not necessarily support more recent efforts to refine water management policy and practice in response to existing and anticipated challenges to water supply reliability.

GCID has prepared an annual *Water Measurement Report* (Annual Report) since 1964 that serves as a record of annual water diversions, operations, and uses. It consists primarily of a series of tables that summarize water diversions, deliveries, drain flows and drain water recapture on a monthly and annual basis, and contains a large amount of information and enables tracking of trends in certain operating parameters. The Annual Report also documents the water rates, rainfall, cropping patterns, and policies in effect each year.

Until 2009, GCID maintained a spreadsheet-based data management system that had been designed to produce operational reports and summary tables contained in the Annual Report. The spreadsheet system employed macro programs to enable semi-automated data entry, but the data was stored in a highly compartmentalized manner, making data access, analysis and reporting difficult. The system performed adequately for nearly 20 years for routine operations but was cumbersome for investigative analyses and ad hoc reporting, and it was not structured to receive and manage data from GCID's expanding SCADA network.

In early 2009, GCID migrated its spreadsheet data system to a Microsoft Access relational data base. This involved extracting data stored in hundreds of spreadsheets and assembling the data in one large Access data base. All of the historical data was salvaged. The new data base retained as much of the terminology as possible from the old system, including measurement site reference numbers and names. Like the old one, the new system includes data input screens designed to facilitate hand entry of operator reports submitted orally by radio and in writing.

One major objective of the conversion to a data base environment was to accommodate the growing volume of operational data that was expected to come from GCID's SCADA system. Over time, it is expected that GCID's reliance on SCADA information will increase and manual operator reporting will decrease. This trend is typical of many irrigation districts that are implementing SCADA systems for remote monitoring and control of water distribution systems.

It is anticipated that the capacity limits of Access will be exceeded and the data base system will have to be migrated to a higher capacity platform, such as SQL server or Oracle. This migration will be relatively straightforward now that data is stored in data base tables. Eventually, GCID intends to house or access all of the data needed for water balance analysis in an integrated Water Information System (WIS). A major

consideration in the design of the WIS is to enable routine updates of GCID's water balance model.

### **SUPERVISORY CONTROL SYSTEM OVERVIEW**

GCID's delivery system is comprised of the main canal, which is the major conveyance feature that extends 65-miles in length from the north to the south end of the District, 24 check structures that maintain upstream water level elevation, approximately 500 miles of laterals that convey water from the main canal, and approximately 2,500 field turnouts. The District's conveyance system includes 19 recapture pump sites and 17 gravity recapture sites that recycle over 200,000 acre-feet annually.

For control purposes, GCID's SCADA Project was designed to maintain constant upstream water elevations. As all water delivered to GCID customers either comes directly from the main canal or laterals from the main canal, it was vital that constant water elevations were maintained which would ensure constant flow deliveries from the main canal. Historically, water operators would make manual gate changes in the main canal check structures (Figure 3) in attempt to match water orders and flow requirements; however, in most instances, it was difficult to match these changes perfectly. The result would be that the water levels in the main canal would fluctuate and result in fluctuating flows to the District's customers.



Figure 3. Typical check structure along the main canal; SCADA allows the radial gates to move automatically, maintaining a selected or targeted upstream water elevation.

In order to meet California's new legislative requirements and to demonstrate that water is being efficiently managed and beneficially used, improving the water deliveries to customers was a critical first step. Due to the hydraulic complexity of the main canal, GCID consulted with Irrigation Training and Research Center (ITRC) personnel at California Polytechnic State University, San Luis Obispo, who developed the technical

specifications, conceptual designs, and control strategies. The design phase began in July of 2007, and was followed by a radio survey conducted in June of 2008. Actual construction of the project commenced in the fall of 2008 and was completed in December 2010. The 2011 irrigation season was the first full season of operations with the SCADA system in place.

The SCADA system has enhanced water management by maintaining constant water levels in the main canal. This allowed water operators to conserve water at the operational spill points, and results in water users conserving water due to the flows into their fields remaining consistent. The project has improved system efficiency by removing the wave actions that historically created difficulties in determining whether river diversions needed to be increased or decreased.

GCID's conveyance system consists of drains supplementing laterals and, in other cases, laterals supplementing other laterals. In order to fully utilize the District's system, it is important to have as much real time information available as possible. Managing the main canal is only the first phase of a long-term strategic plan to enable GCID to monitor all critical points within the system to minimize drain outflows, and beneficially use the water rights of the District.

### **Technical Information**

GCID's SCADA network consists of a dedicated system running ClearSCADA software (2009 version) on dual (redundant) servers in a Windows Server 2003 environment. The main SCADA workstation is a separate desktop computer connected to a 33-inch widescreen flat panel monitor that uses ClearSCADA View X. The SCADA system allows water operations staff to remotely operate the main canal system from work stations located at GCID's main office, or from laptops in the field using an internet connection. (Figure 4) depicts SCADA sites currently being monitored.

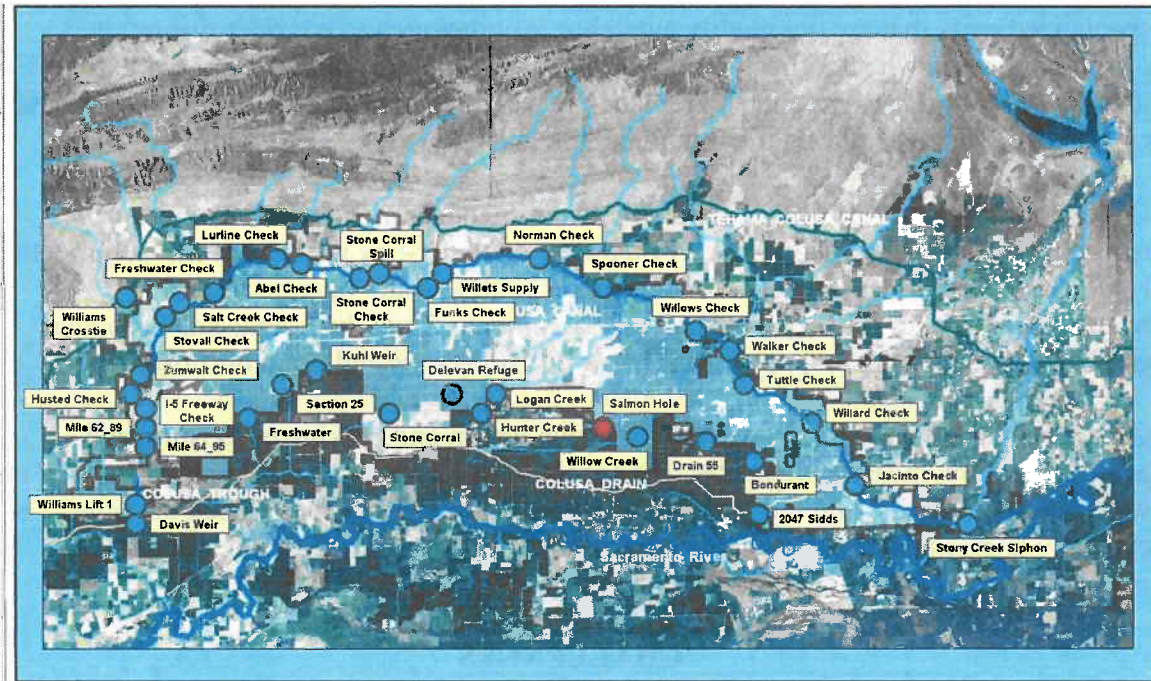


Figure 4. Currently monitored SCADA sites

### Project Considerations

After completion of the design phase by ITRC, the next task was to select an integrator to perform all the technical phases of the project. During the selection process, potential integrators with extensive knowledge in the SCADA field were asked to provide a list of similar projects that they have been involved with, and their work experience was carefully reviewed. Another consideration was ensuring that the company is an established business that will be available to consult in future years.

GCID learned that conducting a radio survey and confirming that the proper radio system was selected was very important. Failure to do this early in the process resulted in time delays and increased costs. While the integrator supplies the necessary information, it is essential to review the decisions based on the technology of the District's system and the area. Deciding what types of SCADA operating screens will be optimal for the system early in the process saves time and effort as the integrator can design them as specified, avoiding the need to alter screens at a later date.

After the completion of the SCADA project, the system requires annual maintenance on all the components. This can be accomplished by establishing an annual maintenance agreement with the integrator, or training personnel to perform these duties. GCID elected to train personnel who conduct inspections and maintenance on the entire system, and consult with the integrator as necessary.

Careful selection of the types of components used as part of the SCADA system, can save time and expense. It is beneficial to avoid the use of proprietary equipment and to choose "shelf items," so that when components inevitably fail there is not a need to wait for



specialized parts that are not readily available. Another area to consider during the planning phase is whether there is capacity to expand the SCADA system in the future, as it can be very costly to expand and replace the existing equipment with components that could have been used during the initial installation.

GCID employs a variety of flow measurement methods, ranging from continuous recording ultrasonic acoustic velocity meters to once-per-day weir depth measurements. Here, too, measurement has evolved to support routine water operations and administration, with primary emphasis on Sacramento River diversions and secondary emphasis on major internal operations (flow division) sites and drain outflows.

GCID recently completed a comprehensive evaluation and ranking of existing and prospective flow measurement sites that considers site importance, the annual volume of water passing the site, and measurement cost. Highest priority was placed on large, currently unmeasured operational and boundary measurement sites. Identified flow measurement improvements will be implemented over a period of several years.

## CHALLENGES

One of the challenges canal operators face is the timing of pump changes as they relate to demand. Prior to the installation of the SCADA system, canal operators would either store water in selected pools along the canal or intentionally lower pools depending on the water orders for the next day. This resulted in fluctuating water elevation in the canal that caused laterals to either spill excess amounts at the end of the lateral, or short the lateral and interrupt service to the water user until the canal pool elevation returned to its original elevation. One of the positive aspects of the SCADA system is that it moves water up and down the canal more quickly and maintains the same water elevation at each check. This is a better result than the operators could accomplish by moving the water manually. Canal operators now make pump changes and are able to conserve water and maintain constant flows into fields, and the only remaining issue is to resolve the timing of when to make the changes with the SCADA system to achieve the best results.

Water velocity in the canal varies between 0.2 feet per-second during low flow condition, and 4.0 feet per-second, during high flow conditions. The period of time it takes the water to move 65 miles down the main canal increases during high demand periods and decreases during the low demand periods. It is imperative that the timing of increasing or decreasing river diversions is precise and has always been a difficult part of operating the system. The SCADA system provides the ability to adjust water elevation targets in selected areas, and helps to prevent either drying up the bottom of the conveyance system or spilling an excess amount of water.

Adjusting the water level sensors to accommodate water levels during the off-peak season has been one of the challenges of fine-tuning the system. Maintaining redundant sensors for water elevations has proven to be time consuming as discrepancies result in continual adjustments and unnecessary alarms. The strategic placement of stilling wells

and accurate calibration of sensors to cover all flow conditions has been an important part of achieving proper operating parameters.

Calibrating gate position sensors is as challenging as calibrating water level sensors. Having a stationary gauge mounted above the water level on each water control gate allows for occasional site visits to actually confirm gate positions with gate sensors. Gate position is critical because the flow at each check structure is based on head pressure versus gate opening. As canal operators started to fill the canal system in spring 2011 and prepared each SCADA site for full automation, it was soon apparent that the flows at each site were not calibrated properly. Once the canal was filled with water the gate openings could not be measured accurately to verify the redundant sensor positions.

The majority of the District's SCADA sites are located in rural areas that experience frequent power outages. In most instances, the SCADA technician has been able to reset fuses or change batteries at the site. However, in some cases it was necessary for the technician to call the integrator to receive direction on how to fix the problem. Some of the older check structures had inadequate electrical equipment, and as the SCADA program constantly moves the gates up and down to maintain a constant water elevation, stress was placed on older components. Eventually the older components were overloaded and would fail, resulting in an alarm being triggered and water elevations not meeting the target. This equipment will be updated and replaced in the future.

## **DATA ACQUISITION AND MANAGEMENT BENEFITS**

While SCADA has resulted in better control of the conveyance system, GCID considers the data acquisition, the management and use of that data to be equally important. In fact, the communication requirements, system architecture, and data-carrying capability of the District's SCADA system were weighed equally to the need for automated control in order to meet the current and future reporting and accounting guidelines at the District, regional, state, and federal level.

### **Water Measurement Reporting and Water Balance Model**

As discussed previously, GCID has converted to a data base environment to accommodate the growing volume of operational data. With its system in operation, GCID is now looking to use data directly from SCADA to populate its Annual Report. Eventually, GCID intends to house or access all of the data needed for water balance analysis in an integrated Water Information System (WIS). A major consideration in the design of the WIS is to enable routine updates of the water balance model.

The objective of the water balance model is to enhance the value of the data presented in the Annual Report by augmenting and combining it in the form of a water balance that accounts for all water entering, leaving and stored within the District over specified periods of time. Beyond tracking trends in certain individual operating parameters, the water balance will allow GCID managers to assess historical operational performance under different water supply and demand conditions. The main outcome from the water

balance will be an improved understanding of GCID system characteristics and operational performance, which, in turn, will provide an improved basis for identifying, assessing and planning potential water management and facility improvements. It is also expected that the water balance will reveal opportunities to improve GCID's water measurement and data management processes.

A particular purpose in developing the water balance is to characterize exchanges of water between GCID canals, laterals, drains and irrigated lands and the underlying groundwater system through the processes of recharge (by canal seepage and deep percolation of applied water) and discharge (groundwater pumping). It is generally accepted that the diversion and application of surface water in GCID results in appreciable net recharge to underlying groundwater aquifers. The water balance will help to improve recharge estimates, and will improve GCID's ability to manage underlying groundwater, including improved calibration of groundwater models.

GCID is currently developing the database component of SCADA so that measurements will feed directly into the Water Balance model, thus eliminating the need to transcribe data into the model, which is time consuming and prone to error. Additionally, GCID will also be able to generate its Annual Report data directly from SCADA.

### **Legislative Mandates**

As mentioned previously, California's policy makers have and will continue to enact legislation requiring agricultural water suppliers (irrigation and water districts) to prove that agricultural water use is efficient and beneficial. In 2009, the legislature passed and the Governor enacted a Comprehensive Water Package that required water agencies to: i) report surface water diversions to the State Water Resources Control Board; ii) monitor and report groundwater elevations to show the health of groundwater basins; iii) provide measurement and volumetric pricing to customers; and iv) quantify agricultural water use efficiency.

Surface Water Diversion Reporting. In 2009, the California Water Code was modified to require diverters, including pre-1914 water right holders, to file Statements to measure their monthly water diversions beginning in January 2012. California Water Code section 5103 subdivision (e)(1) states the following:

*"On and after January 1, 2012, [each statement shall include] monthly records of water diversions. The measurements of the diversion shall be made using best available technologies and best professional practices."*

GCID's SCADA system includes real time monitoring of surface water diversions, including water quality, at its Hamilton City Pumping Plant (HCPP) from the Sacramento River. Currently, fifteen minute data from the HCPP diversion is collected by SCADA; this information is averaged daily and then sent to GCID's Annual Report via SQL server. This information can also be pushed externally to the District's website.

SCADA offers the potential for the entire Sacramento River system to be managed and monitored on a real-time basis. If funding were available to allow other local agencies to install SCADA on their delivery systems, data could be pushed from locally owned, operated, and maintained SCADA systems to a centralized database and operations center that would allow more real-time operations. For example, the Central Valley Operations (CVO) center of the Bureau of Reclamation operates the Sacramento River system from Shasta Reservoir to the California Delta. GCID, along with other Sacramento River Settlement Contractors (SRSC), diverts water between Shasta and the Delta. If real-time SCADA systems existed on all of those diversions, the SRSC and the CVO could jointly operate the system more efficiently to minimize operational losses. While all the SRSC diversions are measured, most do not have an active SCADA system; however, if funding were made available most water agencies would add SCADA to their existing systems.

