ORANGE COUNTY WATER DISTRICT

SURFACE RECHARGE SYSTEM

OPERATIONS MANUAL

2nd Edition

April 12, 2021

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Cover photo: Fifteen-foot Imperial Flume measuring diverted flow at the Imperial Headgates into the Upper Off-River System.

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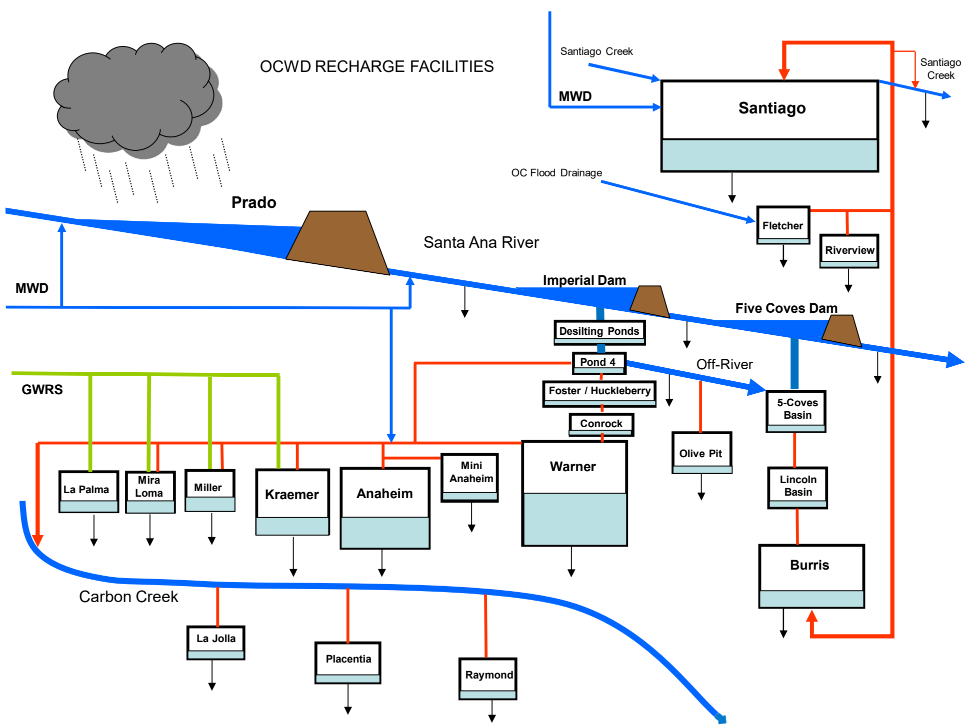
1. INTRODUCTION

The Orange County Water District (OCWD or District) was formed by a special act of the California Legislature in 1933 for the purpose of managing and protecting the Orange County Groundwater Basin. Since its formation, the District has developed a sustainable recharge program. Aquifer recharge activities conducted by OCWD fall into two categories: 1) Surface Recharge and 2) Injection Recharge.

This manual is a working document aimed at providing the reader with a good understanding of OCWD's Surface Recharge System (SRS), and its basic operational procedures. The District's SRS is dynamic with multitudes of operational scenarios. The intent of this manual is to present basic operational procedures commonly used by the SRS operators (SRSOs) as a guide towards responsible system operation.

This document is intended to be updated by qualified staff as new pieces of equipment are added to the system and as better modes of operation are discovered. The District's acting SRS supervisor is responsible for making necessary updates to this document in a time effective manner.



1. **Figure 1-1** Overview flow schematic of OCWD's Surface Recharge System

2. OVERVIEW OF OCWD FOREBAY RECHARGE SYSTEM

The Orange County Groundwater Basin (Basin) underlies the northern half of Orange County and covers approximately 350 square miles (Figure 2-1). The aquifers comprising the basin extend over 2,000 feet deep and form a complex series of interconnected sand and gravel deposits. It is estimated that the Basin contains up to 60 million acre-feet (af) of fresh groundwater. Since the inception of the District the Orange County Groundwater Basin has never been overdrafted more than 500,000 af in one year.

In coastal and central portions of the basin, these deposits tend to be separated by extensive lower-permeability clay and silt deposits, known as aquatards (Pressure area). In the inland area of the basin, generally northeast of Interstate 5, the clay and silt deposits become thinner and more discontinuous, allowing groundwater to flow more easily between ground surface, shallow and deeper aquifers (Forebay).

Shortly after the District was formed in 1933, the District, along with the Orange County Flood Control District (OCFCD), began experimenting with ways to increase the percolation capacity of the Santa Ana River (SAR) channel. These experiments included removing vegetation and re-sculpting the riverbank and river bottom. Based on the success of these experiments, the District began purchasing portions of the SAR channel as they became available. In 1936 the District made its first purchase of 26-acres of the SAR channel for $722. The District eventually acquired six miles of the SAR channel extending from Imperial Highway (SR90) to Ball Road (Figure 2-2).

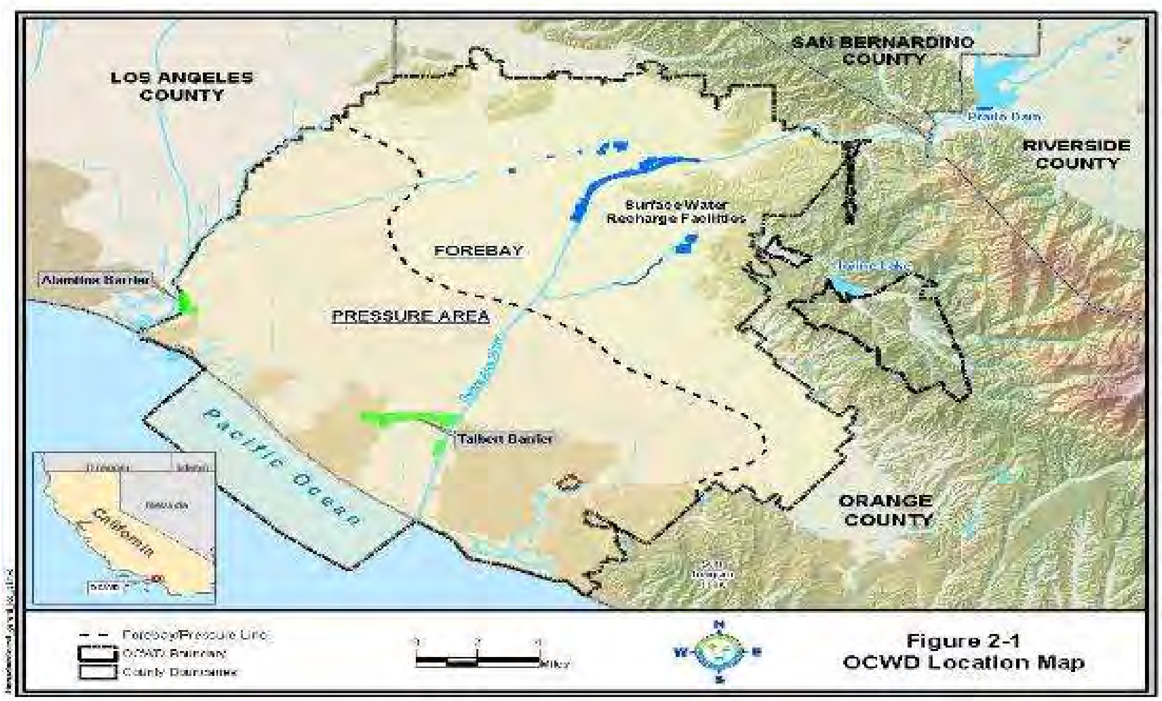


Figure 2-1 Map of OCWD boundary and surrounding region. The Pressure and Forebay areas are shown.

Currently the District owns over 1,625-acres of land within the Forebay containing over two dozen recharge facilities that span nearly 1,100 wetted acres (see Figure 2-2). In addition, the District utilizes several flood control basins owned by the OCFCD for recharge. Along with land purchases, the District invested in infrastructure to maximize the ability of the facilities to recharge water, including four rubber dams, over ten miles of pipelines, ten pump stations, and a fleet of earthmoving equipment. Figure 2-2 shows the District's Surface Recharge Facilities.

Table 1 lists all of the facilities in OCWD's recharge system and summarizes key operational information. This table will serve as a good reference throughout this entire manual.

The main source of inflow to the recharge system is the Santa Ana River (SAR). When SAR flow reaches the Imperial Rubber Dam located just downstream of the Imperial Highway, the flows are divided into two streams. The first stream is diverted from the SAR to the Upper Off-River System. The second stream is by-passed around the Imperial Rubber Dam and placed back into the SAR. The maximum flow that be diverted to the Upper Off- River System is 500 cubic feet per second (cfs) short-term and up to 900 cfs can also bypass the dam and flow down the SAR channel.

Flow diverted by the Imperial Rubber Dam passes, by gravity, through the Upper Off-River System, a series of desilting ponds before being placed in managed recharge basins for percolation into the Basin.

Flow bypassed around the Imperial Rubber Dam remains in the SAR channel for percolation through the riverbed sediments or managed recharge basins further downstream.

The District's surface recharge system is designed to receive flows from four different sources: the SAR base flow, storm water, recycled water, and imported water. The recharge system has roughly 25,000 acre-feet of storage above ground. Table 1 lists all the of the District's Recharge facilities and their respective physical attributes.

Storm flows and base flows combine to make the largest contribution to the District's recharge portfolio. The SRSO works directly with the United States Army Corps of Engineers (USACE) to recharge water captured behind the Prado Dam. The USACE website is located at: https://resreg.spl.usace.army.mil/cgi-bin/slLatestBasin.cgi?sar+elev provides inflow, outflow, and level data for the Prado Dam in 15-minute intervals 24-hours per day, 7 days a week.