Groundwater Monitoring and Reporting. In addition to the surface water diversion reporting, the State Legislature amended the Water Code with SBX7-6, which mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. To achieve that goal, the amendment requires collaboration between local monitoring entities and the Department of Water Resources (DWR) to collect groundwater elevation data. Collection and evaluation of such data on a statewide scale is an important fundamental step toward improving management of California's groundwater resources.

In accordance with this amendment to the Water Code, DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program. The intent of the CASGEM program is to establish a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins. The CASGEM program will rely and build on the many established local long-term groundwater monitoring and management programs. DWR's role is to coordinate the CASGEM program, to work cooperatively with local entities, and to maintain the collected elevation data in a readily and widely available public database.

To comply with this legislation, GCID volunteered to become a local monitoring agency for groundwater elevations within its service areas, which also includes significant portions of Glenn and Colusa counties. Historically, these wells were monitored by GCID staff in the spring and fall of each year, and for those multi-completion monitoring depths, a data recorder was used that measured water levels on a 15-minute interval and was downloaded on monthly intervals.

GCID's SCADA system now allows for these well sites to be measured remotely, with on-off control being a future option. The data collected and pushed to CASGEM is also pushed to GCID's Annual Report, which significantly reduces the time required for GCID personnel to perform the monitoring, and also minimizes the possibility of data being reported incorrectly.

Measurement and Volumetric Pricing to Customers. Also legislated in 2009, California Water Code §10608.48(i)(1) requires the Department of Water Resources 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, which states:

“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.”

To comply with this legislative mandate, GCID is expanding its SCADA system to measure all laterals and other larger diversions from its main canal, which will interrogate flow meters on a real-time basis. Measurement records will be batched to the *Water Measurement Report* to provide for a complete record of District deliveries, and then to the Water Accounting Program that will be used to generate water user billings. The acreage and cropping pattern in each lateral service area is available in GIS format allowing for exact determination of acreage and crop type 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.

The Water Accounting Program will utilize the information from SCADA and the crop information from GIS to develop an application rate (acre-feet/acre) within each service area that will satisfy the pricing requirement based on “in part quantity delivered.” GCID also charges land and crop based assessments in addition to the volumetric charge.

Quantification of Agricultural Water Use Efficiency. Quantifying the efficiency of agricultural water use was directed by policy statements and other language in the 2009 legislation – SBX7-7. Specifically, §10608.64 of the Act states that the Department of Water Resources shall develop a methodology for quantifying the efficiency of agricultural water use and shall report to the Legislature on a proposed methodology and a plan for implementation. The plan shall include the estimated implementation costs and the types of data needed to support the methodology.

One approach for quantifying the efficiency of agricultural water use is to focus on the elements of a water balance (accounting) within an established boundary; for GCID it would be the District boundaries. Using SCADA, GCID is able to measure and record all sources and dispositions of water into, within, and out of a defined boundary. From these water flow elements, various relationships can be evaluated to describe the current water management conditions and assess opportunities for change. As described previously, GCID has developed a water balance program, and SCADA will be a vital tool in quantifying efficiency at the district-scale level.

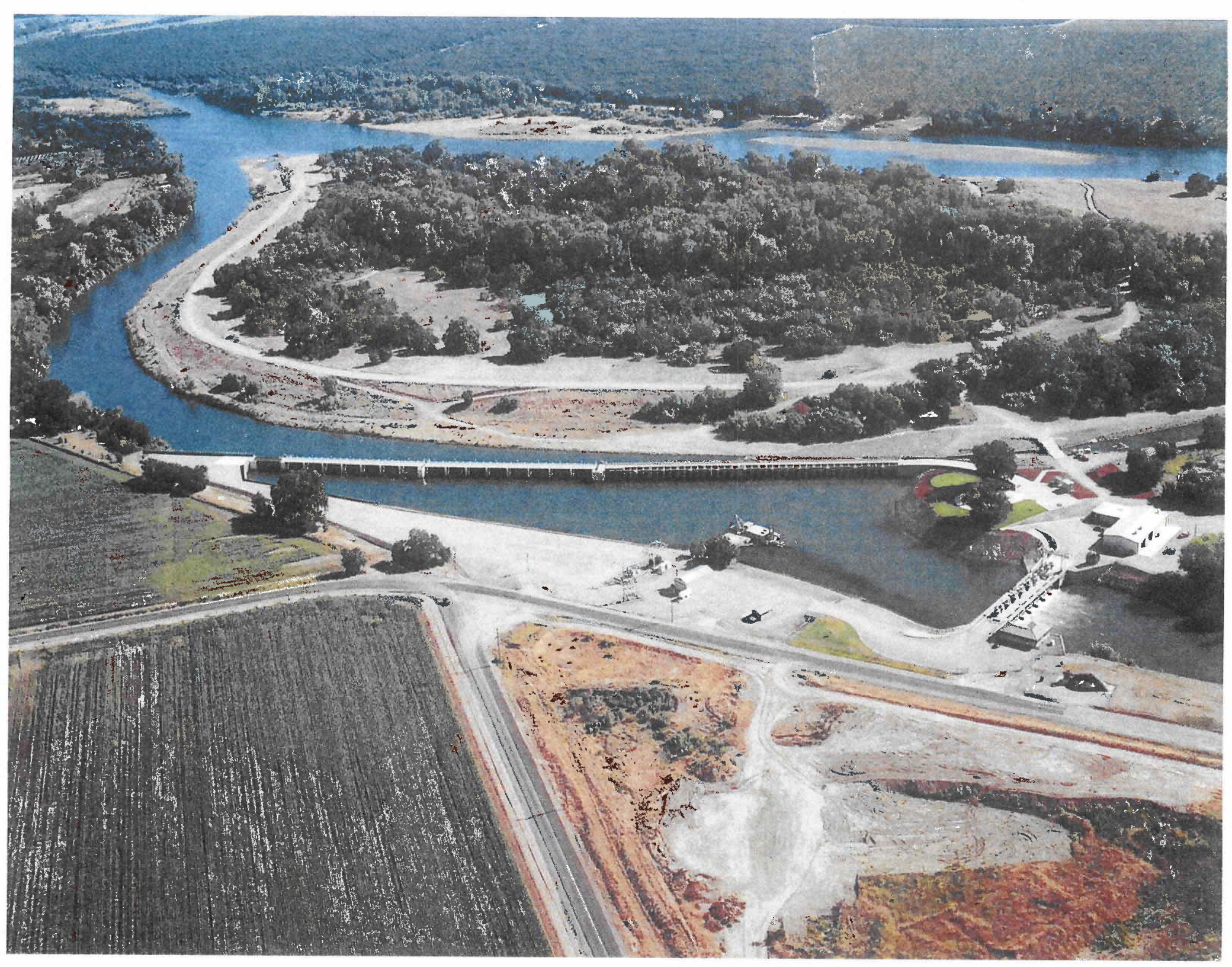


## CONCLUSION

The total initial cost of the SCADA project is currently about \$2.7 million; however, GCID expects this cost to increase as more sites are added. While an expensive investment, GCID is adding tools to the toolbox that will improve conveyance system efficiency, conserve water, improve water quality by reducing Sacramento River diversions by approximately 40,000 acre-feet annually, improve river water temperature to benefit the endangered salmon, and conserve roughly 500,000 KWH annually. From a data perspective, it is now possible to collect real-time, historical, relational and transactional data to create a single virtual data resource that can access, aggregate, correlate and present role-appropriate information to canal operators, supervisors and management. Not all benefits have been realized in the short period of time that SCADA has been implemented, but it is anticipated that in future years GCID will meet and possibly exceed all the primary objectives.

The 2011 irrigation season was the first full season in which GCID operated the main canal in the fully automated position. The benefits were apparent in that service to the growers increased, and fewer man-hours were needed to operate the canal system. SCADA has enabled the District to meet all public policy requirements, while continuing to adhere to the District's mission statement of delivering a reliable supply of water, while protecting the environment and economic viability in the region.









## Long-term Protection for Fisheries

Glenn-Colusa Irrigation District (GCID) has historical water rights on the Sacramento River dating back to 1883, and was one of the first large-scale agricultural water users. The District conveys Sacramento River water through irrigation canals to approximately 141,000 acres of valuable, productive agricultural land. In addition, GCID delivers water to 20,000 acres of critical wildlife habitat comprising the Sacramento, Delevan, and Colusa National Wildlife Refuges.

GCID's Hamilton City pump station is located approximately 100 miles north of the City of Sacramento. The pump station is located on an oxbow off the main stem of the Sacramento River. River flow passes through the fish screens where a portion of it is pumped into GCID's main irrigation canal. The remaining flow in the oxbow passes by the screens and returns to the main stem of the Sacramento River.

GCID diverts a maximum of 3,000 cubic feet per second (cfs) from the Sacramento River, with the peak demand occurring in spring, often at the same time as the peak out-migration



*Aerial photo of the District facilities*

The most important objective of the GCID Fish Screen Improvement Project is to protect fish and wildlife, while ensuring a reliable water supply to District users.

of juvenile salmon. Four runs of Chinook salmon (fall, late fall, winter, and spring) use the Sacramento River. In general, all four runs have declined over the past 25 years. One reason for the decline was the lack of fish screens, or in the case of GCID, poor performance of an existing 20-year-old drum screen.

Because GCID diverts up to 25% of the Sacramento River flow at Hamilton City, GCID pumping operations were identified as a significant impediment to the downstream juvenile salmon migration. Helping fish pass GCID's main diversion facility has been a major challenge in sustaining this important agricultural area. Improving fish passage in the Sacramento River is one of the primary elements in the restoration plans being developed for the anadromous fisheries in the Central Valley by both the U.S. Fish and Wildlife Service and the California Department of Fish and Game.

In 1992, GCID proposed the construction of an interim flat-plate screen across the trashrack in front of the rotary drum screens. The interim flat-plate screen was installed in August 1993. The bypass return channel was also altered to reduce the time it takes for fish to return to the river, thereby enhancing fish protection. Biological monitoring of the interim measures amply demonstrated that the flat-plate screen is a viable method of ensuring long-term fish protection in the Sacramento River.

The design of the long-term screen solution was based, in part, on the interim measures implemented by GCID, with federal assistance from the U.S. Bureau of Reclamation (USBR). A cooperative effort, involving GCID, California Department of Fish and Game, the USBR, the U.S. Army Corps of Engineers, the California Department of Water Resources, NOAA Fisheries, (formerly the National Marine Fisheries Service), U.S. Fish and Wildlife Service, and California State Reclamation Board, resulted in the construction of a state-of-the-art fish screening facility at the Hamilton City pump station.

The GCID Fish Screen Improvement Project minimizes loss of all fish in the vicinity of the pumping plant diversion and meets current fish screening criteria, while maximizing GCID's capability to divert water to meet its water supply delivery obligations.

## Project Funding

The \$76 million project includes the cost of the fish screen, gradient facility, planning, design, environmental planning, and evaluation and monitoring.

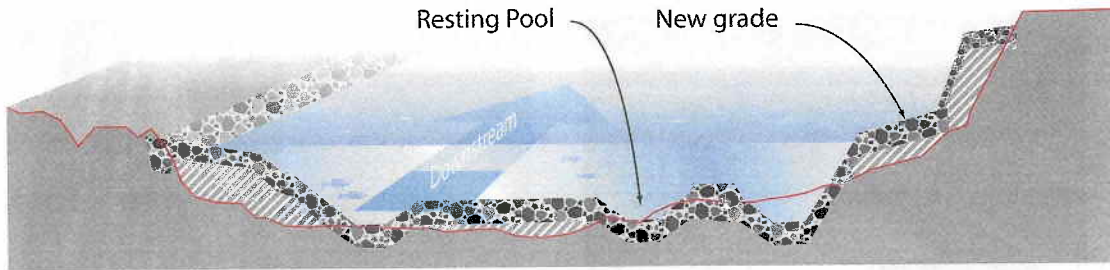
The Central Valley Project Improvement Act (CVPIA) expressly authorized the fish screen improvements at GCID. The CVPIA allocated 75% of the cost to the USBR and the remaining 25% was divided equally between GCID and the State of California.



## Project Objectives

- Ensure minimal impact of water diversion on fish and wildlife
- Make entire system fish-friendly
- Maximize GCID's capacity to pump water to meet delivery obligations

## Beneath the Gradient Facility Surface



Rock slope protection    Fill    Original grade    River

Cross-section view of the gradient facility, which emulates naturally occurring riffles in the Sacramento River



View of fish screen facility from Montgomery Island



Aerial photo of District facilities, including the gradient facility, looking south

The U.S. Army Corps of Engineers designed and managed construction of the gradient facility.

## Project Components

### Fish Screen Extension

The USBR was responsible for the design and construction of the screen extension portion of the project. The new screen consists of an approximately 620-foot extension to the existing interim fish screen, upper oxbow channel improvements, two of the three bypass entrance structures, a new screen wiper (cleaning) assembly, and a flow baffling system to ensure necessary uniform hydraulic conditions across the screen. The screen cleaning wipers and screen baffling system were designed in cooperation with GCID consultants. Construction began in May 1998 and the major components were completed in September 2000.

### Gradient Facility

The gradient facility provides fish-friendly hydraulic conditions designed to ease upstream and downstream fish passage, while providing adequate depths for recreational boats.

The in-river portion of the gradient facility includes sheet piles at specified elevations and intervals in the riverbed. The buried sheet piles are surrounded and covered by rock slope protection. Placement of rock slope protection upstream and downstream along both the river channel and river levee banks helps maintain river channel alignment through the in-river portion of the facility.

### Other Project Features

Modifications to the existing interim screen involved one of the new bypass entrances, a new screen cleaning system, flow control baffles,



### Major Project Attributes

- 620-foot-long fish screen extension
- Screen cleaning assembly
- Channel improvements
- Gradient facility

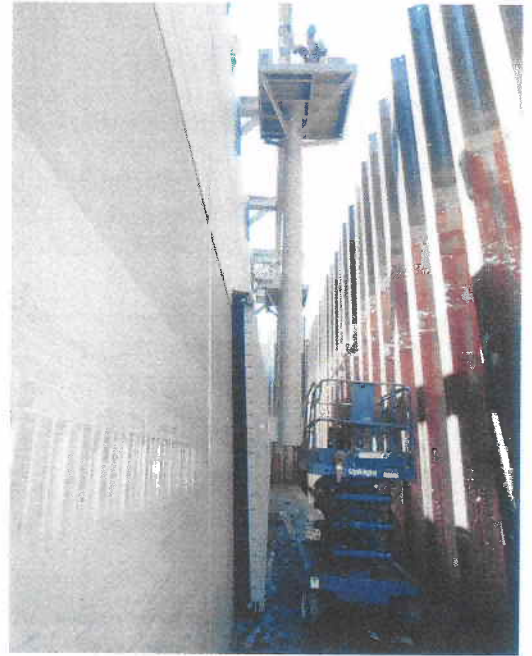




The water control structure resembles a long-throated flume to balance hydraulic conditions



54-inch steel pipe with mortar lined and coated bypass piping to allow tired or stressed fish to bypass structure and be routed downstream of the screens



One of eight sweep-cleaning masts with screen-cleaning brushes attached



View of poppies in pump station forebay; fish screen in background



## Design Challenges

- Ensure a fish-friendly system
- Maintain water deliveries during construction
- Guarantee environmental compliance by conforming with permitting requirements and construction timing windows

structural support enhancement, extension of existing concrete abutments, and completion of the concrete deck.