Table 1

Surface Recharge Facility Information

Basin	Operation Section	Section (Figure 2-3)	Water Source	Start Year	Max Wetted Area (Acres)	Basin Invert Elevation (ft. MSL)	Max Water Surface (MSL)	Max Storage (AF)	Max Percolation (CFS)	Comments
Lower SAR	River Recharge System	3	River, Import	1936	291	270-167			50	Max elevation of 270 ft msl based on ACOE survey data at Imperial Highway. Elevation at Orangewood based on rate of fall of 13 ft/mile from Imperial Highway.
Upper SAR	River Recharge System	3	River, Import	1936	291	270-167			70	Max elevation of 270 ft msl based on ACOE survey data at Imperial Highway. Elevation at Orangewood based on rate of fall of 13 ft/mile from Imperial Highway.
Off-River	Upper Off-River System	4	River, Import	1936	89	241-205			10	Max elevation of 241 ft msl based on top of rip-rap at base of Weir 4 spill.
Off-River	Upper Off-River System	4	River, Import	1936	89	241-205			10	Max elevation of 241 ft msl based on top of rip-rap at base of Weir 4 spill.
Olive Basin	Upper Off-River System	4	River, Import	1973	5.1	187	223	95	20	Spill at 223'
Weir Pond 1	Upper Off-River System	4	River, Import	1973	6	258	263	28	5	Percolation occurs while filling
Weir Pond 2	Upper Off-River System	4	River, Import	1973	9	254	259	42	5	Percolation occurs while filling
Weir Pond 3	Upper Off-River System	4	River, Import	1973	14	247	259	160	5	Percolation occurs while filling
Weir Pond 4	Upper Off-River System	4	River, Import	1973	4	244	255	22	5	Percolation occurs while filling
Conrock Basin	Warner System	5	River, Import	1974	23.5	193	245	661	5	Maximum percolation occurs while filling
Foster-Huckleberry Basin	Warner System	5	River, Import	1974	22.6	210	250	628	15	Maximum percolation occurs while filling
Little Warner Basin	Warner System	5	River, Import	1974	9	205	238.5	250		Maximum percolation occurs while filling
Warner Basin	Warner System	5	River, Import	1974	70	183	238.5	2650	40	Maximum percolation occurs while filling
Anaheim Lake	Upper Recharge System	6	River, Import	1961	71	168	223.6	2300	70	Spill at 224'
Kraemer Basin	Upper Recharge System	6	GWRS, River, Import	1988	30.8	164	217	1055	70	Above 217' nearby vaults get water intrusion and may damage equip.
La Jolla Basin	Upper Recharge System	6	River, Import	2007	6.3	199	203.5	19.8	25	
Miller Basin	Upper Recharge System	6	GWRS, River, Import	1963	24.6	200	220	350	40	Operates under Water Conservation Plan with Orange County Flood Control
Mini Anaheim	Upper Recharge System	6	River, Import	1995	3.8	220	226	10	15	
Placentia Basin	Upper Recharge System	6	River, Import	1962	9	155	175	200	10	In-Active due to quagga mussel constraints. Owned by Orange County
Raymond Basin	Upper Recharge System	6	River, Import	1962	19	145	160	200	10	Owned by Orange County Flood Control
Burris Basin	Lower Off-River System	7	River, Import, Santiago	1977	110	110	171.7	2500	35	Spill 172.2'
Fletcher Basin	Lower Off-River System	7	River	2016	2.8	180	190	14.5	3	Main water source is rain runoff
Lincoln Basin	Lower Off-River System	7	River, Import	1976	10	183	190	60	5	Percolation occurs while filling
Lower Five Coves Basin	Lower Off-River System	7	River, Import	1975	16	179	194	165.8	10	Percolation occurs while filling
Riverview Basin	Lower Off-River System	7	River, Import, Santiago	2003	4	186	189	7.5	12	Receives Burris or Santiago pumped water only
Santiago Basin	Lower Off-River System	7	River, Import, Sant Crk	1990	185	150	285.2	13260	120	Bond and Blue Diamond connect at 220'. Current project will change that to 200'. Santiago basins connect to Smith Basin at 260'.
Lower Santiago Creek	Lower Off-River System	7	River, Import, Sant Crk	2000	10	285-83			15	Creek flow stops at Hart Park, elevation is estimate.
Smith Basin	Lower Off-River System	7	River			260	285.2	311		Wetted area and percolation numbers included with Santiago Basins.
Upper Five Coves Basin	Lower Off-River System	7	River, Import	1975	15	182	196.4	103.3	10	Percolation occurs while filling
La Palma Basin	GWRS Recharge System	8	GWRS	2016	13.1	210	219.7	101	100	Spill at 220.3'
Miraloma Basin	GWRS Recharge System	8	GWRS	2012	9.6	210.5	220	52.6	70	Spill at 220.7'
Mills Pond	Mitigation Site		River, Import							Mitigation use only starting 2015

Note:

msl = mean sea level   " ' " = feet msl   ft. = feet msl   ACOE = Army Corps of Engineers

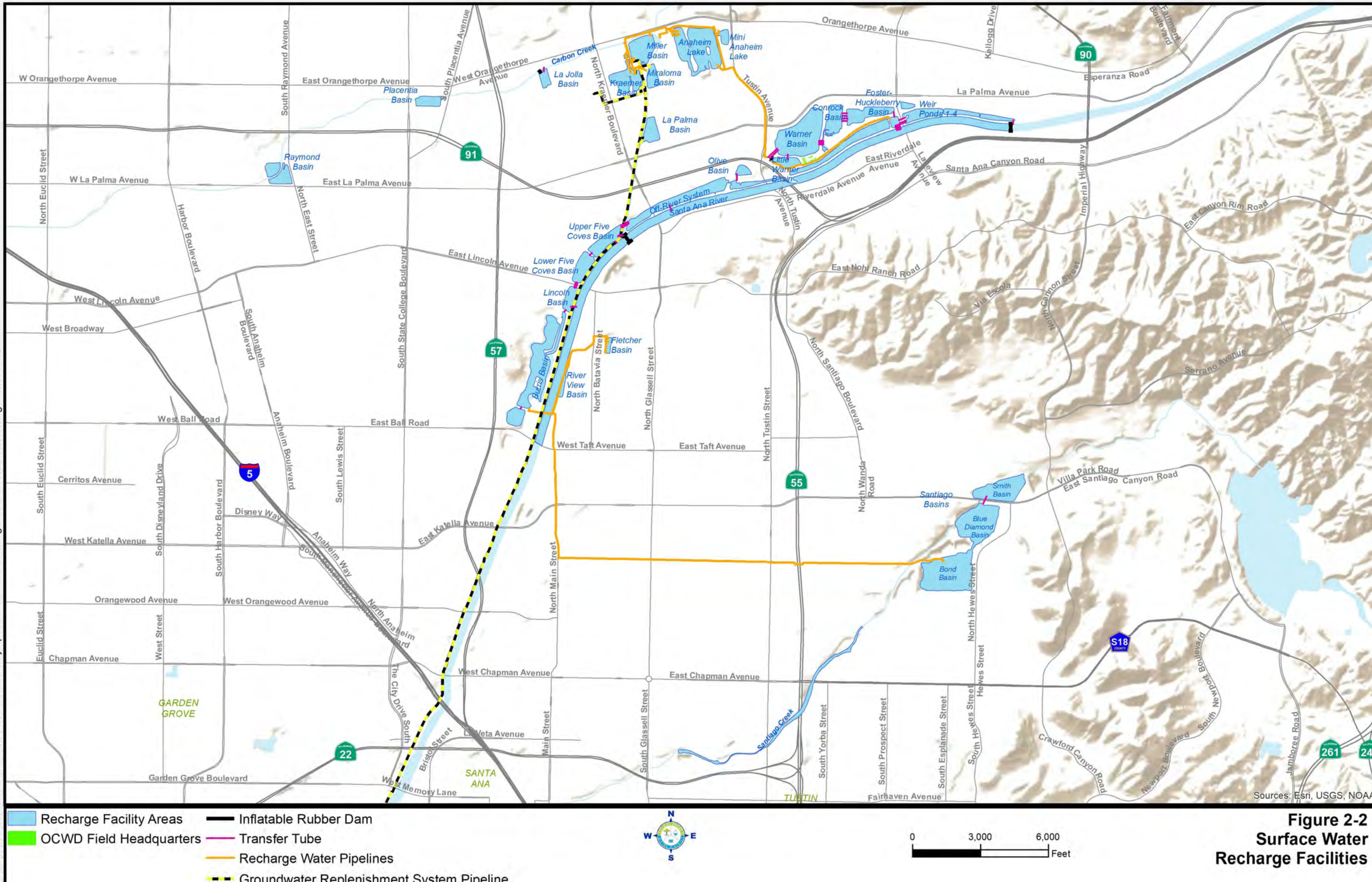


Figure 2-2
Surface Water Recharge Facilities

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Recycled water through the District's Groundwater Replenishment System (GWRS) contributes up to approximately 100,000 acre-feet annually to the Districts overall recharge portfolio.

GWRS began operating at 70 mgd in 2008 and expanded to 100 mgd in 2015. To meet this demand the District constructed Miraloma Basin in 2011 and La Palma Basin in 2016. At the time of this writing the GWRS treatment plant is being expanded from 100 mgd to 130 mgd.

The District is looking for new methods to distribute water into the surface recharge system for the final expansion.

The District often purchases untreated imported water from the Metropolitan Water District of Southern California (MWD). The District has historically purchased approximately 65,000 acre-feet of this water for recharge each year.

Over the past 10 years the District has recharged between 172,500 acre-feet and 268,000 acre-feet of water annually. While the Basin is estimated to contain 60 million acre-feet of fresh groundwater, the District has established the maximum desirable accumulated overdraft of 500,000 acre-feet.

A well-managed surface recharge program is critical to achieving the proper balance within the Basin that ensures high levels of water quality, reliability and sustainability for the residents and businesses it serves.

This manual divides the District's Surface Recharge System into six groups:

- River (SAR) System
- Upper Off-River System
- Warner System
- Upper Recharge System
- Lower Off-River system
- GWRS System

Figure 2-3 shows the locations of these six recharge systems.

To Assist the SRSO, a comprehensive water atlas was developed showing the locations and details of all valves, flow meters and critical supporting appurtenances. It is recommended that the reader refer to this water atlas should additional focus be needed on certain aspects the recharge system. The water atlas is located in Section 9 of this manual.