The lower oxbow channel and training wall improvements help meet hydraulic criteria across the facility. The forebay was enlarged to accommodate the new screen.

In addition, GCID designed a water control structure (weir) to maintain the water elevation at the screens and a removable bridge to allow access to Montgomery Island for routine dredging. These elements were constructed under the USBR's contract.

This significant project represents the culmination of almost 13 years of effort by numerous agencies and countless individuals.

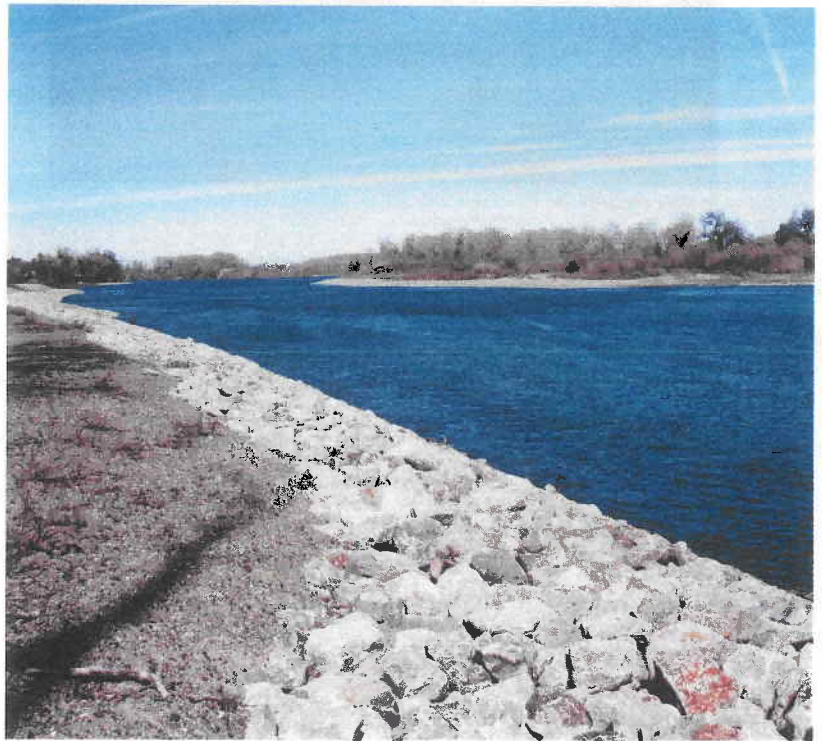
According to GCID Board President Don Bransford, "GCID is committed to obtaining lasting protection of anadromous fisheries at its diversion. The District's goal is to minimize the impact of its diversion on fish and wildlife, while ensuring a reliable water supply to its farmers. The completion of the Fish Screen Improvement Project is a milestone in the District's history."

## Sacramento River Channel Restoration



A major flood in January 1970 significantly changed the shape and flow of the Sacramento River downstream of the Glenn-Colusa Irrigation District (GCID) intake channel. Approximately 4 miles north of Hamilton City, a meander was cut off, which reduced the river reach by approximately 2.5 miles (RM 202.5 to RM 205). The riverbed gradient within this reach continued to degrade with seasonal flood events. The degraded river gradient decreased water surface elevations by 3 feet at the GCID diversion, leaving much of the fish screen out of the water. The lower water elevations contributed to unacceptable fishery losses at the existing drum screen facility.

In 1989, the NOAA Fisheries (formerly the National Marine Fisheries Service) designated the winter-run Chinook salmon as an endangered species. In 1990, federal legislation listed the fish as threatened. Growing resource agency (NOAA Fisheries, California Department of Fish and Game, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers [USACE], U.S. Bureau of Reclamation [USBR], and California Department of Water Resources)



*Upstream view of Sacramento River gradient facility and rock slope protection*

Stabilization of the Sacramento River channel is essential to the success of GCID's fish screen project.





*In-river excavation*



*In-river construction using drag line*



*In-river construction using longitudinal berm*



## Project Objectives

- Ensure fish-friendly flow conditions by emulating natural riffles on the riverbed
- Achieve efficient screen operation by restoring and maintaining the original water surface elevations at the fish screen
- Facilitate safe and effective fish passage across the screen by providing appropriate water velocities
- Provide appropriate water surface elevations to safely conduct fish through the bypass system under gravity flow
- Enable recreational boat navigation in the vicinity of the GCID intake by providing sufficient water depth in the main river channel

concern over the loss of juvenile salmon at the GCID intake led to a federal court injunction against GCID pumping any water out of the river. A stipulated agreement was reached in 1991 that allowed GCID to divert a limited amount of water during the winter-run Chinook's peak migration period, if improvements were made to the intake and exit channels and screening facilities.

During the early 1990s, GCID and the resource agencies began a joint effort to develop a long-term solution. The existing drum screen facility was retrofit with a vertical flat-plate fish screen facility to enable GCID to divert at lower river levels and still allow for safe fish passage. This screen was only an interim solution because it did not meet the resource agencies' new and more stringent performance criteria.

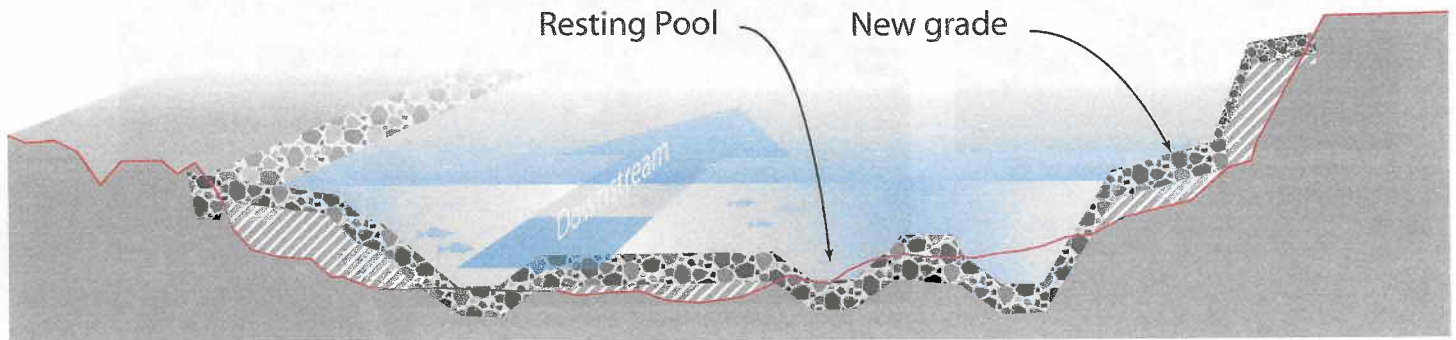
To protect fish and facilitate their safe passage past the GCID intake and pump station, GCID and USBR completed construction of a flat-plate fish screen facility. This approximately 1,100-foot-long structure consists of the 480-foot interim screen, installed in 1993 and upgraded in 2000, and a 620-foot screen extension, completed in 2000.

## The Gradient Facility Project

A long-term solution known as the Gradient Facility was developed to control the meandering of the Sacramento River so that the flow would not be reduced at the intake again.

The USACE was the lead agency for the design and construction of the gradient facility (or riffle) in the Sacramento River. The gradient

# Beneath the Surface



**Rock slope protection** **Fill** **Original grade** **River**

*Cross-section view of the gradient facility, which emulates naturally occurring riffles in the Sacramento River*

facility is critical to the long-term proper operation of the new fish screen structure under inevitable changing river conditions. It ensures effective fish screen operation by stabilizing the riverbed to provide the required water surface elevation at the fish screen.

It also facilitates safe and effective fish passage by providing adequate flow velocity past the screen, as well as flow conditions that enable the screen facility fish bypass system to safely conduct fish downstream of the screens under gravity flow. The design of the gradient facility emulates naturally occurring riffles in the Sacramento River and provides sufficient water depth for recreational boating through this reach of the river.

## Gradient Facility Components

To achieve the desired natural riffle configuration, the in-river portion of the gradient facility includes sheet piles placed at specified elevations and intervals in the riverbed. The top of the structure is as much as 4 feet above the original riverbed. The rock slope protection is supplemented by 3 sheet-pile cutoff walls that extend beyond either riverbank to protect the gradient facility during storms. The buried sheet piles are surrounded and covered by rock slope protection, which extends 1,000 feet along the river channel and along approximately 2,500 feet of the levee banks, both upstream and downstream of the structure. The rock slope protection maintains the proper



## Major Project Elements

- Gradient facility consisting of sheet piles and rock slope protection to emulate natural riffles and stabilize the riverbed
- Bank and channel rock slope protection to maintain the river channel alignment and protect the gradient facility and fish screen from damage during high flows
- Revegetation of the construction site and offsite habitat restoration to mitigate and compensate for effects of construction activities





Replanted vegetation along the banks of the gradient facility



Aerial photo of gradient facility construction on east side of river



## Project Challenges

- Completion of the project in one construction season to comply with regulatory restrictions on the annual timing and duration of in-river construction to minimize impacts to fish
- Concurrent construction of both the fish screen and gradient facility
- Uninterrupted delivery of irrigation water supplies during construction



Sheetpile wall with rock slope protection in place

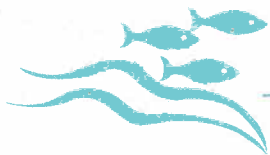


Installation of one of the sheet pile cutoff walls

river channel alignment and protects the gradient facility and fish screen from damage during high flows. A backwater effect resulting in slightly higher water surface elevations upstream is generated by a slight downstream constriction of the protected banks.

## Revegetation

Rock slope protection was covered with fill materials to create a surface to replant riparian vegetation including grass seed and trees, such as willows, elder, ash, alder, valley oak, sycamore, and cottonwood.



## Monitoring the Success of the GCID Fish Screen

The Fish Screen Improvement Project's goal is to provide protective fish passage while ensuring a reliable water supply to Glenn-Colusa Irrigation District (GCID). To demonstrate that the project has achieved its goal, the facility must pass certain performance tests developed by the resource agencies and GCID. The testing program is called the Fish Protection Evaluation and Monitoring Program (FPEMP). Testing is performed under the direction, guidance, and review of the Technical Oversight Committee (TOC), which is composed of representatives from the NOAA Fisheries (formerly the National Marine Fisheries Service), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), U.S. Army Corps of Engineers (USACE), California Department of Fish and Game (CDFG), and GCID.

The FPEMP activities and schedule are flexible and can be amended each year in response to the previous year's results. The TOC reviews preliminary results and determines if any changes or modifications to the testing program are required. Final results of the overall



Maintaining rotary screw trap

“GCID is committed to obtaining lasting protection of anadromous fisheries at its diversion. The District's goal is to minimize the impact of its diversion on fish and wildlife, while ensuring a reliable water supply to its farmers.”

*GCID President, Don Bransford*



evaluation program are ultimately submitted to the TOC for review and approval.

The FPEMP has two major components: biological and hydraulic monitoring.

### The Biological Testing Program

The biological testing program is determining whether fish are protected and how the screen affects fish behavior and health. The following tests are conducted near the fish screen facility:

- Fish survival along the screen
- Biological performance of the gradient facility
- Fish use of the internal bypass system
- Fish migration rate/behavior tests
- Potential physical injury and delayed mortality of fish

#### Fish Survival Tests

Fish survival is measured as juvenile fish pass the fish screen. Experiments are conducted using marked or tagged juvenile salmon and steelhead. The fish are released near the facility, then recaptured at downstream locations to determine the survival rates. Because river and pumping conditions at the site are always changing, the tests are conducted over a wide range of river and pumping conditions, with the bypasses open or closed, to include most of the conditions that will occur in the future.

The tests identify reasons why fish don't survive such as:

- Fish getting stuck on the screen (impingement)
- Fish getting pulled into, under, or around the screen (entrainment)
- Whether the facilities make fish easier than normal to capture by other fish or birds (predation)
- Whether the screens, water control structure, or internal fish bypass system are causing physical injuries

Each of these factors is being studied through a series of experiments and monitoring activities to determine the best methods for operating the fish screen facility.

#### Biological Performance of the Gradient Facility

The gradient facility was designed to minimize the project's effects on the upstream migration of all adult fish and the downstream migration of juvenile fish. The gradient facility is intended to provide water depths and velocities similar to those in natural riffles in the upper Sacramento River. As with the tests at the fish screens, the gradient facility will be evaluated over a wide range of river flows.

#### Upstream Migration

To analyze any potential influence of the gradient facility on upstream migration, sturgeon

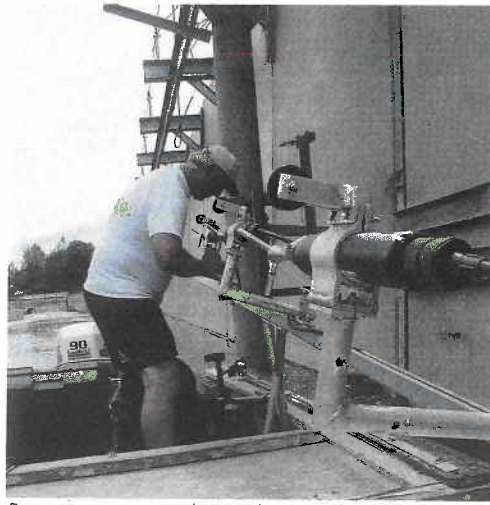


### Monitoring Objectives

- Evaluate the ability of the fish screen facility, gradient facility, and bypass system to pass fish safely and expediently
- Evaluate the optimum operation by measuring velocities at the fish screens, bypass channel, gradient facility, and water control structure
- Review test results and approve long-term operation and maintenance plans or make recommendations for corrective measures



Processing fish for mark and recapture study



Preparing to mount three velocity probes on a screen sweep



Tagging test fish for predation studies

are captured downstream of the site and fitted with radio transmitters. Their upstream movement through the area is monitored, and any changes from normal fish migration behavior, such as delays at the site, will be assessed.

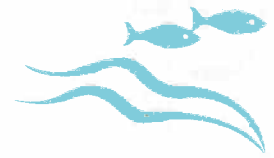
### Downstream Migration

The principal concern for downstream migration of young fish is possible increases in predation rates. Extensive baseline monitoring of predatory fish abundance was performed at the gradient facility site and other natural sites prior to construction. Now that the gradient facility is complete, monitoring of predatory fish

abundance and distribution within the facility and other nearby sites will reveal if any changes occur.

### Fish Migration Rate/Behavior Tests

Travel times of individual fish traversing the length of the screens or passing through the bypass system are determined by releasing tagged fish at a variety of locations in front of the screens or directly into the bypasses. The tags (called PIT tags for “passive integrated transponder”) have individual identification codes that are activated and read by a radio transponder activator. PIT tags are approximately the size of a grain of rice and



## Monitoring Attributes

- Detailed fish handling, marking, and tagging protocols to ensure that accurate data collection and statistical results will be achieved
- Extensive design, fabrication, and testing of equipment for both biological and hydraulic monitoring
- Combined biological and hydraulic monitoring of each facility component used to adjust and optimize performance, and maximize fish passage success



A four month old salmon fingerling to be measured, recorded, and released



Tagging test fish for predation studies

are surgically implanted in the body cavity of the young fish. The tags do not impair normal activities or behavior. Measuring the actual travel time of individual fish provides information to help optimize screen operation for safe fish passage.

#### Potential Physical Injury and Delayed Mortality of Fish

The potential for physical injury to young salmon is assessed by holding and monitoring recaptured fish that were released at various locations in front of the screens or inside the fish bypass system. The fish are held at the site and monitored daily for 5 days. Mortality for these fish will be compared to mortality of “control” fish to help determine whether the screen facility is causing physical injury.