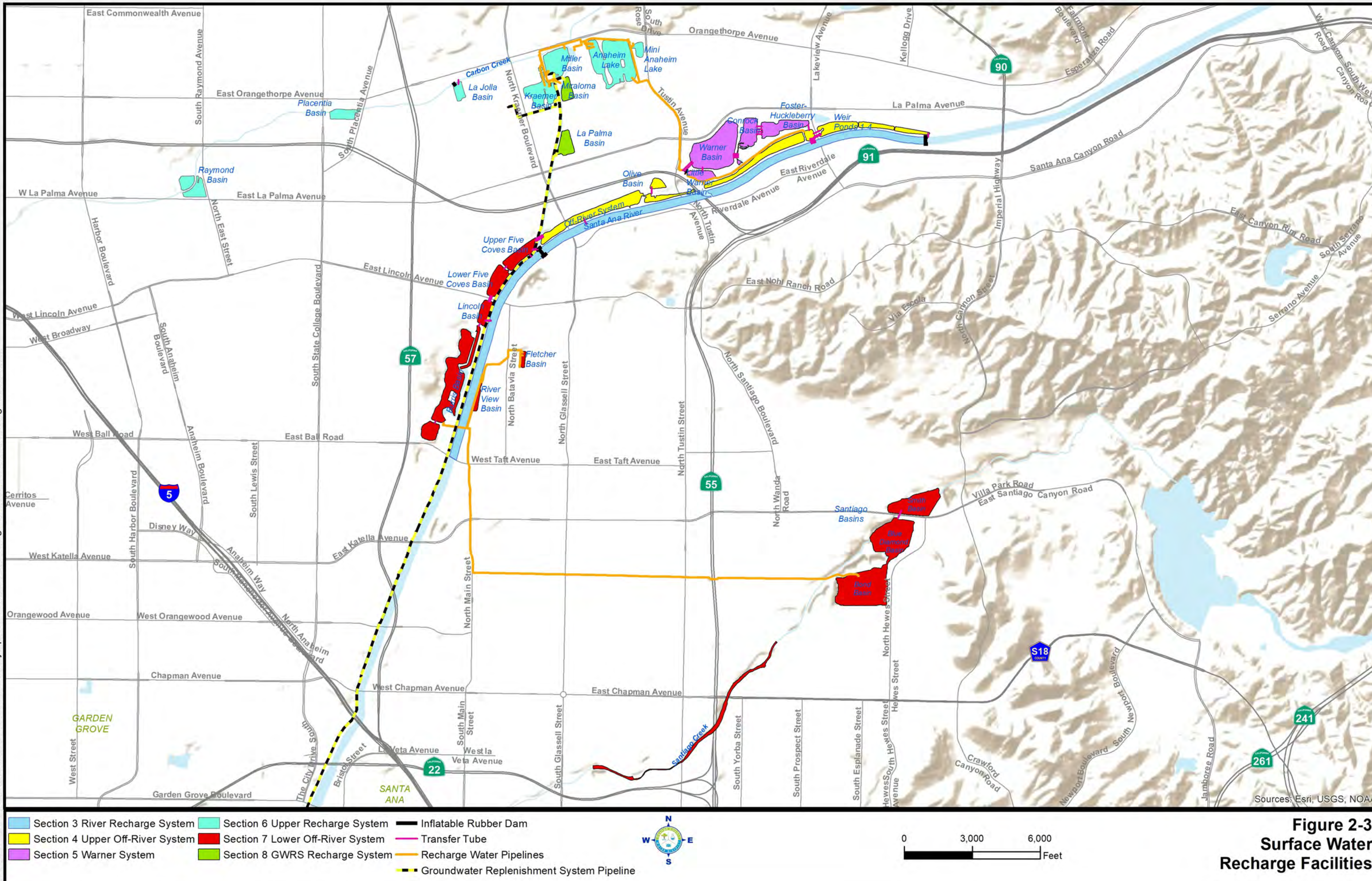

Figure 2-3
Surface Water Recharge Facilities

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3. RIVER RECHARGE SYSTEM OPERATION

The entrance into the Surface Recharge system is the Imperial Head Gates. The Imperial Head Gates are located 0.6 miles west (down-stream) of Imperial Highway. The facility contains an inflatable rubber dam, dam house, trash rack system, diversion structure, bypass structure and back-up diesel generator.

Figure 3-1 Imperial Head Gates looking East (upstream): (A) Imperial Rubber Dam, (B) Trash rack system, (C) Diversion gates, (D) Bypass gates (E) Dam (control) house and (F) generator building.

A. Imperial Rubber Dam

The primary function for the Imperial Head Gates is to divert water from the SAR into the Warner System for groundwater recharge.

The Imperial Rubber Dam (Figure 3-2) is the main diversion-site located on the Santa Ana River 0.6 miles west and downstream of Imperial Highway. The dam is inflatable with air and is 7 ft. in diameter, 300 ft. wide and made from 1-inch-thick steel reinforced rubber. The dam can be inflated or deflated within 20 minutes either on-site inside the control house, or remotely by the Supervisory Control and Data Acquisition (SCADA).

Water impounded behind the Imperial Rubber Dam (Pool) can be diverted to the Upper Off-River System or bypassed around the dam and then back into the SAR. Controls for the diversion and bypass gates can be operated locally, by pushing buttons on the valve actuator motors inside the control house, or remotely by SCADA. SCADA can be accessed through a District provided laptop computer or from a desktop computer in the SCADA room inside the Field Headquarters (FHQ) administrative building. The diversion controls are located at the east side of the control house. There are preset levels for the Imperial Rubber Dam to deflate automatically during storm flows or high flow release periods. One is set from a level transducer and another is set mechanically. For instructions on how to operate the Imperial Rubber Dam see Appendix A-1.

Figure 3-2 Imperial Rubber Dam inflated with pool visible.

Flow can go over the dam either partially or fully inflated (Figure 3-3). Maximum flow over the dam is approximately 600 cfs before the dam deflates automatically

Figure 3-3 Flow over the Imperial Rubber Dam with bypass gate valves and trash rack monorail visible in the upper left-hand corner of image.

a. Trash Rack

The Imperial diversion and bypass intakes are kept clear using a clamshell bucket trash rack system (Figure 3-4). The trash rack system is a 14-pickup station clamshell bucket suspended by cable from a curved monorail that picks up debris in the river blocking the intake structure. The trash rack system can be controlled either remotely by SCADA, locally at the panel inside the control house, or by hand-held remote control. For trash rack control operation details see Appendix A-2.

Figure 3-4 Imperial trash rack system. The grabber claw is visible at the bend in the monorail. The dump station and debris pile are visible at the upstream end of the monorail. The bypass intake structure is visible in the lower right-hand corner of the image. The debris piles are periodically removed by the Heavy Equipment Operators.

There are three ways flow can be directed at the Imperial Dam when inflated: Over the dam, by-passed around the dam or diverted out of the SAR Channel.

b. Imperial Diversion

Flow diverted enters the Off-River System through three 5 ft. by 5 ft. concrete box culverts (Figure 3-5) equipped with electrically actuated slide gate valves. The slide gate valves can be controlled either locally onsite or remotely using SCADA. For operational details on slide gate valve operations see Appendix A-3. The diversion gate actuators are located inside the dam control building. A maximum flowrate up to 500 cfs is acceptable for short periods of time. A diverted flowrate of 350 cfs can be sustained long-term. Diverted flow is measured at a 15 ft. Parshall Flume located approximately 200 ft. downstream of the box culverts at the beginning of the Off-River System.

Figure 3-5 Imperial Diversion Boxes. Trash rack monorail visible above dam house.

c. Imperial Bypass

Bypass flow reenters the SAR through two 8 ft. by 5 ft. concrete box culverts (Figure 3-6) equipped with electrically actuated slide gate valves. The slide gate valves can be controlled either locally onsite or remotely using SCADA. Appendix A-3 provides instructional detail regarding the operation of motor operated gate valve actuators. Flow is measured using a Sontek Acoustic Doppler meter in each box and viewed on SCADA. The Bypass slide gate valves are adjusted to create a full pipe condition as required for flow meter application (pre-programmed area). A maximum flowrate of 450 is acceptable, flows exceeding 450 cfs are subject to entrained air (air bubbles) and may cause a loss of accuracy.

The maximum total SAR flow before deflating the dam is between 1,600 to 1,850 cfs (350 cfs diverted, 900 cfs bypassed and up to 600 cfs over the top of the Imperial Rubber Dam).

Flow through the bypass structure directs back into the SAR. Flow over the Imperial Rubber Dam remains in the SAR. Flow through diversion enters the Upper Off-River System (Weir Ponds 1, 2, 3 and then 4). The Upper Off-River System is described in Section 4 of this manual.

Figure 3-6 Imperial Bypass Gates

B. Upper SAR (between Imperial Dam and 5 Coves Dam)

Flow bypassed around the Imperial Rubber Dam passes over this section of the SAR (Figure 3-7). During periods of high flow this section has bank to bank coverage and maximum percolation occurs. During periods of low flow runner dikes are built of riverbed sand to minimize the flow path footprint which increases velocities. This mechanical control is used to mitigate midge fly population growth during warm weather. The percolation range in this upper section of the SAR is 15 cfs to 50 cfs depending on the configuration, condition of the river bottom and adjoining Off-River water levels. Flow that does not percolate in this upper section is either captured at the Five Coves Dam (if inflated) or percolates in the Lower SAR.

In this upper portion of the river there are two locations flow can be diverted from the SAR into the Upper Off-River System (Figure 3-7). In both cases a diagonal sand dike needs to be built from the center levee 200 ft upstream of the respective canal gate valves (Figure 3-8). The sand dike impounds and channelizes water, and the flow is controlled by the gate valve openings. The gate valves are opened manually using a hand crank or with the hydraulic operator. For operational detail of the portable hydraulic valve operator see Appendix A-4. There is no flow measuring device at these two diversion-sites.

Figure 3-7 Aerial image of Upper Santa Ana River showing locations of two connection points (temporary diversions) between the Upper-Off-River and the Santa Ana River.

a. Upper SAR Temporary Diversion 1: Four Pipes/Gates SAR to Weir Pond 4

West of Lakeview Avenue there are four 48-inch canal gate valves and pipes (Figure 3-8) capable of diverting up to 50 cfs of SAR flow into Weir Pond 4. A diagonal sand dike needs to be built using river sand from the center levee 200 ft upstream of the canal gate valves so that an elevation head creates gravity flow from the Upper SAR into Weir Pond 4. The sand dike impounds and channelizes water and the flow into Weir Pond 4 is controlled by the canal gate valve operation. These four canal gate valves are controlled manually using a hand crank or with the portable hydraulic operator (Appendix A-4). There is no flow measuring device at this diversion-site.

Figure 3-8 Four canal gate valves and pipes connecting the SAR to Weir Pond 4. Lakeview Avenue in the background. Yellow line indicates location of temporary sand dike.

b. <u>Upper SAR Temporary Diversion 2: Four Pipes/Gates SAR to Upper Off-River</u>

West of the Tustin Avenue train bridge there are four 48-inch canal gate valves and pipes (Figure 3-9) capable of diverting up to 30 cfs of SAR flow into the Upper Off-River System. A diagonal sand dike needs to be built from the center levee 200 ft upstream of the canal gate valves. The sand dike impounds water and directs the flow. Flow is controlled by operating the canal gate valves. The canal gate valves are opened manually using a hand crank or with the portable hydraulic operator (Appendix A-4). There is no flow measuring device at this temporary diversion-site.

Figure 3-9 Four canal gate valves and pipes connecting the SAR to Off-River. Tustin Avenue Train Bridge in the background. Yellow line indicates location of temporary sand dike.

C. Five Coves Site

a. Rubber Dam

The purpose of the Five Coves Rubber Dam (Figure 3-10) is to regulate flow to the Lower SAR by diverting excess flow to the Lower Off-River System. The Five Coves Rubber Dam is located about 3.4 miles downstream of the Imperial Rubber Dam approximately a quarter mile southwest of Glassell Avenue. The dam is a 7ft in diameter, 300 ft. wide, ¾-inch thick rubber diversion structure. The dam can be inflated or deflated within 20 minutes either on-site, inside the dam control house or remotely by SCADA. For operational details of the Five Coves Rubber Dam see Appendix A-5.

Figure 3-10 Five Coves Dam site looking Northeast (upstream): (A) Upper SAR Five Coves Rubber Dam, (B) trash rack system covering diversion and bypass intake gates, (C) dam (control) house, (D) generator building, (E) bypass gates into SAR, (F) diversion gates into Upper Five Coves Basin, (G) SAR to Upper Five Coves gates with sand berm in place, (H) Carbon Diversion Channel, (I) Lower Off-River System (dry), (J) Upper Five Coves Basin and (K) Glassell Avenue.