#### The Hydraulic Testing Program

Fish passage relies on the interrelation between project hydraulics and fish behavior. Fish screen hydraulics include water moving past the screen, water moving through the screen, water moving through the bypass system, and water staying in the main river channel. Enough water needs

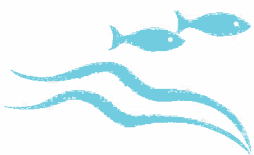
to flow past the screen quickly enough (velocity) to transport the fish back to the river as quickly as possible, and slow enough through the screen to not impinge the fish.

Testing and monitoring system hydraulics offers the best chance for success of a fish passage project by helping to identify and avoid adverse hydraulic conditions. Maintaining hydraulic balance across the system helps maximize the opportunities for fish to safely pass through the facility.

- Adequate velocity past the screen to move juveniles quickly to the river and minimize predator habitat
- Approach velocities to the screen that meet state and federal criteria
- Effects of varying water surface elevations and diversion flows on intake and screen hydraulics
- Uniformity of flows through the screens
- Slow velocity areas that may harbor predators
- Velocity and depth profiles through the gradient facility near Montgomery Island

#### Conclusion

Data collected from the FPEMP will be used to ensure that the GCID project is performing to design criteria.



#### Project Elements

- Biological Testing Program
- Hydraulic Testing Program



# Habitat Restoration for a Healthier Environment



Glenn-Colusa Irrigation District (GCID), in partnership with the U.S. Bureau of Reclamation (USBR), completed construction of fish screens at its Hamilton City pump station on an oxbow channel off the Sacramento River main stem. The U.S. Army Corps of Engineers (USACE) constructed a gradient facility on the main stem to restore and stabilize the river channel and surface water elevations at the fish screen to ensure safe fish passage conditions and effective screen performance.

## Benefiting People, Fish, and the Environment

The fish screen and gradient restoration facility were designed and constructed to benefit fish, particularly protected species of anadromous (i.e., migratory) fish, such as Chinook salmon and steelhead trout. These facilities enable GCID to divert its full entitlement of water with minimal impact to fish. This benefits people by helping farmers to grow the food that feeds our country and keeping the Sacramento Valley economy vibrant. The facilities also allow GCID to deliver a reliable water supply to three national wildlife refuges to maintain and enhance critical habitat for waterfowl and other wildlife.



*Elderberry mitigation site*

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Elderberry is a host plant to the threatened valley elderberry longhorn beetle (VELB) and is critical to the VELB's long-term survival.

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## Mitigation Objectives

- Maintain protection of threatened VELB
- Compensate for loss of elderberry plants and associated riparian vegetation
- Ensure protection of river and aquatic habitats and wildlife from excessive sedimentation by restoring and maintaining riparian vegetation communities

## Mitigation and Monitoring Attributes

- To preserve 211 elderberry plants in the construction zones, they were transplanted to four nearby protected sites along the river in a process purposely timed to ensure minimal disturbances to the VELB during critical periods of its life cycle
- To create a natural habitat along the river for the VELB, the 211 transplants were planted along with 6,718 riparian associates in 29 acres of land specifically set aside for mitigation
- To ensure that plant survival rates and other mitigation requirements were met, transplant sites were monitored for 3 years



Elderberry bush in bloom



Closeup of elderberry bush in bloom

Although the fish screens and gradient facility benefit people, fish, and the environment, any construction in and along the river can potentially result in environmental impacts. A project Environmental Impact Report/ Environmental Impact Statement (EIR/EIS) prepared by USBR, USACE, GCID, and California Department of Fish and Game, in cooperation with NOAA Fisheries (formerly National Marine Fisheries Service), described the potential environmental effects of constructing the fish screens and gradient facility. A mitigation and monitoring plan prepared in conjunction with the EIR/EIS specified required mitigation actions and ensured their successful implementation.

### Valley Elderberry Longhorn Beetle Mitigation Project

It was determined that construction of the facilities would affect elderberry plants and other riparian vegetation. Elderberry is a host plant to the threatened VELB and is critical to

the VELB's long-term survival. To mitigate the impact, a total of 29 acres was planted with 211 elderberry plant transplants and 6,718 riparian associate seedlings at 4 nearby protected sites along the river.

Transplanting was performed along with field monitoring for 3 consecutive years to ensure that the growth and survival rates and field conditions of the transplanted vegetation satisfied the conditions specified by the resource agencies.

The selected sites are protected and, thus, will provide productive habitat for the VELB and many other wildlife species in perpetuity. The riparian vegetation community created through GCID's mitigation program also will help to keep the river and its habitats and wildlife healthy by filtering out sediments and other constituents before they reach the river and by preventing riverbank erosion.



## Year-round Water Supply for Wildlife

Glenn-Colusa Irrigation District (GCID) was selected as the preferred delivery alternative to convey a continuous, year-round water supply to three National Wildlife Refuges in the Sacramento Valley.

The Sacramento, Delevan, and Colusa National Wildlife Refuges are contiguous with the boundaries of GCID and receive their total water supply through GCID's irrigation system. In the past, GCID provided conveyance during summer and fall, but was unable to deliver water to the refuges on a consistent 12-month basis because of the nature of the delivery system. One of the critical periods for the refuges is late fall and early winter, the months during which GCID historically shut down its system for maintenance. In addition, some facilities had served dual purposes by conveying drainage runoff during winter and had to be modified for year-round use.

The Central Valley Project Improvement Act was enacted in 1992 to provide for, among other things, restoration and protection of fisheries and wildlife habitat. One of the



Our goal is to maintain the flexibility necessary to provide year-round service to the wildlife refuges with the least amount of disruption to our water users as possible.



provisions of the Act directed the U.S. Bureau of Reclamation (USBR) to increase the wildlife refuge water supplies to optimum levels by 2001. Historically, wildlife refuges did not receive full water supplies during critical dry years and were functioning with less than optimum water supplies in all other years.

In 1994, GCID proposed to use its system to deliver water during these months. This proposal was selected as the most efficient and cost-effective method to increase the quantity and reliability of water supplies to the refuges. The supply to the 20,000 acres of wildlife refuges will increase from 60,000 acre-feet to a maximum of 105,000 acre-feet annually.

A 50-year agreement (2001 - 2050) was negotiated between the USBR and GCID to provide for the conveyance of water to the refuges. Under the previous agreement, the Tehama-Colusa Canal Authority (TCCA) received reimbursement from USBR for water conveyed through the Tehama-Colusa Canal into GCID's system for delivery to the refuges. The new agreement provides for the conveyance of a minimum of 25,000 acre-feet, annually, through the Tehama-Colusa Canal, paid for

by GCID at the same conveyance rate that TCCA charges the USBR.

## The Project

GCID identified approximately 100 minor structures and 7 major structures that required improvement to deliver water to refuges on a year-round basis through the GCID Main Canal.

These structures included the Stony Creek Siphon, Bondurant Slough Siphon, Willows Resident Drain Undercrossing, the Airport Structure Undercrossing, the Baker Creek Crossing, the Willits Slough Crossing, and the Hunter Creek Crossing. Although GCID constructed the Baker Creek Crossing, Airport Structure Undercrossing, and Willits Slough Crossing between 1994 and 1997, they are considered a part of the project.

This project, totaling \$15 million, was part of a cost-share program. The federal government had a 75% cost-share, and the local government cost-share was 25%. Construction on the project occurred over a 2-year period in fall and winter 1998/1999 and 1999/2000.

To implement this project, the District entered into a unique agreement with USBR. Under this agreement, USBR had responsibility for the design and construction of the Stony Creek Siphon, the largest component of the project.



## Project Objectives

- Provide year-round water delivery to refuges
- Achieve 105,000 acre-feet of water delivery annually to the 20,000 acres of wildlife refuges
- Ensure year-round delivery of agricultural irrigation water with minimal disruption





Delevan



Sacramento

Colusa



*Refuge locations and examples of the many varieties of wildlife found in the refuges*

In the past, a temporary gravel dam was placed across the creek every year to allow the District's main canal to convey Sacramento River water through the District. Construction of the siphon was completed in 1999.

GCID had responsibility for all of the remaining 100 minor structures and the three remaining large siphons. District forces performed a portion of the work, with the remainder being performed by outside contractors. Because of the dry weather conditions during the winters of 1998/1999, more work was accomplished than was originally anticipated, which left approximately 30 construction projects to be completed in 1999. The majority of the construction was scheduled for winter to avoid adverse effects on deliveries to the District's water users. Construction undertaken during

the irrigation season featured bypasses around the construction sites.

"Our goal was to achieve the flexibility necessary to provide year-round service to the wildlife refuges with the least amount of disruption to our water users as possible," said General Manager Van Tenney. "With the completion of this project, our growers have the advantage of being able to order water at times of the year that we previously were not capable of delivering water."

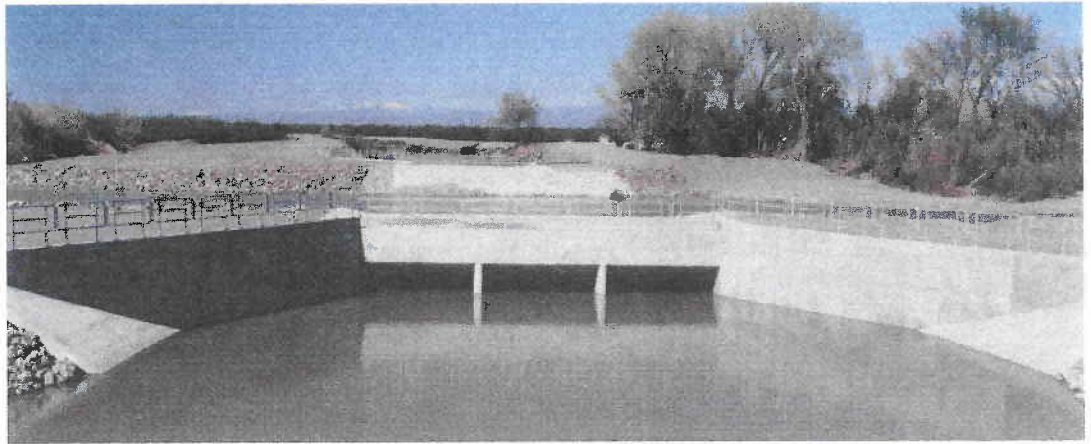
### Benefits

This project enhances deliveries that assist in providing and maintaining wetland habitat for the migratory birds of the Pacific Flyway. GCID has had a long-standing cooperative arrangement with the Sacramento National



### Major Project Facilities

- Stony Creek Siphon
- Bondurant Slough Siphon
- Willows Resident Drain Undercrossing
- Airport Structure Undercrossing
- Baker Creek Crossing
- Willits Slough Crossing
- Hunter Creek Crossing
- Approximately 100 minor structures



The completed Stony Creek Siphon allows GCID's main canal to be routed under Stony Creek



## Design Challenges

- Maintain water deliveries during construction
- Protect facilities from flood damage
- Ensure environmental compliance by conforming with permitting requirements and construction timing windows

Wildlife Refuges, and is now able to increase the level of service provided to the refuges during times of the year when it is essential to receive high quality and quantities of water for migratory waterfowl. The modifications will also allow delivery of water within GCID for winter flooding, which will augment wildlife habitat, assist in the decomposition of rice straw, and provide the opportunity for Stony Creek restoration.

GCID Board President Don Bransford said, "The Board of Directors is very proud to be a part of the Refuge Conveyance Project. We are especially pleased to have the Stony Creek Siphon in place. Our two major priorities have been to see that the fish screen is constructed and to put a siphon under Stony Creek. Routing our canal under the creek affords us the opportunity to deliver water to the refuges during the winter months when there is water in Stony Creek, and not impede any other Stony Creek restoration efforts. This project

improves the water supply situation for wildlife and agricultural users."

According to Gary Kramer, former Sacramento National Wildlife Refuge Complex Refuge Manager, "The main thing the Refuge Complex gains through the Refuge Conveyance Project is an assured year-round water supply. Under the previous circumstances, when GCID ceased service at the end of November, the ability to add water to most of our wetlands was not possible. As a result, we were forced to over-fill our wetlands in the fall in hopes of having enough water to last through the winter." He added, "By maintaining unsatisfactory water levels, we had to compromise our habitat management goals. The completion of the Refuge Conveyance Project allows the delivery and optimum management of water throughout the year, ensuring that we provide the nearly two million ducks, half-million geese, and numerous other wildlife species the best habitat possible."

### **Sites JPA**

The Sites Joint Powers Authority (JPA), comprised of Glenn-Colusa Irrigation District, Reclamation District 108, Tehama-Colusa Canal Authority, Maxwell Irrigation District, Yolo County Flood Control and Water Conservation District, County of Glenn, and County of Colusa, was formed more than one year ago. The mission of the JPA is to be a proponent and facilitator to potentially acquire, design, construct, manage, govern and operate Sites Reservoir and related facilities to improve the operation of the state's water system and to provide a net improvement in ecosystem and water quality conditions in the Sacramento River system and the Delta.

The Central Valley Project and State Water Project were originally very flexible; however, over time the storage and flexibility of the projects eroded due to increases in uses, increases in contractual obligations, endangered species and refuge supplies requirements and climate change.

The California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (Bureau) are working with local, regional, State and federal agencies, and stakeholders to study North-of-the-Delta Offstream Storage (NODOS) opportunities. The purpose of the investigation is to improve the operational flexibility of the Bay-Delta watershed systems by providing integrated and efficient surface storage in the northern Sacramento Valley in a manner protective of the environment.

The Sites JPA is partnering with the DWR and the Bureau to complete a feasibility study and an Environmental Impact Study/Report for the NODOS Investigation to quantify benefits, identify beneficiaries, and meet other requirements as set forth in SB7x\_2 (the Water Bond).

The funds for this effort were recently awarded to the JPA through a grant of \$1.75 million from Proposition 204, (The Safe, Clean, Reliable Water Supply Act of 1996), which provided \$25 million for the "Sacramento Valley Water Management and Habitat Protection Measures." Sites Reservoir is one of the water management tools identified in the Phase 8 agreement "...that could be implemented to develop increased water supply reliability, and operational flexibility." The Phase 8 agreement provided a means to implement projects to help meet Delta water quality objectives.

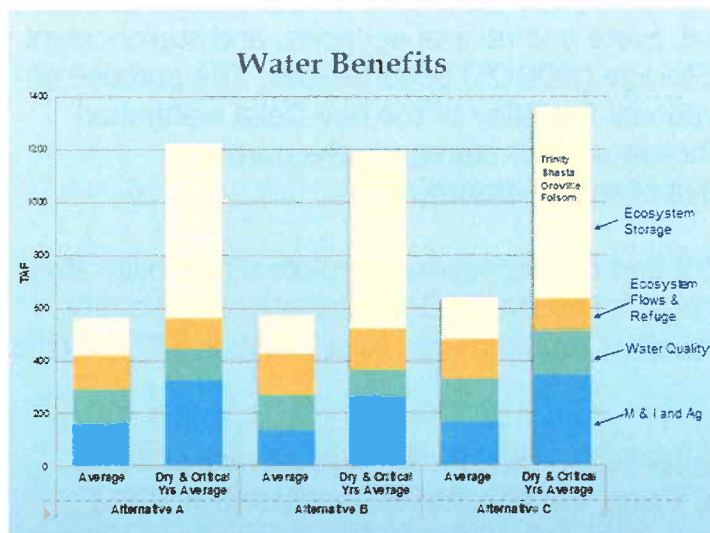
On October 25, 2011, GCID General Manager Thaddeus Bettner represented the JPA and made a presentation to the California Water Commission explaining the foundation principles of the JPA, as well as some of the potential benefits that Sites Reservoir could provide to the environment and to California's water supply.