Water impounded behind the Five Coves Rubber Dam (Pool) can be diverted into the Lower Off-River System from the SAR or bypassed around the Five Coves Rubber Dam and back into the SAR. Controls for the diversion and bypass gate can be operated locally inside the dam control building at the gate valve actuators or remotely by SCADA (FHQ or laptop). The diversion gate valve actuator controls are located at the east end of Upper Five Coves Basin and the bypass gate valve actuator controls are located west of the dam on the right bank of the SAR. The dam has a mechanical deflate valve that will open when the pool level reaches 1 foot of flow over the dam. When the mechanical deflate is activated it will need to be reset in the field before the dam can be re-inflated. Approximately 600 cfs of flow can go over the dam (1 ft. of water) before the mechanical deflate is triggered. Flow over the dam remains in the SAR (Figure 3-11).

Figure 3-11 Flow over the Five Coves Rubber Dam

b. <u>Trash Rack</u>

The Five Coves diversion and bypass intakes are cleared using an automated trash rack system (Figure 3-12). The trash rack system can be operated manually (controls on the south wall inside or outside the Dam Control Building) or remotely using SCADA. For operational details of the Five Coves Trash Rack System see Appendix A-6.

Figure 3-12 Five Coves Trash Rack System.

c. Diversion

Flow diverted by the Five Coves Rubber Dam enters Upper Five Coves Basin through two 8 ft. by 5 ft. concrete box culverts (Figure 3-13) equipped with electrically actuated slide gate valves. The slide gate valves can be controlled locally (Appendix A-3) onsite or remotely using SCADA. The maximum combined diverted flowrate is 500 cfs. A sustainable diverted flowrate depends on how much flow is entering Upper Five Coves Basin from the Upper Off-River System and the available storage in Burris Basin. The maximum transfer rate from Five Coves to Lincoln to Burris Basins is 500 cfs. Each of the two diversion boxes at the Five Coves site measures flow using a 4-path Rittmeyer flow meter that communicate with SCADA. The diversion gate valve actuators are above the gate valves located at the east end of Upper Five Coves Basin (Figure 3-13).

Figure 3-13 Five Coves two 8-foot by 5-foot concrete diversion boxes daylighting into Upper Five Coves Basin. The Five Coves trash rack and control building can be seen in the background.

d. Bypass

Flow can go around the dam and remain in the SAR through two 6 ft. by 3 ft. bypass box culverts (Figure 3-14) equipped with electrically actuated slide gate valves. The slide gate valves can be controlled locally or remotely by SCADA. A maximum flowrate of 400 cfs is acceptable, flow exceeding 200 cfs per box are subject to entrained air (air bubbles) and may cause loss of accuracy. Flow is measured using a 2 Path Rittmeyer flowmeter in each box that communicate with SCADA. The bypass gate valve actuators are located above the gate valves west of the dam at the right bank of the SAR.

Figure 3-14 Two Five Coves 6-foot by 3-foot bypass box culverts with slide gate valves that discharge into the Santa Ana River. The Five Coves Rubber Dam is deflated in this image.

D. Lower SAR (between Five Coves Dam and Chapman Ave)

Flow bypassed around the Five Coves Rubber Dam flows over the lower section of the SAR. During periods of high flow, the Lower SAR has bank to bank coverage and maximum percolation occurs. During periods of low flow, runner dikes are built using SAR sand to minimize the flow path footprint which increases velocities. This mechanical control is used to mitigate midge fly population growth during warm weather. Percolation in the Lower SAR ranges from 40 cfs - 70 cfs depending on the configuration, condition of the river bottom and adjoining Off-River water levels. Bypassed flow is regulated to ensure flow does not pass beyond Orangewood Avenue.

In this lower portion of the SAR there are two locations flow can be temporarily diverted from the SAR, into Upper Five Coves and into Lincoln basins. To accomplish this a 200 ft. diagonal sand dike needs to be built at each location.

There are three main tributaries to this section of the river, Carbon Diversion Channel, Chantilly Drain and Katella Drain. There is no flow measuring device for tributaries contributing to the Lower SAR.

a. Carbon Diversion Channel

Carbon Diversion (Figure 3-10(H)) flow is derived from Carbon Canyon Dam flow and the many street drains which feed the channel north of the SAR. The Carbon Diversion Channel enters the SAR from the north, immediately west of the Five Coves Dam. Flows from the diversion that enter the SAR have been estimated to be as high as 500 cfs.

b. Lower SAR Temporary Diversion 1: Two pipes/gates to Upper Five Coves Basin

West of the Carbon Diversion Channel and Five Coves Dam there are two 60-inch canal gate valves (Figure 3-10(G)) and pipes capable of diverting 50 cfs of SAR flow to Upper Five Coves Basin. A diagonal sand dike needs to be built across the river from the center levee 200 ft upstream of the slide gate valves. The sand dike impounds water in the Lower SAR and channelizes the flow into Upper Five Coves Basin. Diverted flow is controlled by the gate valve openings. The gate valves are opened manually using a hand crank or with the portable hydraulic operator (Appendix A-4). There is no flow measuring device at this temporary diversion site.

c. Lower SAR Temporary Diversion 2: Two pipes/gates SAR to Lincoln Basin

West of Lincoln Avenue there are two 36-inch canal gate valves (Figure 3-15) and pipes capable of diverting 25 cfs of SAR flow into Lincoln Basin. Lincoln Basin must be empty when these gates are used. A diagonal sand dike needs to be built across the river from the center levee 200 ft upstream of the canal gate valves. The sand dike impounds water and the flow into Upper Lincoln Basin is controlled by the canal gate valves opening. The gate valves are opened manually using a hand crank or with the hydraulic operator (Appendix A-4). There is no flow measuring device at this diversion-site.

Figure 3-15 Aerial view of the Lower SAR temporary diversion structure: two gated pipes SAR to Lincoln Basin with sand berm built. Also visible in the lower SAR channel is a concrete structure built by the USACE to stabilize the hydraulic conditions during high flow events.

d. Ball Road Gaging Station

The Ball Road Gaging Station relies on a sand dike configuration (Figure 3-16) designed to channelize the SAR flow over a “bubbler” level sensor near the center levee. The level is monitored on SCADA by recharge operators. There is a look-up table available to estimate flow when the sand dikes are intact or completely removed (and flow is of reasonably uniform thickness). See Appendix A-7 for look-up tables. It is common during high flows that the sand dikes get damaged, in this case flow is unmeasurable.

Figure 3-16 Ball Road Gaging Station with sand dikes configured. The bubbler gas line conduit is visible running down the western bank of SAR. The Ball Road gauge house is out of view (left-hand side of image).

e. Ball Road to Chapman Ave.

"T & L" levees are built in this section of the SAR to slow the flow and to maintain bank to bank coverage to maximize percolation. Daily field observations of water coverage and flow are made by recharge operators in this section of the SAR. Using the Ball Rd. SCADA information and observations, SRSOs regulate dam bypass flows (either Imperial Dam, or Five Coves Dam if inflated). The flows are adjusted to maximize percolation in the SAR as far downstream as the 57 Freeway. If the river is wetted and flowing past the freeway, bypass flows are reduced. If the SAR is dry above the 57 Freeway, bypass flows are increased. The section of SAR from the 57 Freeway and Chapman Avenue is used as a buffer and indicator for necessary flow adjustments. Water past Chapman Avenue is considered lost to the ocean. This flow is detected at the United States Geological Survey (USGS) 5th Street Gaging Site in Santa Ana. Data for this gauging station can be found at:
https://waterdata.usgs.gov/usa/nwis/uv?site_no=11078000

4. UPPER OFF-RIVER SYSTEM (Imperial Flume to Carbon Diversion)

Flow diverted by the Imperial Rubber Dam passes through the Imperial Flume to enter the Upper Off-River System. The Upper Off-River system is a series of Weir Ponds.

Figure 4-1 Aerial view of the beginning of the Upper Off-River System showing diverted flow entering the (A) Imperial Flume and (B) Upper Weir Pond 1. Other important features visible in this image include: (C) Imperial Rubber Dam, (D) Imperial Control House with removable roof panels above the Imperial Diversion Gates and (E) diversion flow boxes.

a. <u>Imperial Flume</u>

Flow passes through the Imperial Flume shortly after being diverted off of the main SAR channel. This is a 15 ft Parshall Flume for manually measuring diverted flow. A look-up table for this flume is in Appendix A-8. A level transducer and a down-looking electronic level sensor are both located at the Imperial Flume and feed data into the SCADA system. Measurement accuracy of the Imperial Flume requires unobstructed flow upstream and downstream of the flume. Common obstructions include sediment accumulation and vegetation growth.

Figure 4-2 Imperial Flume showing locations of down-looking flow sensor (left image) and transducer/stilling well (right image). The catwalk bridge is used for manual flow measurements and removal of physical obstructions. A staff gauge is mounted on the North wall of the flume and is not visible in this figure.

b. Weir Ponds 1, 2 and 3

The primary function of the Weir Ponds is to reduce the amount of silt in the diverted flow stream. Silt deposition is the primary cause of recharge basin clogging. The combined wetted area of Weir Ponds 1, 2, 3 and 4 is 33-acres with a maximum of 252 acre-feet of water storage.

Flow diverted at the Imperial Dam travels through the upper off-river system going through Weir Ponds 1, 2, 3 and 4 by gravity surface transfer.

Weir Pond 1

Flow is measured entering Weir Pond 1 using the Imperial Flume. Flow leaves Weir Pond 1 and enters Weir Pond 2 over a broad crested weir. Weir Pond 1 contains one 36-inch drain tube with a manually controlled slide gate valve that discharges into Weir Pond 2. Flow into all Weir Ponds is controlled by throttling the diversion gate valves at the Imperial Rubber Dam.

Weir Pond 2

Weir Pond 2 contains one 36-inch drain tube with a manually controlled slide gate valve that discharges into Weir Pond 3. Flow Leaves Weir Pond 2 over a 99-foot sharp crested weir with end contractions (Figure 4-3). A look-up table for this weir is provided in Appendix A-8. Flow leaving Weir Pond 2 is also measured using a level transducer that provides real-time feed into the SCADA system.

Figure 4-3 Flow over the 99-foot sharp crested weir between Weir Ponds 2 and 3. Note obstructions, as shown in figure can create inaccuracies in flow measurement and should be removed quickly so wildlife habitat does not develop.

Weir Pond 3

Flow Leaving Weir Pond 3 is manually measured using 40-foot and 30-foot sharp crested weirs that are offset in elevation for higher accuracy. Both weirs are equipped with end contractions. Look-up tables for these weirs are provided in Appendix A-8. Flow leaving Weir Pond 3 is also measured using a level transducer that provides real-time feed into the SCADA system.