Foundation principles:

- Sites should meet multiple objectives that can then meet multiple needs
- California’s large water systems have become inflexible; Sites should be operated to provide flexibility back to the system
- Sites must be integrated with existing storage projects
- Sites must perform in “Uncertain Future” scenarios, which includes existing operations and conveyance as well as a post-Bay Delta Conservation Plan scenario
- Sites should maximize existing infrastructure to minimize capital costs
- Sites should minimize the environmental “Footprint” of the reservoir location

The presentation also included a summary of the potential water benefits that could accrue to different ecosystem and water supply needs based on the integration of Sites Reservoir with Shasta, Oroville, Trinity, and Folsom reservoirs.

The figure below depicts the volume of water available during average and critical years under three various storage and conveyance alternatives.



Additional information from the presentation is available from the California Water Commission’s website: <http://www.cwc.ca.gov/cwc/workshops.cfm>

Bettner explained that the investigation and completion of a feasibility study and Environmental Impact Study/Report is essential to determine the public benefit that would be funded from the Water Bond proceeds. This effort will assist in framing the Water Bond debate and whether the Water Bond is on the 2012 ballot.



## SITES RESERVIOR JOINT POWERS AUTHORITY

### FINANCING, OPERATIONAL MODELING, AND OUTREACH ACTION PLAN

#### Guiding Principles of New Storage

New storage will only be viable if it's affordable to the beneficiaries investing in the project (including public benefits), can be constructed and operated in changing delta environmental and conveyance conditions, and is acceptable to local and regional stakeholders.

#### Role of the Joint Powers Authority

To pursue the viability of Sites Reservoir based on the above guiding principles and implement new storage consistent with Water Code Section 79749(a), and the California Water Bond which states:

*"The funds allocated for the design, acquisition, and construction of surface storage projects identified in the CALFED Bay-Delta Record of Decision, dated August 28, 2000, pursuant to this chapter may be provided for those purposes to local joint powers authorities formed by irrigation districts and other local water districts and local governments within the applicable hydrologic region to design, acquire, and construct those projects."*

#### Action Plan Components

##### Address Financing and Affordability

Addressing affordability to potential beneficiaries including both water supply and public benefits will be critical to success of the project. While agencies including DWR and USBR are investigating the project based on financial feasibility (does the value exceed the costs?), affordability will address whether beneficiaries have a "willingness to pay" based on the benefits, these approaches are fundamentally differed and critical to repayment of the project.

To address critical elements of affordability, the JPA will focus on the following items:

- Evaluating a new construction cost estimate to replace the current study which is a decade old.
- Expediting construction schedule and scheduling purchasing to minimize construction interest.
- Focusing on financial fundamentals of correlating water supply benefits and public benefits to project costs and allocation, i.e. "What will I get, and what will it cost me?"
- Examining public project investment options including local bonding or full project bonding?
- Analyzing repayment methods including annualized repayment, fluctuating payments based on deliveries, or initial principal payments.
- Coordination with the California Water Commission and the Water Bond Chapter 8 language to propose options for how the public benefits of the project could be funded?
- Valuing additional benefits that will accrue through operational flexibility?
- Develop a financial modeling tool to evaluate different funding and payment scenarios.

### Address Operational Modeling Scenarios

Through the Administrative Draft Feasibility Report (FR) and Environmental Impact Report/ Environmental Impact Study, the Sites Reservoir (NODOS) project has been shown to be capable of providing multi-use benefits sufficient to be feasible from a design, construction, operations, economic and environmental standpoint. The question becomes how would the multi-use benefits of NODOS change if integrated with other programs such as the Bay Delta Conservation Plan (BDCP).

To date, the agencies have viewed BDCP and other programs as speculative and too uncertain to evaluate in the project alternatives, however, the JPA does not have this limitation when evaluating alternatives. This effort will examine BDCP and NODOS modeling and information and investigate a scenario that integrates elements of NODOS and BDCP together. The result would demonstrate how NODOS can provide multi-use benefits under existing conditions with no new conveyance as well as potentially identify new opportunities for the BDCP and NODOS projects.

### Address Outreach to Stakeholders

The JPA is actively funding and coordinating with DWR and the Center for Collaborative Policy to focus outreach on local and regional stakeholders including the following:

- Landowners within the entire Project Footprint
- Colusa and Glenn Counties affected by road relocation, bridge, recreation areas, and tax base
- Sacramento Valley Region including other water districts, counties, IWRM groups
- Environmental interests to discuss aquatic and terrestrial needs and objectives

A major benefit of the JPA conducting outreach is that it is not limited by state and federal concerns of the Sites project being pre-decisional prior to the completion of the environmental review process. The JPA can pursue the project that maximizes benefits at the lowest cost while keeping all interests equally informed. Additionally, this outreach effort will improve the content of the environmental documents to improve the formal public review process.

# RECLAMATION

## *Managing Water in the West*

### North-Of-The-Delta Off stream Storage

#### Facts

- New 1.8 million acre-foot off stream reservoir proposed to divert Sacramento River water
- Estimated \$3.4 to \$3.9 billion to construct
- Facilities may include: 2 main dams, 9 saddle dams, pumping and power generation plant, larger Funks Reservoir, new regulating reservoir, and new pipeline from the Sacramento River

The ongoing North-of-the-Delta Off stream Storage (NODOS) Feasibility Study (Study) a joint undertaking between Reclamation, the California Department of Water Resources (DWR), and recently, the Sites Joint Powers Authority (JPA), was authorized by Congress in 2003. The feasibility study was included in the Surface Storage Program described in the 2000 CALFED Bay-Delta Program Record of Decision. The CALFED Bay-Delta Program includes a series of interrelated programs to provide comprehensive solutions to the problems of ecosystem quality, water supply reliability, water quality, and Delta levee and channel integrity.

The Study is a collaborative effort to evaluate the feasibility of alternative plans to increase surface water supply storage north of the Sacramento-San Joaquin Delta, improve water management and flexibility for beneficial uses in the Bay-Delta system, and restore ecological health in the Sacramento River and Delta. Water would be diverted from the Sacramento River during high flow periods via new screened diversion facilities and conveyed via existing and new pipelines. Water would be delivered to water users via existing and new conveyance facilities and through flows returned to the Sacramento River.

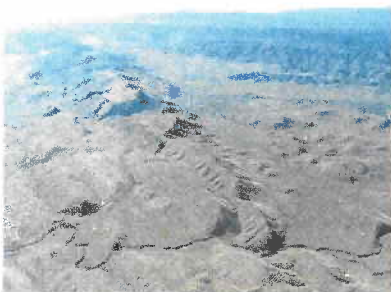
#### Objectives

##### Primary objectives include:

- Increase water supply, water supply reliability, and water management flexibility
- Improve Delta water quality
- Increase anadromous fish survival and the health of other endemic aquatic species populations in the Sacramento River
- Provide flexible power generation to support renewable energy, such as wind and solar

##### Secondary objectives include:

- Develop water-based recreation opportunities
- Provide additional flood damage reduction benefits on local streams





## Alternatives Considered

### Alternatives currently considered in-

- Construct a 1.27 million acre-foot Sites reservoir and a new pipeline used to convey water to and from the Sacramento River in addition to using existing canals, new hydropower facilities, and ecosystem enhancement actions
- Construct a 1.81 million acre-foot Sites reservoir and a new pipeline used to convey water to and from, or alternatively just from, the Sacramento River in addition to using existing canals; new hydropower facilities; and ecosystem enhancement actions
- No Action

## Potential Benefits

(Source: <http://sitesjpa.net/Projects.html>  
**NODOS Power Point Presentation 8/3/2011**

- Increased water supply reliability ranging from 530,000 to 640,000 acre-feet per year in dry periods for all beneficial uses
- Increased water storage from 1.27 to 1.81 million acre-feet per year providing greater system flexibility
- Increased September cold water pool carryover storage in existing state/federal system of reservoirs
- Increased water supply for ecosystem enhancement and refuges ranging from 128,000 to 152,000 acre-feet per year

## Status

2012 – Sites JPA becomes a cost-share partner for the Investigations

2012 to 2013 - Complete Draft Feasibility Report and EIS/R

2014 to 2016 - Complete Final Feasibility Reports and EIS/R

## Contact Info

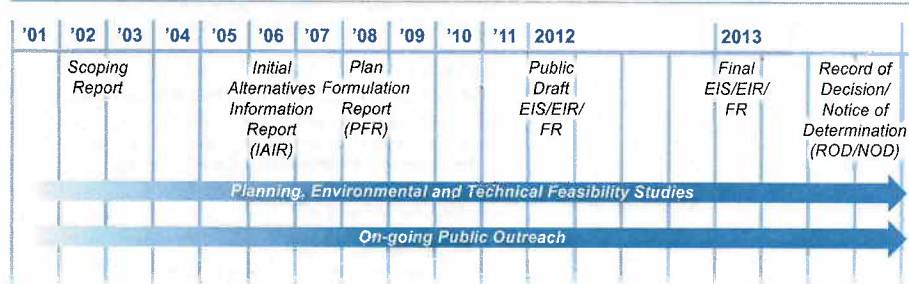
**Sharon McHale,**  
**Project Manager**  
(916) 978-5060  
[smchale@usbr.gov](mailto:smchale@usbr.gov)

**Project Website**  
[www.water.ca.gov/storage/](http://www.water.ca.gov/storage/)

## Potential Project Location

Approximately 10 miles west of Maxwell, CA, and 70 miles north of Sacramento, CA..

## NODOS Feasibility Investigation Timeline



### What is Offstream Storage?

The NODOS Investigation focuses on offstream storage north-of-the-Delta. Consistent with CALFED solution principles, constructing new dams across rivers (that is, on-stream storage) was not considered. Instead, storage locations that would not add a new dam on a major stream were considered and evaluated. Offstream storage located north-of-the-Delta would require conveying water from the Sacramento River or one of its major tributaries to the new storage location. An offstream storage conveyance system could either use existing diversions and canals or new diversions and conveyance. Water would be diverted during periods of relatively higher flow through the conveyance system, into the new offstream storage reservoir, and stored until it is needed to meet the planning objectives.

Reclamation and DWR are lead agencies pursuant to NEPA and CEQA for the NODOS Investigation and feasibility studies. Reclamation and DWR have taken primary responsibility for preparing the environmental review and feasibility documents. The following agencies have acted as cooperating agencies under NEPA based on their individual jurisdiction or special expertise as it relates to the NODOS project: Sites Project Joint Powers Authority, Bureau of Indian Affairs, Colusa Indian Community Council, Cortina Indian Rancheria, Western Area Power Administration, and the U.S. Army Corps of Engineers.

#### FOR ADDITIONAL INFORMATION

contact Sean Sou, 916.651.9269 (DWR) or Sharon McHale, 916.978.5086 (Reclamation), or visit: [www.water.ca.gov/storage/northdelta/index.cfm](http://www.water.ca.gov/storage/northdelta/index.cfm) or [www.usbr.gov/mp/nodos/index.html](http://www.usbr.gov/mp/nodos/index.html)



## North-of-the-Delta Offstream Storage

### FACT SHEET

### Feasibility Investigation



May 2011

### Primary Planning Objectives



#### Improve Water Supply Reliability

**How**—Through additional surface storage capacity and integrated water system operations, which could improve water system flexibility and reliability for agricultural, urban, and environmental uses. Water stored in the winter during relatively higher flow conditions could allow additional water to be carried over in storage from year to year, helping mitigate the effects of drought and providing emergency water during a catastrophic event in the Bay-Delta or tributary watersheds.



#### Improve Water Quality

**How**—Through dedicated water released from storage that flows to the Delta, which could result in supplemental fresh water flows and improved drinking and environmental water quality during periods when quality is diminished.



#### Provide Flexible Hydropower Generation

**How**—Through hydropower generation timed to support integration of renewable energy sources. Flexible hydropower generation associated with offstream storage could be quickly ramped up or down to complement other renewable energy sources to support reliable operation of the power grid.



#### Increase Fish Survival

**How**—Through the support of specific ecosystem restoration and enhancement actions accomplished by dedicating water in storage for purposes that benefit anadromous fish and other aquatic species. These actions could improve environmental conditions, including improved cold water pool management to benefit fish during extended droughts, and flow modifications to manage river temperatures, habitat conditions, flow stability, and Delta X2.

### Secondary Planning Objectives



#### Develop Additional Recreation

**How**—Through the development of recreation facilities along the perimeter of the proposed reservoir. Recreation opportunities include boating, camping, picnicking, swimming, fishing, and hiking.



#### Provide Incremental Flood Damage Reduction

**How**—Through reduced flows on local streams provided by storage.

### Background

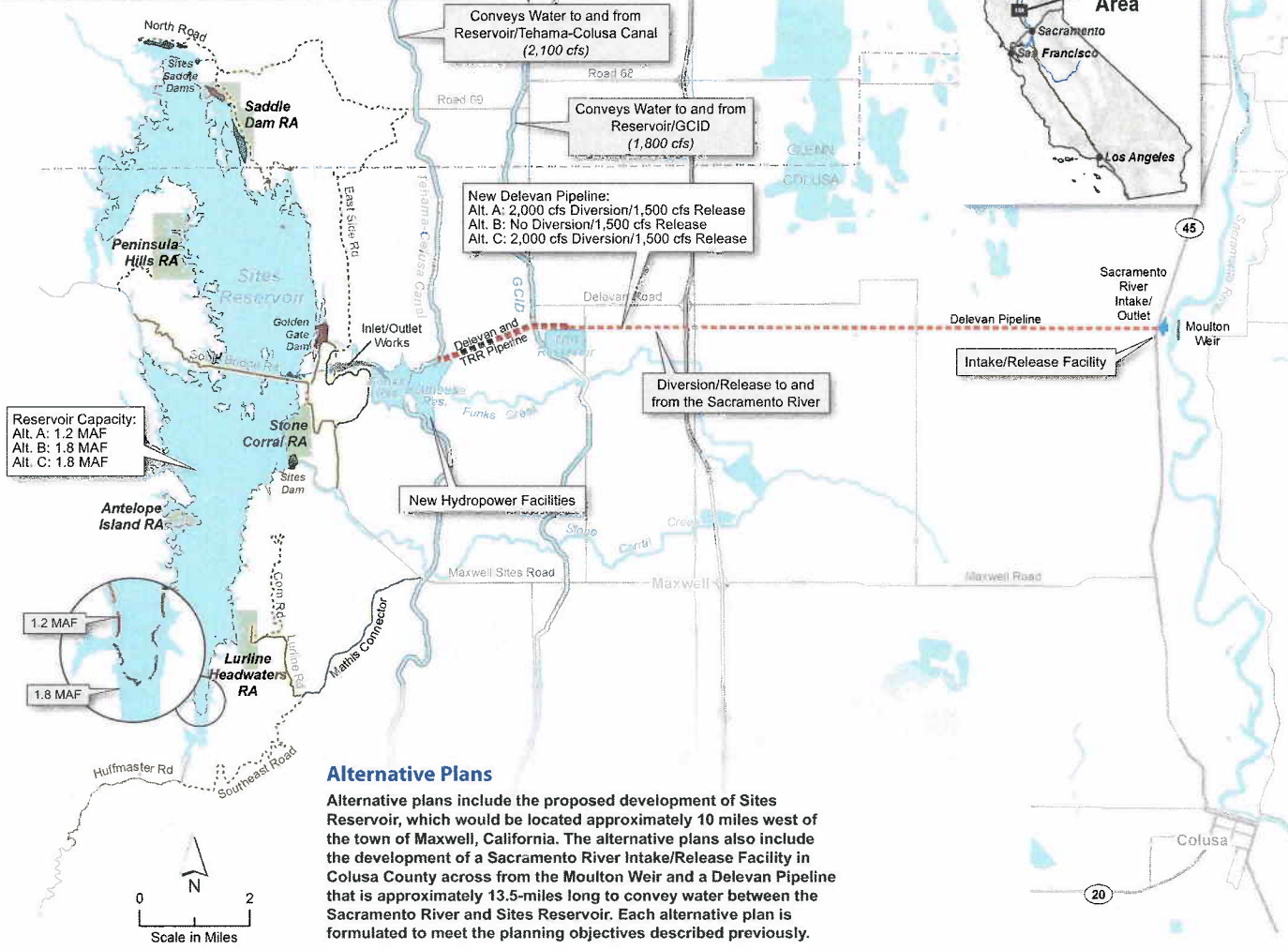
The Bureau of Reclamation and the California Department of Water Resources (DWR), working in cooperation with other federal, state, and local agencies, are studying alternative plans to increase surface storage north of the Sacramento-San Joaquin Delta. The CALFED Bay-Delta Programmatic Record of Decision (2000) identified five surface storage locations statewide for further consideration and analysis. The North-of-the-Delta Offstream Storage (NODOS) Investigation is evaluating the potential for surface storage to support restoration of ecological health and improve water management for beneficial uses in the Bay-Delta system.