Flow over the Pond 3 weir(s) travels through a concrete transfer box under Lakeview Avenue and into Weir Pond 4. Weir Pond 3 has a 48-inch drain tube and manually operated slide gate valve with hand wheel that discharges into Weir Pond 4.

During storms local inflow can enter the SAR between the diversion flume and Weir 3 (Pond 2 street drain), it is suggested that no more than 350 cfs maximum goes through the Lakeview transfer box for a sustained period per OCWD Engineering Department following completion of a relining project. The structure was originally designed to transfer 500 cfs. Now, when flowing more than 350 cfs through the Lakeview transfer box it is critical to closely monitor the water surface for vortexes on both sides of the Lakeview Avenue. Erosion of the bank is of primary concern.

Figure 4-4 Aerial image of Weir Pond 3 looking west (downstream). Visible features include: (A) measuring weir, (B) transfer box under Lakeview Avenue, (C) 48-inch drain valve operator. Also visible in this image is (D) Weir Pond 4, (E) Foster Huckleberry Basin and (F) the SAR. The dry “Passive System” (G) can be seen directly downstream (below) Weir Pond 4 in the Upper Off-River system.

c. Weir Pond 4

The primary function of Weir Pond 4 is to direct flow diverted off the SAR. Weir Pond 4 is the only diversion point into the Warner System (Figure 2-3).

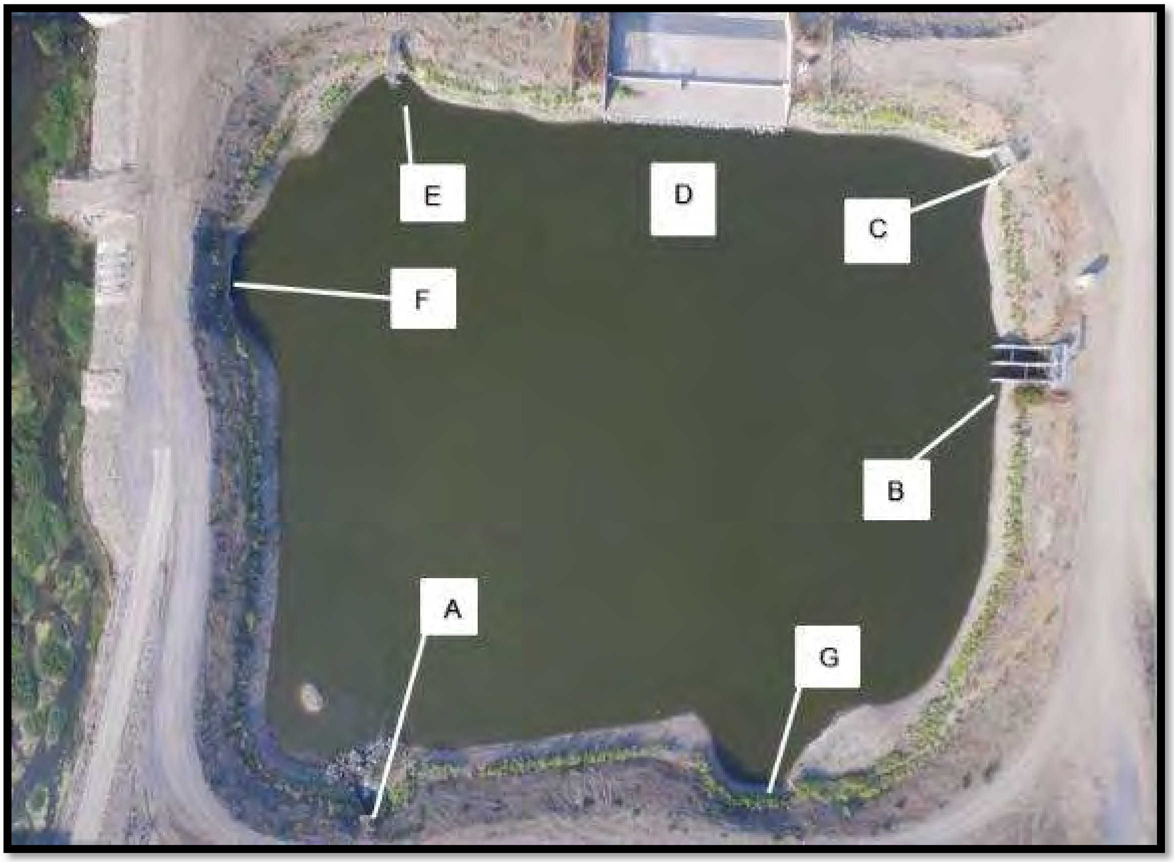


Figure 4-5 Aerial Image of Weir Pond 4 showing: (A) transfer box under Lakeview Avenue, (B) two 60-inch pipes with slide gate valve gravity feeding water into the Warner System, (C) 60-inch slide gate valve into the Warner Bypass Pipeline, (D) Measuring Weirs, (E) 48-inch drain canal gate valves, (F) four 36-inch gated pipes to the SAR and (G) Weir Pond 3 48-inch drain discharge.

Flow can enter Weir Pond 4 from three places:

- Flow can come from Weir Pond 3 over a sharp crested weir then through a 7 ft. by 7 ft. surface transfer box (Figure 4-5(A)). The box was originally designed for 500 cfs, it was later relined due to wear. The engineer involved suggested no more than 350 cfs due to possibility of vortexes developing on both sides of the box that may cause erosion issues with Lakeview Avenue.
- Flow can come from Weir Pond 3 via one gated 48-inch pipe. This valved pipe is manually operated and not available on the SCADA system. The estimated maximum flow is 125 cfs.

- Flow can come from the SAR through four 36-inch canal gate valves (Figure 4-5 (F)). These four gate valves are not available on the SCADA system and require local operation using the portable hydraulic valve operator (Appendix A-4). Sand diversion dikes can be built using bulldozers to force water from the SAR into Weir Pond 4 through these four 36-inch pipes with slide gate valves. Estimated maximum flow is about 100 cfs for all four 36-inch pipes (Figure 4-6).

Figure 4-6 Four 36-inch pipes with canal gate valves connecting the SAR to Weir Pond 4. The portable hydraulic valve operator connects to the valve nut visible at the end of the valve stem.

Flow can leave Weir Pond four different ways:

- Flow can be sent to Foster-Huckleberry (beginning of the Warner System, see Section 5 and Figure 4-7) using two 60-inch pipes with slide gate valves capable of maximum flow of 200 cfs. Sending water in this direction mostly depends on storage and elevation differences of downstream basins. These gate valves can either be controlled locally or remotely using SCADA. Flow measured into this system is the byproduct of Weir Pond 3 flow minus flow over Weir 4 or through the Weir Pond 4 drain (Warner bypass on occasion).

Figure 4-7 Slide gate valve intake for two 60-inch pipes that gravity feed into Foster-Huckleberry Basin.

- Flow can be sent into the Warner Bypass Pipeline using a 60-inch slide gate valve (Figure 4-8). The slide gate valve is located at the northwest corner of Weir Pond 4. This slide gate valve is not connected to SCADA but controlled locally at the electric actuator. Maximum flow through the Warner Bypass Pipeline is approximately 150 cfs (no flow meter).

Figure 4-8 Slide gate valve intake for 60-inch Warner Bypass Pipeline.

- Flow can continue down the Upper Off-River system by flowing over a 60-foot and/or a 40-foot sharp crested weir that are offset in elevation for higher accuracy. The weirs are located on the west side of Weir Pond 4 and north of the 48-inch canal gate valve drain (See Figure 4-9).

Figure 4-9 Bi-level 60-foot and 40-foot weirs at Weir Pond 4. Note: physical obstructions like the debris shown, can cause inaccuracies in flow measurements.

- Flow can leave Weir Pond 4 through a 48-inch canal gate valve drain located on the south west corner. This canal gate valve is used to drain Weir Ponds into the Upper Off-River. This canal gate valve has no SCADA connection, local operation with portable hydraulic operation (Appendix A-4) or hand crank. Maximum flow through this discharge point is no more than 30 cfs. This drain has no flowmeter, flow is spot measured with the Flow Tracker field device (Figure 4-10).

Figure 4-10 Weir Pond 4, 48-inch canal gate valve drain.

Level in Weir Pond 4 is monitored using a shaft encoder/position analog transmitter (shaft encoder) that communicates with the SCADA system.

As flow continues down the Upper Off-River System, the channel bottom serves both a conveyance and recharge function. This section of the Off-River is prone to becoming wildlife habitat. Careful landscape management is required.

Flow can enter this lower segment of the Upper Off-River System from 4 sources:

- The maximum flow over the two sharp crested weirs at Weir Pond 4 (Figure 4-9) is 250 cfs. Flow is measured using a level sensor (SCADA) and rating curve (Appendix A-8).
- Weir Pond 4, 48-inch canal gate valve drain (Figure 4-10). This drain is used mostly to drain the Weir Ponds. This drain has no flowmeter, flow is spot measured with the Flow Tracker field device.
- Warner Bypass Pipeline 60-inch slide gate valve above the 91 Freeway (Figure 4-11). This flow may come from Weir Pond 4 or from the Warner Outflow channel and is generally no more than 30 cfs. There is no flowmeter for this discharge point. Flow is approximated from manually spot checking over the years with the flow tracker measuring device.

Figure 4-11 Warner Bypass Pipeline 60-inch slide gate valve to Upper Off-River, 91 Freeway Bridge in background.

- SAR below the train bridge and above Five Coves Dam four 36-inch canal gate valves (Figures 3-7, 3-9). Building a sand dike below the canal gate valves and extending it upstream creates depth and allows flow into Upper Off-River System. Approximately 50 cfs maximum.

Flow can leave the Upper Off-River System from four 48-inch slide gate valves at the downstream end, west of Glassell Avenue. These slide gate valves are controlled locally using valve actuator controls or remotely from SCADA. (Figure 4-12).

Figure 4-12 Aerial image of Four 48-inch slide gate valves into Upper Five Coves Basin and ten flap gates into Carbon Diversion Channel. Two-tier crested measuring weir off-set in elevation (Weir 5) can be seen in front of the four slide gate valves. Upper Five Coves Basin is visible below the Carbon Diversion Channel.

The Upper Off-River System will spill into Carbon Diversion through ten 84-inch by 48-inch box culverts with 84-inch by 12-inch metal flap valves above the slide gate valves. If the four 48-inch slide gate valves are closed or throttled, clogged or flow exceeds capacity, flow will spill through the flap valves into the Carbon Diversion Channel. The flap valves are designed for 500 cfs.

At this structure there are three 28-foot weirs with two different elevations for accuracy. The first weir point of zero flow (pzf) is 206' msl that flows 50 cfs over before the second tier is reached at elevation 206.7' msl. The second and third weirs are located on each side of the lower weir. The maximum flow over all three weirs is 200 cfs. Flow is measured electronically using a down looking level sensor and look-up tables viewed on SCADA.

d. Passive System

Immediately downstream of Weir Pond 4 lies the passive system (Figure 4-4(G)). The passive system is an ongoing research project that collects water just beneath the ground surface and transfers the flow into Olive Basin (Figure 4-13) for percolation. This project is operated by the Districts Field Research Laboratory and the Recharge Planner. The SRSOs are not responsible for the operation of the passive system. A document explaining the project is provided as Appendix B.

Olive Basin is the only recharge basin that is part of the Upper Off-River System. This basin receives flow from the passive system and surface flow from the Upper Off-River System. Olive Basin is approximately 10 wetted acres and is equipped with a submersible pump for dewatering. This pump can be controlled locally or remotely using the SCADA system. For Olive Basin Pump Operation details see Appendix A-9.

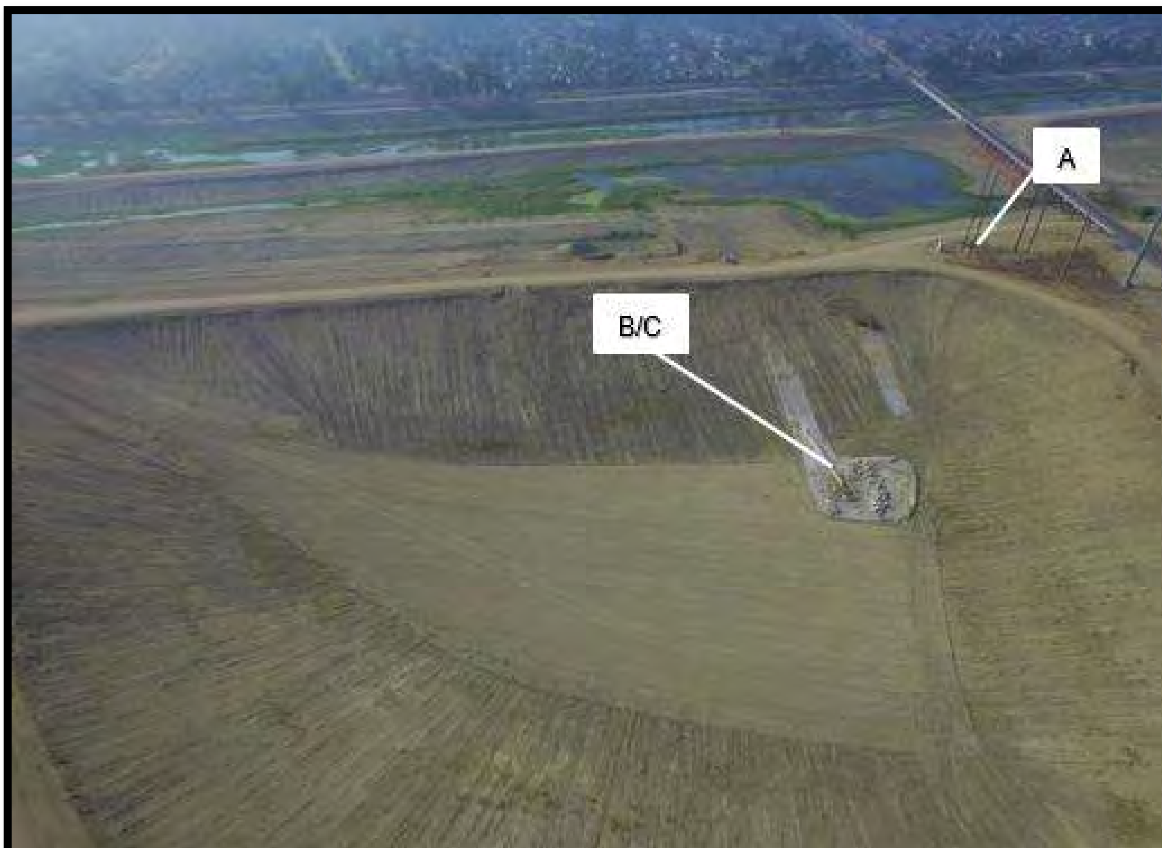


Figure 4-13 Aerial image of Olive Basin showing the (A) dewatering pump control building, (B) sump pump intake structure and (C) basin inlet portal.

5. WARNER SYSTEM

Flow leaving Weir Pond 4 can flow through the Warner System. The Warner System includes Foster-Huckleberry, Conrock, Warner and Little Warner Basins for a combined wetted area of approximately 125-acres with a maximum of 4,189 acre-feet of water storage (Figure 5-1).

Figure 5-1 Aerial view of (A) Foster-Huckleberry Basin, (B) Conrock Basin, (C) Warner Basin, and (D) Little Warner Basin. Other important features visible include: (E) Foster-Huckleberry 36-inch drain, (F) four 48-inch transfer pipes from Foster-Huckleberry Basin into Conrock Basin and (G) City street storm drain portal. Note: below the road between Conrock and Warner Basin lies a large diameter MWD water transmission pipeline.

Although the Warner System is capable of recharge, its primary function acts as a desilting system for the Upper Recharge System. It also serves as a concession for fishing which can sometimes be a conflict when planning recharge operations. Without the fishing concession, the Warner System could be cleaned more frequently and increase the overall capacity of OCWD's Recharge System. Care should be taken when filling the Warner system from an empty state. To prevent erosion, no more than 15 feet of head differential between all three basins should be maintained during filling. MWD has a large diameter transmission pipeline that runs beneath the road separating Conrock and Warner Basins.

a. Foster-Huckleberry Basin

Flow enters Foster-Huckleberry Basins from Weir Pond 4 through two 60-inch pipes with slide gate valves (Figures 4-5(B), 4-7). The slide gate valves are designed for a maximum inflow of 300 cfs but when the Warner System is full, the maximum inflow is no more than 200 cfs. Flows and levels through the Warner System are controlled by adjusting these slide gate valves. These valves are controlled locally or remotely using SCADA. See Appendix A-3 for actuator gate valve operational instructions. Levels at various basins within the Warner System can be viewed on SCADA.

Flow exits Foster-Huckleberry Basin at southwest corner through four 48-inch surface transfer pipes at elevation 245-feet above msl (Figure 5-2). These transfer pipes are flow-through and do not have gate valves. Flow can also leave the basin through one 36-inch drain valve used only for draining of basin (Figure 5-1(E)). This valve is controlled locally with the portable hydraulic operator. This drain discharges to Conrock Basin. There is no flowmeter to determine the discharge flow rate. Level is measured using a pressure transducer and a Waterlog 3551 bubbler located at the Weir Pond 4 communication hub (house), An orifice line runs into the southeast corner of Foster/ Huckleberry Basin (the high end of basin) and the basin level is available on SCADA.

Figure 5-2 Four 48-inch transfer pipes leaving Foster/Huckleberry Basin.

b. Conrock Basin

Flow enters Conrock Basin from the four 48-inch subsurface transfer pipes leaving Foster-Huckleberry Basin (Figure 5-2). Flow exits Conrock Basin at southwest corner through four 48-inch surface pipes with slide gate valves at elevation 240 ft. msl (Figure 5-3(D)). These gate valves are not on SCADA and are operated locally with the portable hydraulic operator or hand crank. Flow can also leave through an 18-inch and

36-inch drain valve, both valves are pneumatically operated locally. For operational instructions on pneumatic valve operation see Appendix A-10. These are only used to drain Conrock Basin and to fill Warner Basin. There is an Accusonic flowmeter and down looking level sensor (at level 230 msl) that can be seen on SCADA when surface transferring. These drains have no meters.

c. Warner and Little Warner Basins

Flow from Conrock Basin enters Warner Basin through four 48-inch surface transfer pipes located in the south east corner of Warner Basin at elevation 240 ft. msl during normal operation. This flow is measured with a 4 path Rittmeyer flowmeter under the foot bridge (Figure 5-3(C)).

Figure 5-3 Aerial Image showing (A) Conrock Basin, (B) Conrock Channel, (C) gauging station and (D) 4 transfer pipes into Warner Basin. FHQ Buildings are visible in the background. Note a large diameter MWD water transmission pipeline lies under the road separating Conrock and Warner Basin.

When Warner Basin is being filled from empty or a very low level, flow can also come into Warner Basin through an 18-inch and a 36-inch drain valve. These drain valves are pneumatically operated locally and should always be opened when Warner Basin is begin filled to equalize water levels between Warner Basin and Conrock Basin. For the pneumatic valve operation instructions see Appendix A-10. The drains are located at mid-point of both Conrock and Foster- Huckleberry Basins.

d. Warner Bypass Pipeline

The primary function of this pipeline is to bypass flow around the Warner System to Anaheim Lake when Warner Basin is being cleaned. The Warner Bypass Pipeline can also be used to backflow water through the Warner Outflow Channel into Little Warner Basin and into Warner Basin at an estimated maximum flow rate of 25 cfs.

The flow enters the Warner Bypass Pipeline through a 60-inch locally controlled electrically actuated slide gate valve at the northwest corner of Weir Pond 4 (Figures 4-5(C), 4-8). Weir Pond 4 and discharges into the Warner Outflow channel. This bypass was designed to send water around the Foster-Huckleberry, Conrock and Warner Basins during dewatering and cleaning events. There is no flowmeter for the Warner Bypass Pipeline.

The Warner Bypass Pipeline can also be used to fill Warner Basin at a maximum flow rate of 25 cfs. Flow enters the Warner Outflow Channel from the bypass pipeline into Little Warner Basin then transfers to Warner Basin. This can be done simultaneously while filling Warner Basin using the Conrock Basin drains.

The Warner Bypass Pipeline delivers water to two places:

- Flow can be sent to the Upper Off-River through a 60-inch pipe/slide gate valve just upstream of the 91 Freeway. (Figure 4-11). This slide gate valve has no SCADA connection, local operation with portable hydraulic operation (Appendix A-4) or hand crank. Maximum flow through this discharge point is no more than 30 cfs.

- Flow can be sent to the Warner Outflow Channel through a 60-inch slide gate valve located at the termination of the Warner Bypass Pipeline (Figure 5-4). This gate valve has no SCADA connection, local operation with hydraulic operator or hand crank only. In general, maximum flow is no more than 150 cfs.

e. Warner Outflow Channel

The Warner Outflow channel is used to transfer flow out of the Warner System (Figure 5-4).

Figure 5-4 Warner Outflow Channel. Visible in this image is: (A) Little Warner Basin, (B) the Warner By-pass Pipeline terminus and (C) the Warner Basin Outflow Slide Gate Valve (beginning of 66-inch Warner-Anaheim Pipeline).

The Little Warner Channel Rubber Dam is near the inlet side of the Warner Outflow Channel and is used during the dewatering of Warner Basin and using the Warner Bypass while transferring flow to Anaheim Lake. When the dam is inflated flow can be pumped out of Warner Basin using 1 or 2 submersible pumps. Water flows by gravity from the Warner Outflow Channel into the Warner-Anaheim Pipeline. See Appendix A-11 for Warner Outflow Channel Rubber Dam operation instructions. Warner Basin is dewatered on average once every five years and this process takes months to empty and clean the basin. Challenges associated with cleaning this basin includes seepage along the south bank and fish die-off. See Appendix A-9 for Warner Basin dewatering pump operation.