The NODOS Investigation is developing an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) to analyze the proposed project alternatives in compliance with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). The EIS/EIR will evaluate a No Action/No Project Alternative and three Comprehensive Alternative Plans. In addition, a Feasibility Report (FR) will evaluate and present the ability of the alternatives to satisfy the NODOS planning objectives.



**Legend**

— New/Improved Road (Paved)	MAF - million acre-feet
----- New/Improved Road (Gravel)	cfs - cubic feet per second
■ Recreation Area Alternatives	TRR - Terminal Regulating Reservoir



**Alternative Plans**

Alternative plans include the proposed development of Sites Reservoir, which would be located approximately 10 miles west of the town of Maxwell, California. The alternative plans also include the development of a Sacramento River Intake/Release Facility in Colusa County across from the Moulton Weir and a Delevan Pipeline that is approximately 13.5-miles long to convey water between the Sacramento River and Sites Reservoir. Each alternative plan is formulated to meet the planning objectives described previously.

**ALTERNATIVE PLANS**

**No Action/No Project Alternative**  
No actions would be taken to provide storage north of the Delta to meet the planning objectives.

**ALTERNATIVE A:  
1.2 MAF Sites Reservoir with Delevan Pipeline**

- 1.2 MAF (million acre feet) Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa Canal and Glenn Colusa Irrigation District (GCID) Canal
- New Delevan Pipeline (2,000-cfs diversion/1,500-cfs release)
- New hydropower facilities
- Ecosystem enhancement actions to support anadromous and endemic fish populations.

**ALTERNATIVE B:  
1.8 MAF Sites Reservoir with Release-only Delevan Pipeline**

- 1.8 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa Canal and GCID Canal
- New release-only Delevan Pipeline (1,500-cfs release)
- New hydropower facilities
- Ecosystem enhancement actions to support anadromous and endemic fish populations.

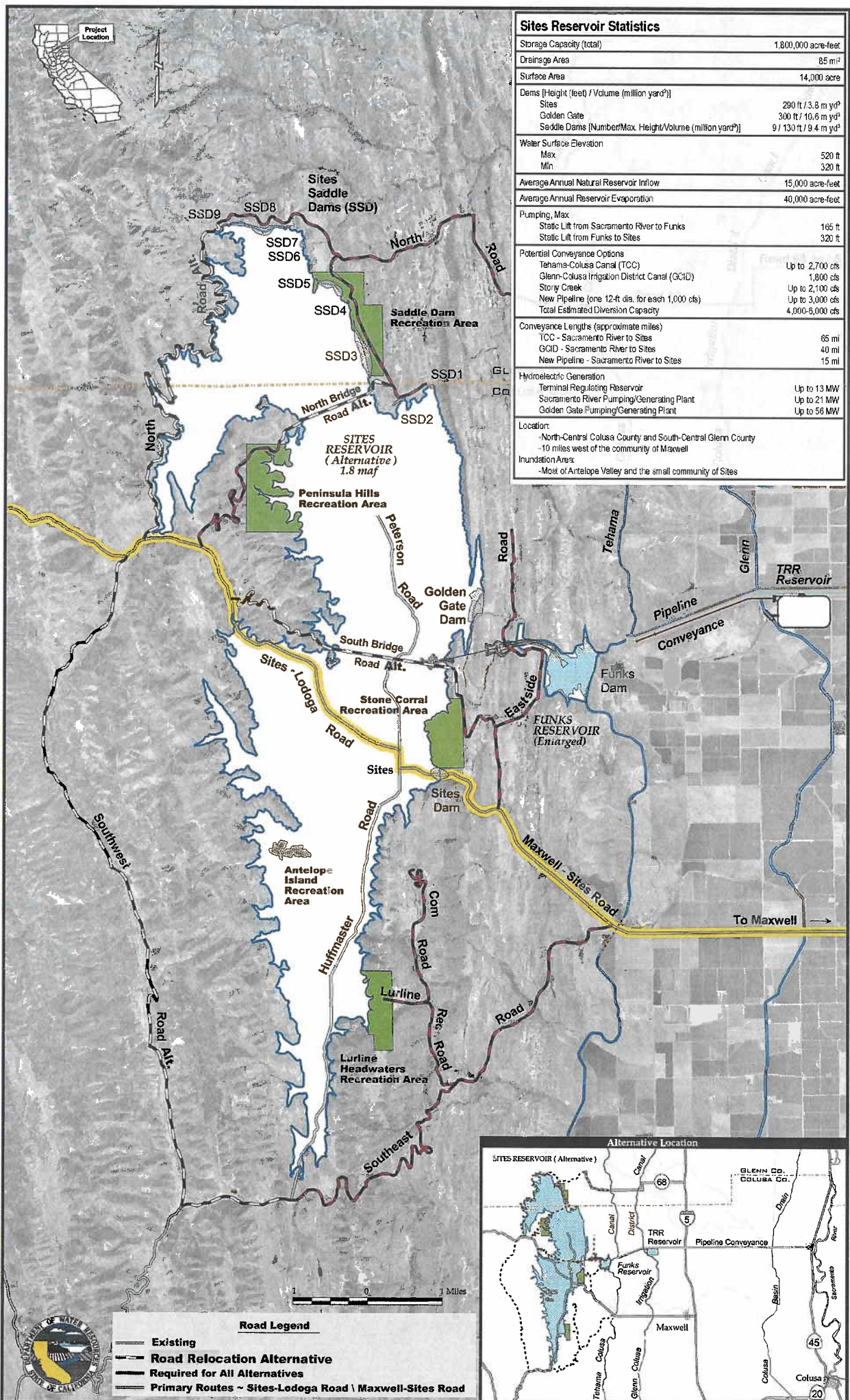
**ALTERNATIVE C:  
1.8 MAF Sites Reservoir with Delevan Pipeline**

- 1.8 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa Canal and GCID Canal
- New Delevan Pipeline (2,000-cfs diversion/1,500-cfs release)
- New hydropower facilities
- Ecosystem enhancement actions to support anadromous and endemic fish populations.

**Alternatives Considered and Eliminated From Further Detailed Analysis**

Initially, 52 alternative reservoir sites were considered before identifying Sites Reservoir as the preferred location for additional storage. The iterative plan formulation and screening process is documented in the Initial Alternatives Information Report (2006) and Plan Formulation Report (2008).





Sites Reservoir Statistics	
Storage Capacity (total)	1,800,000 acre-feet
Drainage Area	85 mi <sup>2</sup>
Surface Area	14,000 acre
Dams [Height (feet) / Volume (million yard <sup>3</sup> )]	
Sites	290 ft / 3.8 m yd <sup>3</sup>
Golden Gate	300 ft / 10.6 m yd <sup>3</sup>
Saddle Dams [Number/Max. Height/Volume (million yard <sup>3</sup> )]	9 / 133 ft / 9.4 m yd <sup>3</sup>
Water Surface Elevation	
Max	520 ft
Min	320 ft
Average Annual Natural Reservoir Inflow	15,000 acre-feet
Average Annual Reservoir Evaporation	40,000 acre-feet
Pumping, Max	
Static Lift from Sacramento River to Funks	165 ft
Static Lift from Funks to Sites	320 ft
Potential Conveyance Options	
Tehama-Colusa Canal (TCC)	Up to 2,700 cfs
Glenn-Colusa Irrigation District Canal (GCID)	1,800 cfs
Story Creek	Up to 2,100 cfs
New Pipeline (one 12-ft dia. for each 1,000 cfs)	Up to 3,000 cfs
Total Estimated Diversion Capacity	4,000-6,000 cfs
Conveyance Lengths (approximate miles)	
TCC - Sacramento River to Sites	65 mi
GCID - Sacramento River to Sites	40 mi
New Pipeline - Sacramento River to Sites	15 mi
Hydroelectric Generation	
Terminal Regulating Reservoir	Up to 13 MW
Sacramento River Pumping/Generating Plant	Up to 21 MW
Golden Gate Pumping/Generating Plant	Up to 56 MW
Location:	
-North-Central Colusa County and South-Central Glenn County	
-10 miles west of the community of Maxwell	
Inundation Area:	
-Most of Antelope Valley and the small community of Sites	

**Road Legend**

- Existing
- Road Relocation Alternative
- Required for All Alternatives
- Primary Routes ~ Sites-Lodoga Road \ Maxwell-Sites Road





# ***NORTH-OF-THE-DELTA OFFSTREAM STORAGE***



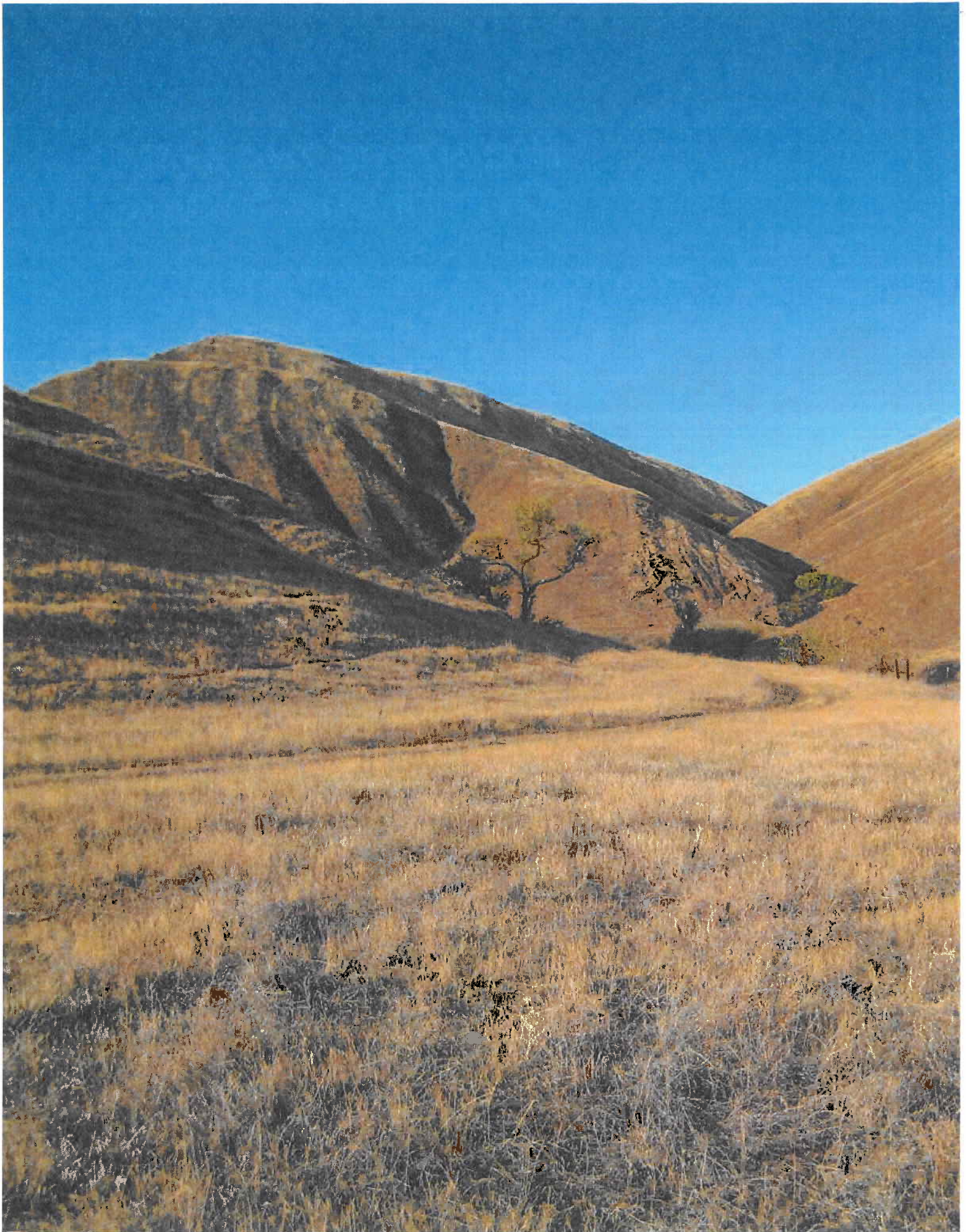
**Investigation Highlights**  
*May 2014*

PUBLIC SAFETY

ENVIRONMENTAL STEWARDSHIP

ECONOMIC STABILITY







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# INVESTIGATION HIGHLIGHTS

## A Summary

- North-of-the-Delta Offstream Storage (NODOS) would provide a robust set of benefits, including water supply reliability for municipal and industrial uses, agriculture, and wildlife refuges; ecosystem enhancement actions to improve fish survival in major northern California rivers and the Sacramento-San Joaquin Delta (Delta); water quality improvements for Delta water users and estuarine species; flexible hydropower generation to support renewable energy sources such as wind and solar; recreation opportunities at the new reservoir and improved recreation at existing reservoirs; and local flood damage reduction below the new reservoir. Total water supply benefits would be up to 500 thousand acre-feet (TAF) per year on average and over 600 TAF per year during dry and critical years.
- The mix of NODOS benefits would also support improved flexibility and long-term viability of the Central Valley Project (CVP) and State Water Project (SWP). As the current drought is showing, flexibility of these projects is impaired during multiple dry years or droughts. In addition to providing the benefits described above, NODOS would improve CVP and SWP flexibility by increasing water in storage, including during drought conditions. Average annual improved storage would be up to 1.4 million acre-feet (MAF); annual drought period storage would be improved by up to 1.1 MAF.
- Estimated project cost ranges between \$3.6 billion and \$4.1 billion.
- Benefits would exceed costs. Net benefits, or the total economic value of annual benefits would exceed total annual costs by \$61 million, \$77 million, and \$72 million for Alternatives A, B, and C respectively. The benefit-cost ratios for the three alternatives would be 1.32, 1.43, and 1.35 respectively.
- NODOS benefits would be resilient. A slightly modified operation and emphasis of objective priorities would be required with Bay Delta Conservation Plan (BDCP) conveyance and operations. The mix of water supply benefits would remain robust. NODOS operations would also be resilient to climate change effects, including potential changes in runoff and sea level rise. Total water supply benefits decreased by 4% in one BDCP scenario; and total water supply benefits increased or were unchanged in the climate change scenario and the BDCP with climate change scenario.
- Public benefits can be quantified for the benefit packages evaluated. The currently released reports do not include the final cost allocation, which would provide an approach to determining public and non-public investment needs. Even so, a preliminary cost allocation estimates the public benefit allocation at about 40%, including ecosystem restoration, water quality, water supply reliability for wildlife refuges, recreation, and flood damage reduction.
- The impacts of NODOS implementation are evaluated and potential mitigation measures are described in the Preliminary Administrative Draft (PAD) Environmental Impact Report (EIR). DWR is not soliciting and will not respond to comments submitted on this PADEIR, although any comments received will be retained and may be considered during preparation of a future public draft EIR.
- The Governor's California Water Action Plan (Water Action Plan) directs the California Department of Water Resources (DWR) to work with the Legislature, U.S. Bureau of Reclamation (Reclamation), and Sites Project Joint Powers Authority (JPA) to help facilitate a funding partnership in support of a financeable, multi-benefit storage project.