Flow can enter the Warner Outflow Channel from three places:

- Flow can enter from the Warner Bypass Pipeline through a 60-inch slide gate valve at terminus of pipe (Figure 5-4(B)).
- Flow can enter using pumps at bottom of Warner Basin usually when the Little Warner Channel Rubber Dam is inflated.

Flow can surface transfer from the Little Warner Basin when the Little Warner Channel Rubber Dam is deflated above elevation 229 ft. msl.
Flow can be directed out of the Warner Outflow Channel to three places:

- Flow can be sent to the Upper Off-River through the 60-inch Warner Bypass Pipeline (as previously mentioned) (Figure 4-11).
- Flow can be sent into Little Warner Basin if the water surface elevation is greater in channel (if dam is not inflated while pumping or flow is coming from Warner Bypass).
- Flow can be sent out through the Warner Basin outflow slide gate valve to the 66-inch Warner-Anaheim Pipeline that connects to the Miraloma Transfer Box using SCADA or controls on valve actuator (Figure 5-5). Care must be taken when going from an empty pipe to full pipe flow of 180 cfs. The Warner Basin elevation needs to be 238 feet msl to achieve this flow rate. During this condition, the slide gate valve should be opened at small intervals and watched until about 130 cfs, at this point the pipe should be full and void of air pockets. Flow is measured with an Accusonic 4 path system available on SCADA.

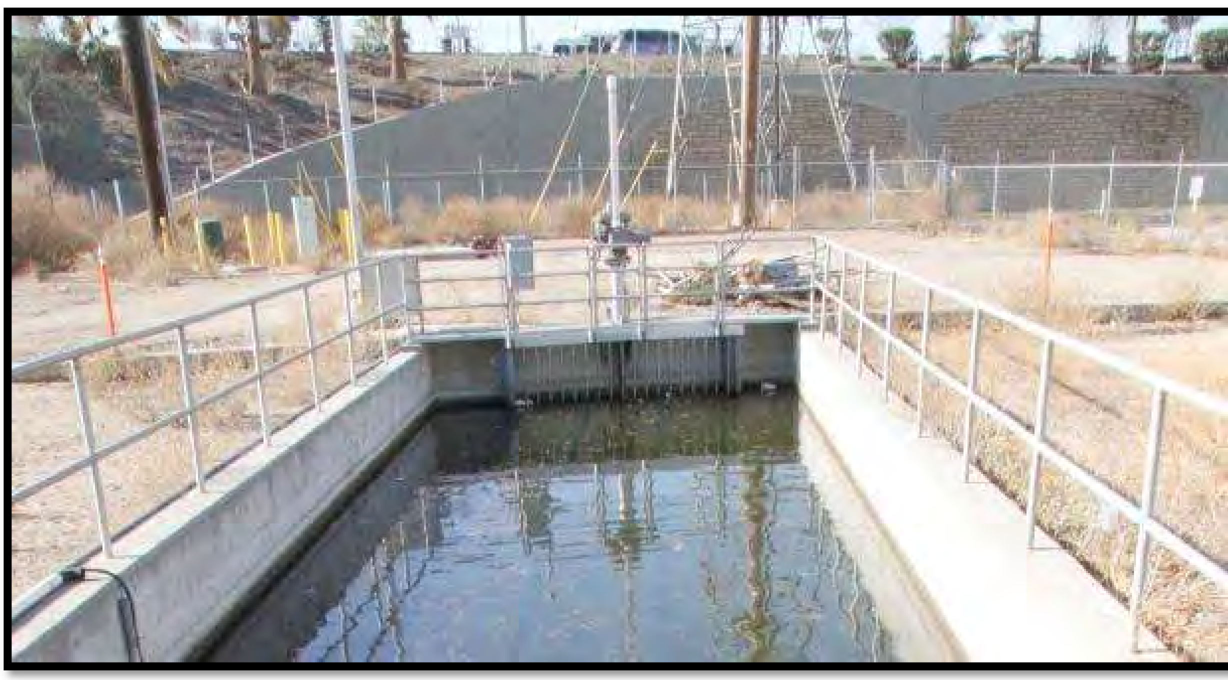


Figure 5-5 A full Warner Outflow Channel showing the 66-inch slide gate valve into the Warner-Anaheim Pipeline. Gravity fed flow into the Warner-Anaheim Pipeline is measured by a 4 Path Accusonic flow meter linked to SCADA.

6. UPPER RECHARGE SYSTEM

The Upper Recharge System contains the following recharge basins: Anaheim Lake, Mini Anaheim Lake, Miller Basin, Kraemer Basin, La Jolla Basin, Placentia Basin and Raymond Basin (Figure 6-1). In addition to basins, the Upper Recharge System utilizes: the Miraloma Transfer Box, Phase I and Phase II Pipelines, imported water connection OC-28 (Tubs), Attwood Channel and Carbon Creek.

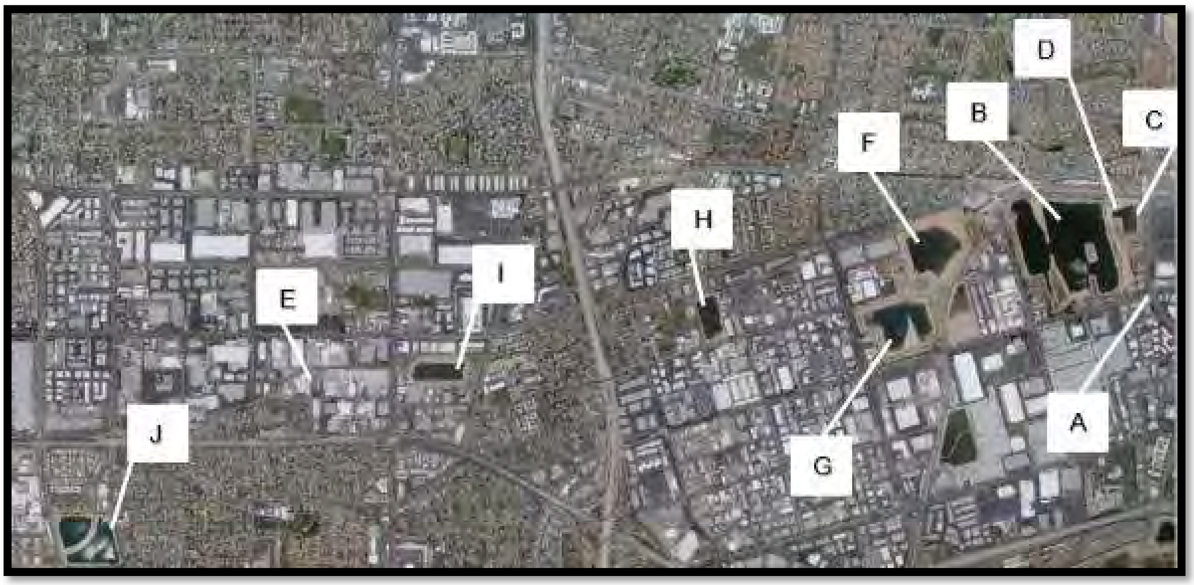


Figure 6-1 Aerial Image of the Upper Recharge Systems including: (A) Miraloma Transfer Box, (B) Anaheim Lake, (C) Mini Anaheim Lake, (D) OC-28 (Tubs), (E) Carbon Creek, (F) Miller Basin, (G) Kraemer Basin, (H) La Jolla Basin, (I) Placentia Basin and (J) Raymond Basin.

a. Miraloma Transfer Box

The primary function of this site is to direct water from Warner Basin into Anaheim Lake or the Phase I 72-inch pipeline. The Miraloma Transfer Box is a buried concreted diversion structure at the terminus of the Warner-Anaheim Pipeline. The Miraloma Transfer Box is designed for flows up to 180 cfs.

The Miraloma Transfer Box is located about 300 feet southwest of the Tustin/Rose Avenue intersection and diverts flow into Anaheim Lake or the Phase I Pipeline (Figure 6-2).

Figure 6-2 Aerial view looking west showing the (A) Miraloma Transfer Box, (B) control house and (C) terminus of 66-inch pipeline from the Miraloma Transfer Box into Anaheim Lake.

Flow can enter the Miraloma Transfer Box from two places:

- Flow can enter from the Warner Outflow Channel by gravity through the 66-inch Warner-Anaheim Pipeline.
- Flow can enter from the Phase I 72-inch pipeline (pumped around Anaheim Lake into the Phase I Pipeline or by gravity from Mini Anaheim inflow/outflow line).

Flow can be directed from the Miraloma Transfer Box two places:

- Flow can be sent into Anaheim Lake through a 66-inch motor operated butterfly valve either locally with an electrical valve actuator or with SCADA. Flow is metered by a Sontek Doppler sonic meter seen on SCADA. There is an independent level transmitter used to monitor level inside the Miraloma Transfer Box. Level is viewed on SCADA. To avoid surfacing water onto Miraloma Avenue, level should ***not*** exceed13 feet. Maximum flows of 180 cfs when 100%

is going into Anaheim Lake and 140 cfs when the flow is divided with the Phase I Pipeline.

- Flow can be sent into the 72-inch Phase I Pipeline using a motor operated slide gate valve on the Phase I Pipeline just north of the Miraloma Transfer Box with SCADA or local control (Figure 6-2). This is possible when the Anaheim Lake 66-inch butterfly valve is either closed or partially closed (throttled, restricting flow causing it to back up into the Phase I Pipeline).

b. Phase I Pipeline

Flow in the Phase I Pipeline travels north from the Miraloma Transfer Box to the northeast corner of Anaheim Lake by gravity. The path splits between Anaheim Lake to the west and Mini Anaheim Lake to the east and into two 48-inch pipes that go under the OC-28 (Anaheim Tubs) Spillway.

Flow can enter the Phase I Pipeline from three places:

- Flow can enter from the Miraloma Transfer Box (Figure 6-1, 6-2).
- Flow can enter from the Mini Anaheim 36-inch slide gate valve while Mini Anaheim Lake is draining (Figure 6-3).
- Flow can enter from the Phase II Pipeline through two 48-inch butterfly valves.

Flow can be directed from the Phase I Pipeline to four places:

- Flow can be sent to the Miraloma Transfer Box and into Anaheim Lake through the 66-inch butterfly valve (generally, when dewatering Mini Anaheim by gravity).
- Flow can be sent to Atwood Channel through two 48-inch butterfly valves. These two 48-inch butterfly valves are local controlled only, no SCADA. The valves are currently non-operational and targeted to be replaced in the future.
- Flow can be sent into the 72-inch Phase II Pipeline through two 48-inch butterfly valves that can be controlled locally or remotely by SCADA.
- Flow can be sent to Mini Anaheim Lake through a 36-inch Magmeter and actuated slide gate valve that can be controlled remotely by the SCADA system.

c. Mini Anaheim Lake

Mini Anaheim Lake is located just southwest of the intersection of Tustin and Orangethorpe Avenue (Figure 6-3). The wetted area is 3.8-acres with a maximum of 10-acre-feet of water storage.