## Introduction

The Governor's Water Action Plan and the current drought have re-energized discussions of the need for more storage. The Water Action Plan presents water challenges facing California and lays out three over-arching goals: reliability, restoration, and resilience. One of ten actions to meet these goals is, "expand water storage capacity and improve groundwater management." This document highlights how NODOS would improve the reliability, restoration, and resilience of California's water resources to support the Water Action Plan goals.

Five documents associated with the NODOS Investigation are available online at <http://www.water.ca.gov/storage>:

- NODOS Investigation Highlights (this report), by DWR
- NODOS Preliminary Administrative Draft EIR, by DWR
- NODOS Investigation 2013 Progress Report, by Reclamation and DWR
- NODOS Preliminary Design and Cost Estimate Report, by DWR
- NODOS Sensitivity Analysis of Operations with the BDCP Technical Memorandum, by the Sites Project JPA

This document highlights important information from these planning documents, which comprise most of the administrative drafts of the environmental and feasibility reports being prepared for the investigation.

Offstream storage reservoirs located north-of-the-Delta

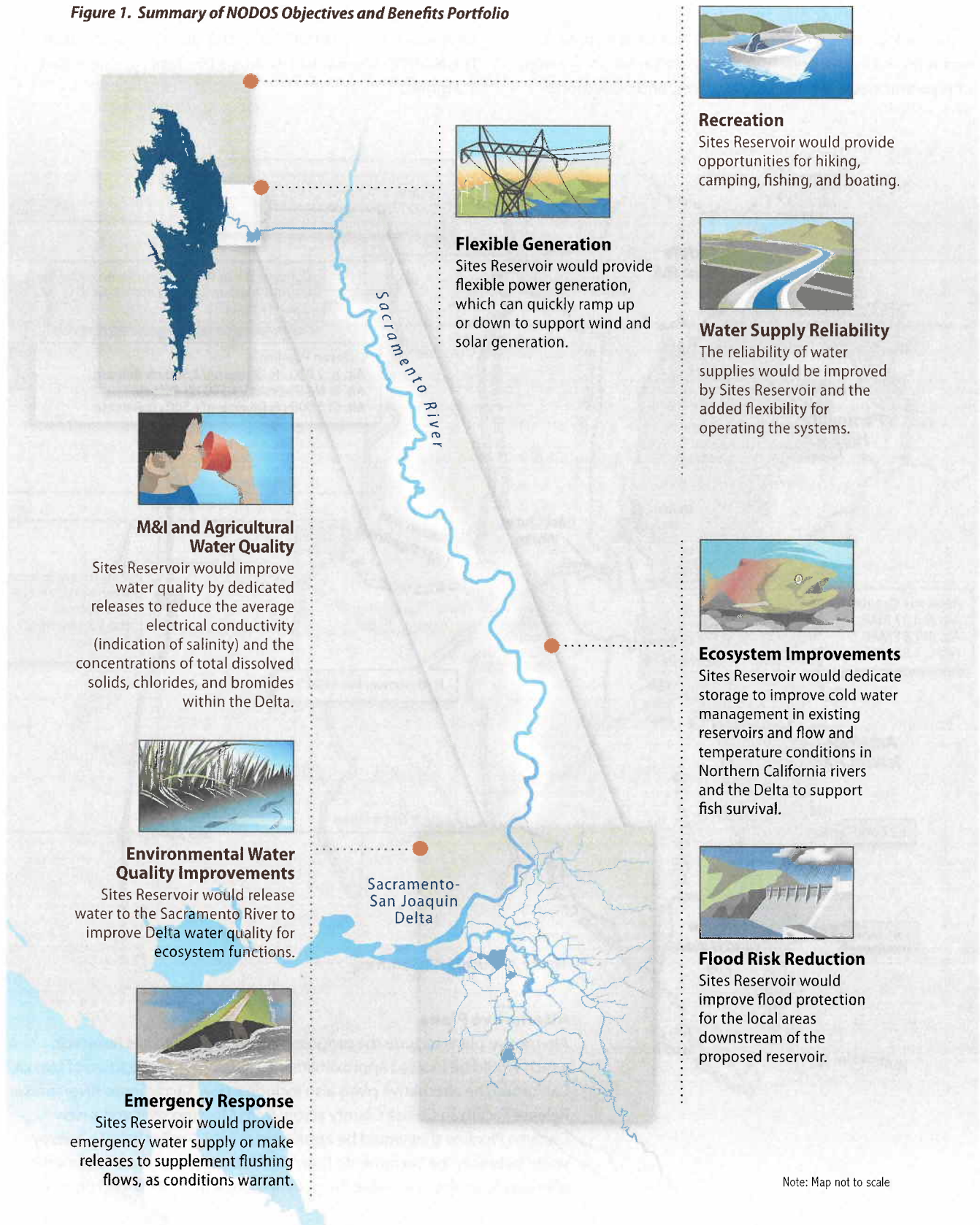
have been studied since the 1940s. The CALFED Bay-Delta Program (CALFED), a cooperative Federal and State agency partnership, recommended further study of NODOS in 2000. DWR and Reclamation are nearing completion of a Feasibility Study, including an EIR/EIS and Feasibility Report, in cooperation with local and regional water interests.

An initial step in the NODOS Investigation was consideration of problems and needs in the study area, which defined the NODOS planning objectives. The project objectives and portfolio of benefits are shown in Figure 1. Additionally, operational flexibility would be supported by additional water in storage. Operational flexibility of the SWP and CVP systems has diminished over time. Contractual commitments to water users, as well as water quality and fish survival requirements, have all increased since California's two largest water projects were built. These increasing demands on the systems have resulted in less water in storage. The CVP and SWP systems have become increasingly inflexible—a "loss of resiliency," as described in the California Water Plan Update. As the reservoirs are operated to meet these increasing commitments, additional stressors are anticipated. Climate change effects will require increased reservoir releases to maintain Delta salinity and to control water temperatures downstream of existing reservoirs.



*NODOS would take advantage of existing water facilities, including Tehama-Colusa Canal, as shown here.*

Figure 1. Summary of NODOS Objectives and Benefits Portfolio





Through a robust plan formulation process, many reservoir locations were considered and Sites Reservoir was selected as the preferred location alternative. A range of reservoir sizes, various conveyances, and operational

scenarios were also considered. The operation of Sites Reservoir is an essential part of the NODOS investigation. The NODOS alternatives evaluated in detail are depicted in Figure 2.

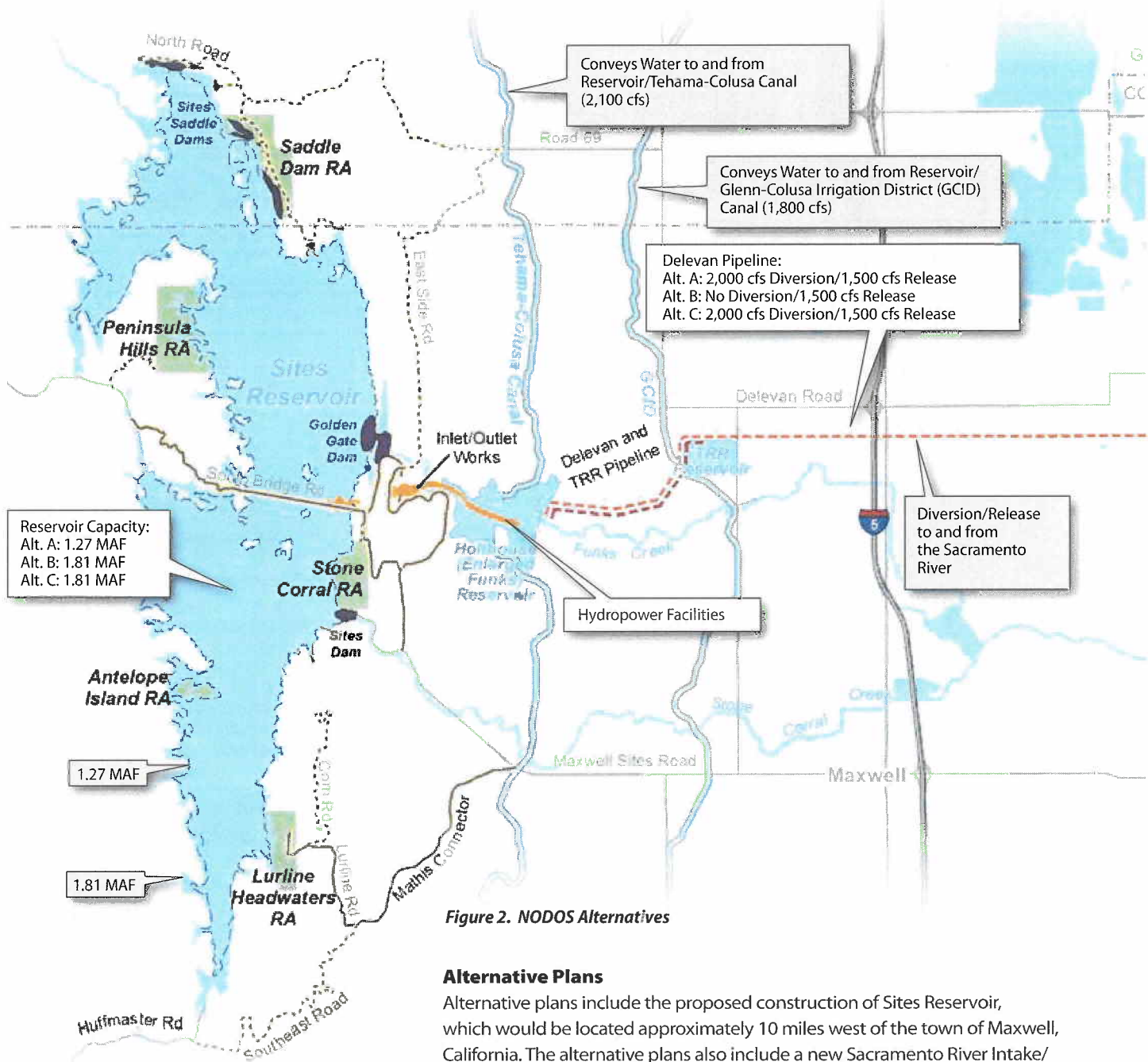
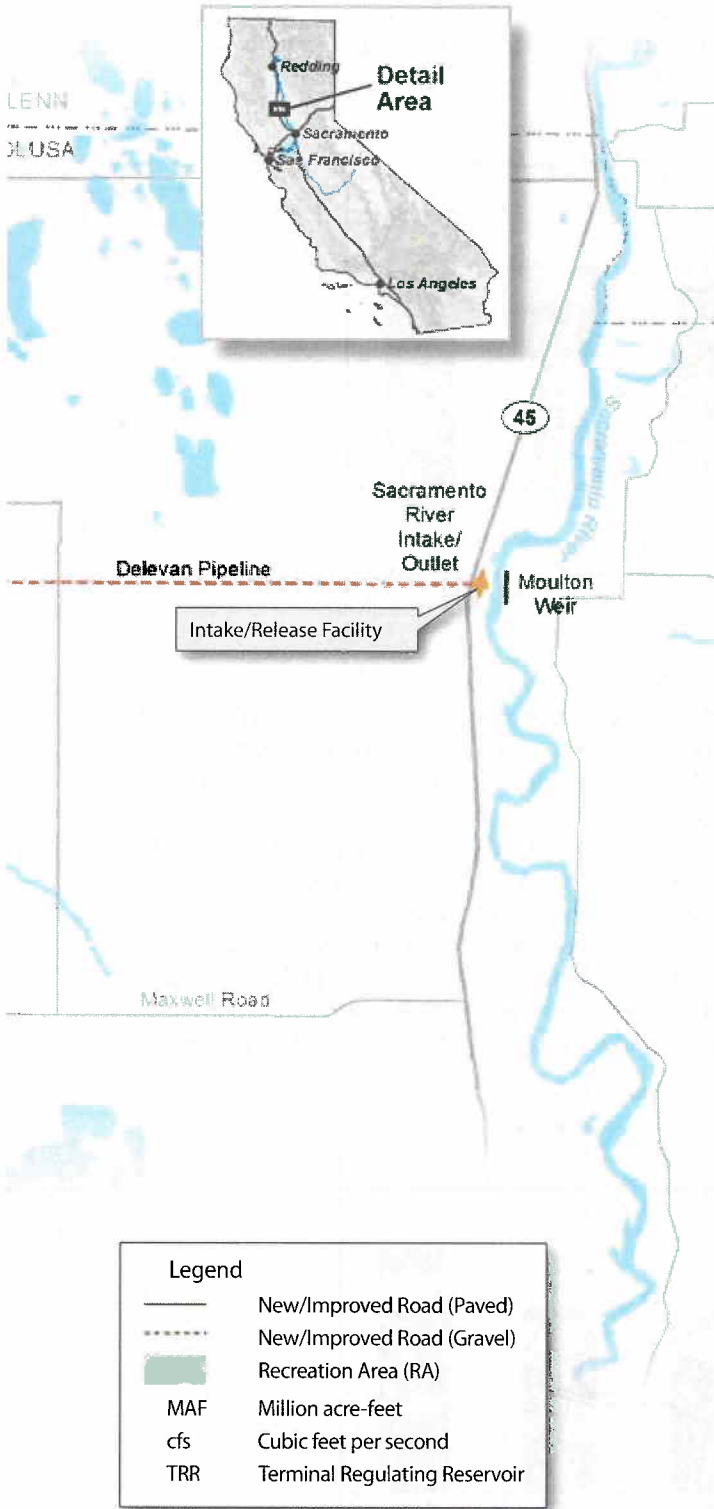


Figure 2. NODOS Alternatives

**Alternative Plans**

Alternative plans include the proposed construction of Sites Reservoir, which would be located approximately 10 miles west of the town of Maxwell, California. The alternative plans also include a new Sacramento River Intake/Release Facility in Colusa County across from Moulton Weir and a new Delevan Pipeline that would be approximately 13.5-miles long to convey water between the Sacramento River and Sites Reservoir. Each alternative plan was formulated to meet the planning objectives described previously.



## ALTERNATIVE PLANS

### No Project/No Action Alternative

No actions would be taken to provide storage north of the Delta to meet the planning objectives.

### ALTERNATIVE A:

#### 1.27 MAF Sites Reservoir with Delevan Pipeline

- 1.27 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal
- New Delevan Pipeline (2,000-cfs diversion/1,500-cfs release)
- New hydropower facilities
- Ecosystem enhancement actions to support anadromous and endemic fish populations

### ALTERNATIVE B:

#### 1.81 MAF Sites Reservoir with Release-only Delevan Pipeline

- 1.81 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal
- New release-only Delevan Pipeline (1,500-cfs release)
- New hydropower facilities
- Ecosystem enhancement actions to support anadromous and endemic fish populations

### ALTERNATIVE C:

#### 1.81 MAF Sites Reservoir with Delevan Pipeline

- 1.81 MAF Sites Reservoir with conveyance to and from the reservoir provided by the existing Tehama-Colusa Canal and Glenn-Colusa Irrigation District Canal
- New Delevan Pipeline (2,000-cfs diversion/1,500-cfs release)
- New hydropower facilities
- Ecosystem enhancement actions to support anadromous and endemic fish populations

### Alternatives Considered and Eliminated From Further Detailed Analysis

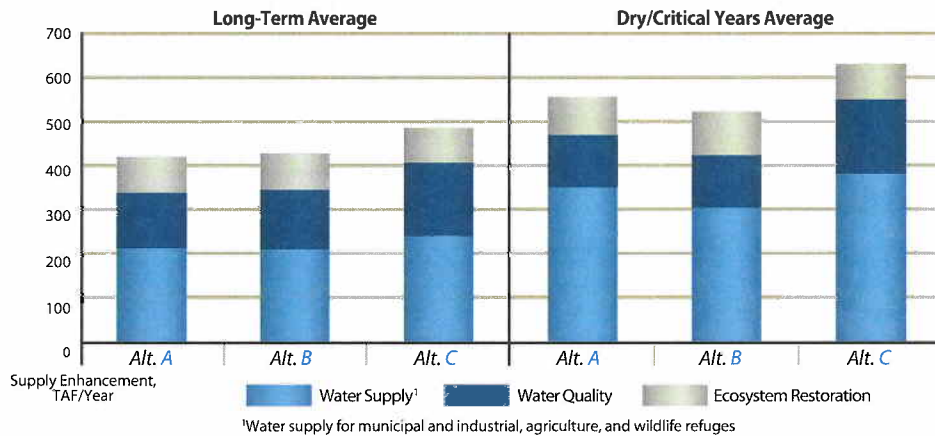
Initially, 52 alternative reservoir locations were considered before identifying Sites Reservoir as the preferred location for additional storage. The iterative plan formulation and screening process is documented in the NODOS Preliminary Administrative Draft Environmental Impact Report (2014) and the Progress Report (2013).

### Benefits

NODOS benefits focus on reliability, restoration, and resilience for much of California. Benefits would occur from Trinity to San Diego counties (north to south) and Butte to Santa Clara counties (east to west), as well as in the Sacramento-San Joaquin Delta. Water supply benefits are described in three

purpose categories: water supply reliability (labeled as water supply), water quality, and ecosystem restoration. Figure 3 shows the quantities of water supply (in thousands of acre-feet (TAF)) dedicated to these purposes for the three alternatives.

**Figure 3. NODOS would increase water supply for multiple purposes**



### Reliability

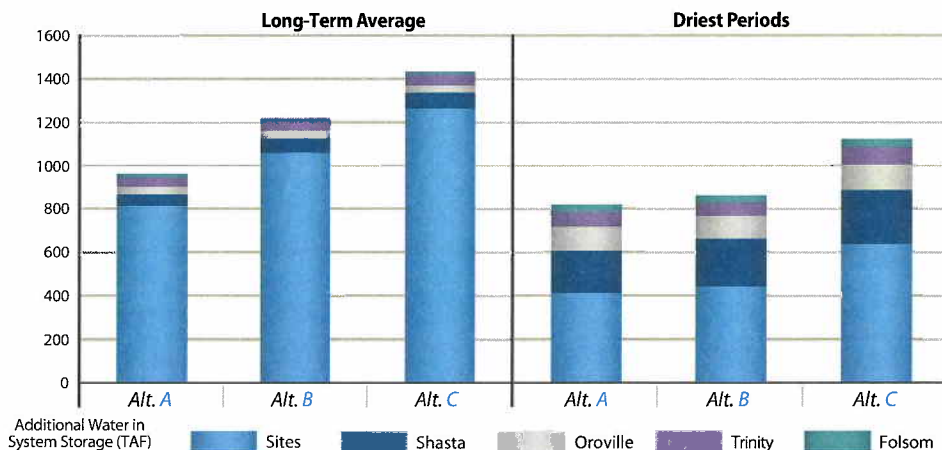
Reliability would be improved for all three water supply purposes: water supply, water quality, and restoration. Water supply reliability would be improved for municipal and industrial, agriculture, and wildlife refuge users. Water quality would be improved by providing dedicated supplemental Delta outflow. Restoration water supply would be dedicated to support actions in the Delta and its tributaries.

Average annual water supplies would range from 400 to almost 500 TAF per year. The proposed reservoir's operations have been designed to emphasize supplies during drier conditions. Consequently, when the State is experiencing dry conditions (during Dry and Critical years), water supplies would increase

to from 500 to over 600 TAF per year. In addition to these water benefits, flexible hydropower generation to support renewable energy sources such as wind and solar would be included.

NODOS also would support a more robust water system by improving storage conditions in reservoirs north-of-the-Delta (NOD). Figure 4 shows that NODOS would increase the average NOD storage by about 1.0 MAF/year to 1.4 MAF/year; during driest periods (droughts), storage would be improved by over 800 TAF (17% system storage improvement) to 1.1 MAF (23% system storage improvement). Having this additional water in the existing reservoirs would improve fishery conditions below those dams and the viability of the CVP and SWP systems.

**Figure 4. NODOS would increase system flexibility through additional water in system storage**





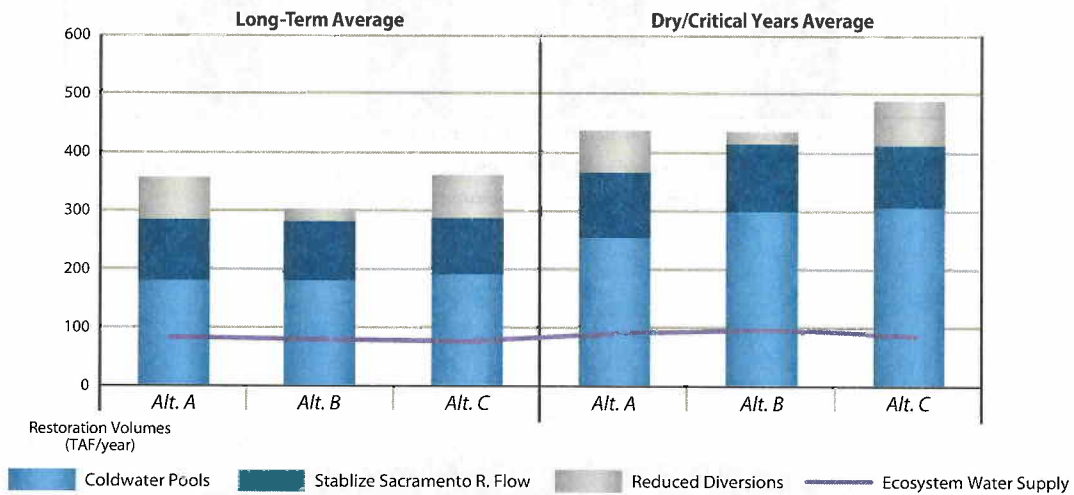
## Restoration

Storage from NODOS would provide a source of additional water within the SWP and CVP systems that could be used to facilitate several ecosystem restoration actions to improve conditions in the Delta and Sacramento River watershed. Restoration would be accomplished by providing improved streamflow and lower water temperatures below existing reservoirs and in the Delta to support ecosystem needs. NODOS would improve ecosystem conditions by: increasing the reliability of coldwater pool storage at Shasta Lake (and by extension Trinity Lake), Lake Oroville, and Folsom Lake; providing supplemental releases from Shasta Lake to improve the temperature regime of the Upper Sacramento River; providing stable flow regimes in the Sacramento and American rivers to improve egg survival and fish habitat; increasing the flexibility of the SWP and CVP to meet salinity standards and improving salinity conditions in the Delta with dedicated releases to support estuarine fish species; and providing increased flows (Spring–Fall) in the lower Sacramento River

by reducing diversions at Red Bluff and Hamilton City and by providing supplemental flows at the new Delevan Pipeline.

The volumes of water associated with most NODOS restoration actions are shown in Figure 5. Average coldwater pool augmentation at Shasta, Trinity, Oroville, and Folsom would range from 180 TAF/year to 190 TAF/year, while during drier conditions (i.e. Dry and Critical years), coldwater pools would be improved by 250 TAF/year to 300 TAF/year. Supplemental Sacramento River stability flows and reduced diversions are also shown, with average total volumes of water ranging from 300 TAF/year to 350 TAF/year and drier conditions volume ranging from 430 TAF/year to 480 TAF/year. Also shown in Figure 5 is the dedicated restoration water supply quantity from Figure 3, indicating NODOS project efficiencies in providing the ecosystem actions. Much of the restoration water volume would be used again for other purposes. Restoration volumes would be almost four to over five times the restoration water supply.

**Figure 5. NODOS would provide Ecosystem Restoration Action Volumes**

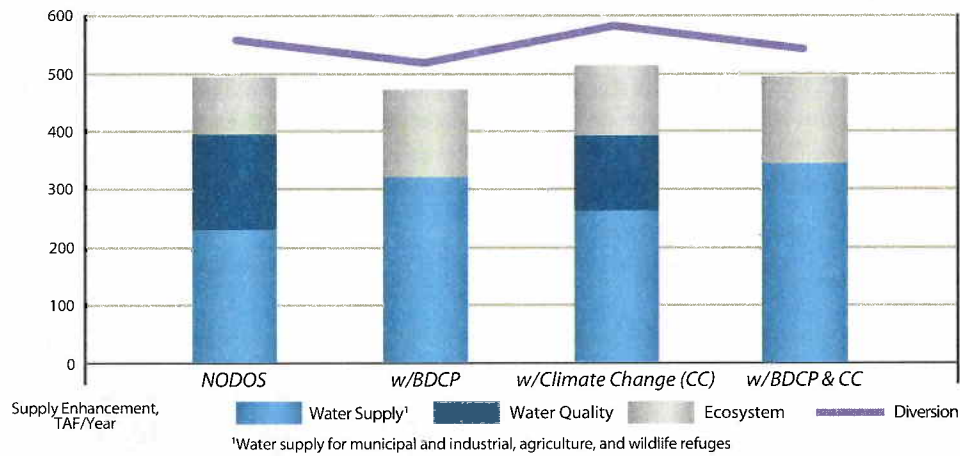


## Resilience

The NODOS Investigation evaluated NODOS performance with potential alternative futures, including four climate change scenarios and three BDCP conveyance and operations scenarios. While the operations of NODOS were modified to accommodate alternative futures (particularly with BDCP), sensitivity studies indicate that NODOS performance would be resilient. Figure 6 shows a comparison of NODOS performance (Alternative C) with alternative futures. For example, water diversion to fill NODOS would be reduced by 7% with BDCP, increased by 4% with climate change and sea level rise, and decreased by

3% with both climate change and BDCP. NODOS water quality actions would not be needed with the BDCP scenarios because BDCP would provide significant water quality improvements with its north Delta diversion location. With BDCP, NODOS water would be shifted for uses supporting restoration and increasing water supply reliability. Both water supply reliability and restoration benefits would be increased with each alternative future as compared to the No Action future. Total benefits would be decreased by 4% with BDCP, increased by 4% with climate change, and unchanged with both.

**Figure 6. NODOS would be resilient with alternative futures**





## Benefits and Costs

A comparison of the project benefits and costs indicates economic feasibility, as shown in Table 1. Total estimated project costs range from \$3.6 billion to \$4.1 billion, resulting in annual costs (including construction, interest during construction, and operations and maintenance) of \$178 million to \$204 million. The value of annual benefits would range from \$249 million to \$276 million, resulting in benefit-cost ratios (i.e. Total Benefits/ Total Costs) of 1.32, 1.43, and 1.35 for alternatives A, B, and C respectively.

Net Benefits would range from \$61 million to \$77 million per year.

A NODOS Value Planning Study has identified up to \$600 million in total project savings. Proposals for cost savings include use of roller-compacted concrete for the main dams, moving or modifying various reservoir-related structures, and refining pipeline conveyance designs. These cost saving proposals will be considered and incorporated in the NODOS Feasibility Report.

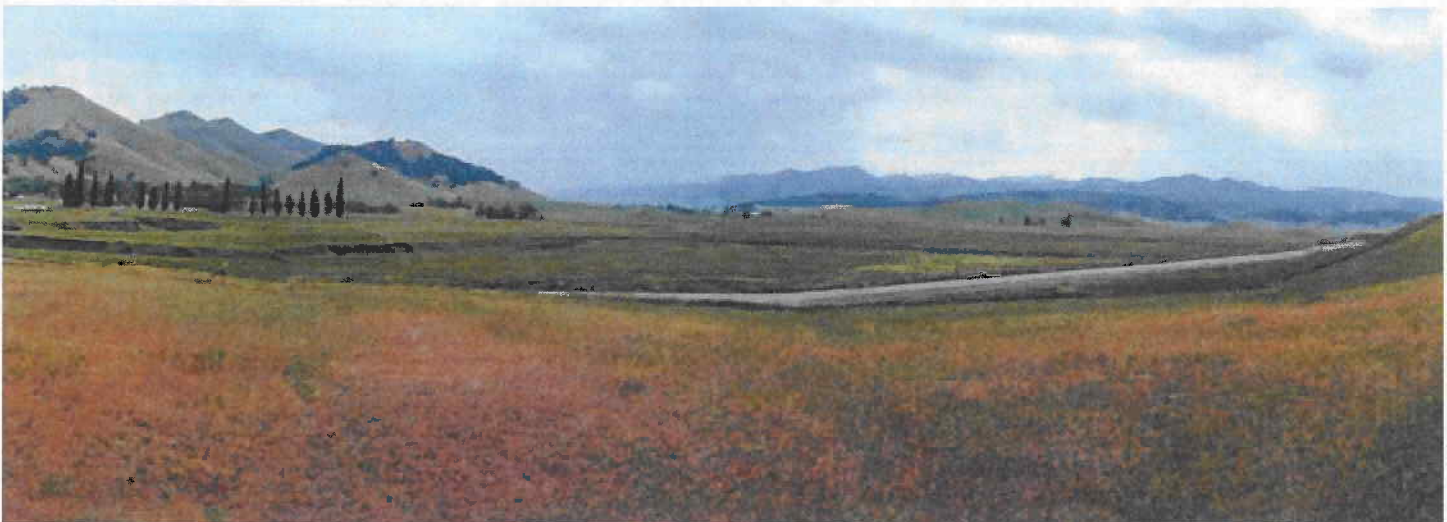
**Table 1. Preliminary estimated NODOS benefits and costs (\$Million, 2013 dollars)**

	Alternative A	Alternative B	Alternative C
Total Project Cost	3,823	3,623	4,140
Annual Cost (C)	189	178	204
Annual Benefits (B)	249	255	276
Annual Net Benefits (B-C)	61	77	72
Benefit-Cost Ratio (B/C)	1.32	1.43	1.35

## Next Steps

The impacts of NODOS implementation are evaluated and potential mitigation measures are described in The Preliminary Administrative Draft EIR. DWR is not soliciting and will not respond to comments submitted on this PADEIR, although any comments received will be retained and may be considered

during preparation of a future public draft EIR. DWR will work with the Legislature, Reclamation, and the Sites Project JPA to help facilitate a funding partnership in support of a financeable multi-benefit offstream storage project.





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by Reclamation and DWR

**NODOS Preliminary Design and Cost Estimate Report** by DWR

**NODOS Sensitivity Analysis of Operations with the  
BDCP Technical Memorandum** by the Sites Project JPA

Any questions, contact: Sean Sou, DWR (916) 651-9269,  
[Sean.Sou@water.ca.gov](mailto:Sean.Sou@water.ca.gov)



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