Figure 6-3 Mini Anaheim Lake featuring: (A) 36-inch slide gate valve connected to the 72-inch Phase I pipeline and (B) 30-inch slide gate valve connected to OC-28. A portion of OC-28 (Tubs) is also visible in lower left.

Flow can enter Mini Anaheim Lake from two places:

- Flow can come from the 72-inch Phase I Pipeline through a 36-inch lateral pipeline slide gate valve at the west end of Mini Anaheim Lake (Figure 6-3(A)). This slide gate valve can be controlled by SCADA or locally with an electric actuator. Flow is measured with a Magmeter seen on SCADA.
- Flow can come from the imported water connection OC-28 (Tubs) through a 30-inch slide gate valve at the north end of the basin (Figure 6-3(B)). This flow is measured by a Magmeter and viewed on SCADA. A maximum flow rate of 15 cfs for short periods and flow of 5-10 cfs can be sustained.

Mini Anaheim Lake does not have a dewatering pump. It can be drained by gravity into the Phase I Pipeline back down to the Miraloma Transfer Box and into Anaheim Lake through the 66-inch butterfly valve. Normally this basin is left to recharge water until it is dry. This basin is not used when Anaheim Lake is being drained because of seepage and possible subsurface piping on the east bank of Anaheim Lake. Level at Mini Anaheim Lake is measured with a pressure transducer located between the two connections and displayed on SCADA.

d. Imported Water Connection OC-28 Anaheim Tubs

Imported flow from the Colorado River Aqueduct contains Quagga Mussel, while flow from the State Water Project does not contain Quagga Mussel. Water with Quagga Mussel is restricted to percolate only in the Upper Recharge System basins which can be desiccated per the Quagga Mussel Plan (See Appendix C).

The imported water connection OC-28 is located at the northeast side of Anaheim Lake. This structure receives and distributes imported flow from MWD. This structure is often referred to as the “Tubs”. The Tubs (Figure 6-4) are located at the terminus of the MWD OC-28 pipeline. The OC-28 pipeline originates at the MWD Diemer Treatment Plant located in Yorba Linda, CA. The Diemer Treatment Plant receives flow from the Colorado River Aqueduct and/or the State Water Project. Level at the Tubs is measured using a shaft encoder and visible on SCADA.

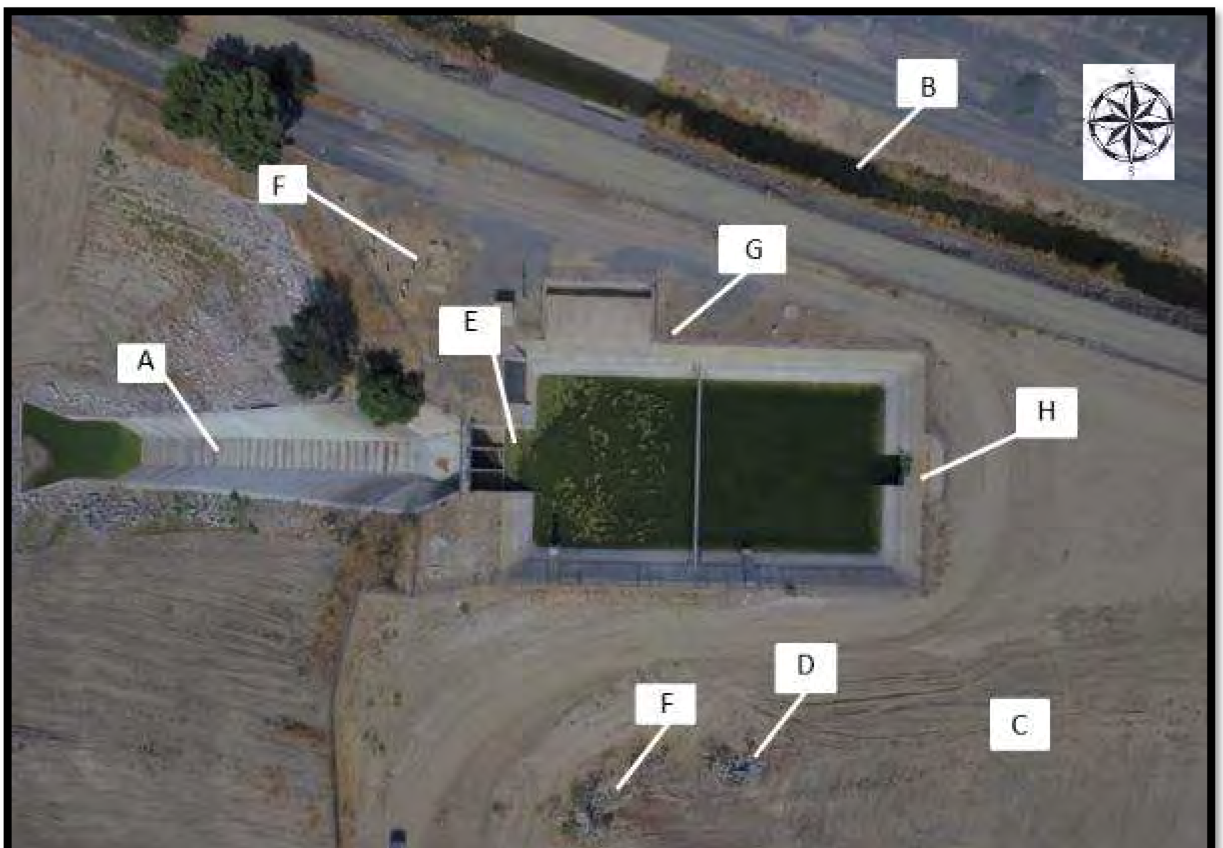


Figure 6-4 Import water connection OC-28 (tubs), (A) spillway into Anaheim Lake, (B) Attwood Channel, (C) Mini Anaheim Lake, (D) location of actuator for 30-inch slide gate valve to Mini Anaheim Lake, (E) three 48-inch slide gate valves into Anaheim Lake, (F) location of actuator for the 36-inch slide gate valve into Phase II Pipeline, (G) Atwood Channel Side Spill and (H) Inlet from MWD pipeline.

Imported flow from the Colorado River Aqueduct contains Quagga mussel and is restricted to percolate only in recharge basins that can be quickly dewatered (i.e., pumped) and include Anaheim Lake, Kraemer, and Miller basins. Other basins, the Off-River (Upper and Lower), and the Santa Ana River are restricted from receiving water containing Quagga mussels.

Flow can be directed out of OC-28 (Tubs) to four places:

- Flow can be sent to Mini Anaheim Lake using a 30-inch gate valve at the south end (Figure 6-4(D)). This valve can be controlled locally or remotely by SCADA. Flow is measured using a Magmeter that communicates with SCADA. A maximum flow of 15 cfs for short periods and flow of 5-10 cfs can be sustained.
- Flow can be sent into Anaheim Lake over a 29 ft. weir with end contractions then through three 48-inch slide gate valves at the southwest side of OC-28 (Tubs) and down a concrete spillway (Figure 6-4(E)). These gate valves can be controlled locally or remotely by SCADA. A shaft encoder is used to measure level and a look up table is used to determine flow over the weir and viewed on SCADA. Maximum flow is 180 cfs. See Appendix A-11 for OC-28 (Tubs) Weir rating table.
- Flow can be sent to the 72-inch Phase II Pipeline using a 72-inch butterfly valve located at northwest side of the OC-28 area (Figure 6-4(F)). This 72-inch butterfly valve can be operated locally or remotely by SCADA. Flow is measured using an Sontek acoustic doppler flowmeter that communicates with SCADA. Maximum flow of 180 cfs and 100 cfs can be sustained.
- Flow can be side spilled into Atwood Channel (not preferred) (Figure 6-4(G)). Side spilling was one of the methods used prior to the installation of the Phase II Pipeline. This need no longer exists as additional silts are transported to basins receiving side spilled flows.

e. Atwood Channel

Flow can enter the Atwood Channel from three places:

- Phase I Pipeline, two 48-inch butterfly valves located at northeast corner of Anaheim Lake, valves are controlled locally.
- Flow can come from the OC-28 (Tubs) side spill. To calculate flow (from side spill) subtract from the MWD flow the OC-28 flow and/or the 72-inch North Shore Sontek acoustic doppler flowmeter.
- Flow can come from the Anaheim Lake overflow spillway located at northwest corner of Anaheim Lake.

Flow from the Atwood Channel goes to Carbon Diversion. Four canal gate valves control flow that go from the Atwood Channel/Carbon Diversion into Carbon Creek. Carbon Creek is owned by OCFCD. The four canal gate valves are also owned by OCFCD. These four gate valves are non-operational and remain in the closed position.

f. Anaheim Lake

Anaheim Lake is located northwest of the Tustin Avenue and Miraloma Avenue intersection (Figure 6-5). The primary function of Anaheim Lake is recharge. Anaheim Lake has a wetted area of 71-acres with a maximum 2,300 acre-feet of water storage. Percolation rates in Anaheim Lake range from 20-70 cfs.

Figure 6-5 Aerial image of Anaheim Lake including: (A) submersible dewatering pump sump, (B) submersible pump control panels, (C) vertical turbine pump intake structure, (D) vertical turbine control panel, (E) concrete spill structure, (F) (superimposed) Phase II Pipeline, (G) spillway from OC-28, (H) entry point from Miraloma Transfer Box and (I) Anaheim Lake inflow line 42-inch butterfly valve. Miller street is visible in the lower right corner of the image.

Flow can enter Anaheim Lake three ways:

- The 66-inch pipe and butterfly valve off the Miraloma Transfer Box (Section 6a). This valve can be controlled locally or remotely by SCADA. Flow is measured by a Sontek flowmeter.
- Flow can enter from OC-28 (Section 6d). Flow is measured by the weir and shaft encoder and seen on SCADA.
- Flow from the Phase II Pipeline can enter the Anaheim Lake 42-inch inflow line into the pump sump. Flow is measured using an in-line propeller flowmeter and viewed on SCADA.

Flow can exit Anaheim Lake two ways:

- Four submersible pumps and a vertical turbine pump are used to dewater Anaheim Lake. Submersible pump discharge flows through the 42-inch discharge line (SCADA and local control at actuator). Each submersible pump discharge line has its own motor operated valve (MOV) and a shared propeller flowmeter that is viewed on SCADA. These submersible pumps move between 25-40+ cfs of discharge each, depending on basin level. The vertical turbine pump has its own discharge line and propeller meter that connects to the Phase II Pipeline. The vertical turbine pump moves between 40-55 cfs of discharge depending on the head conditions in Anaheim Lake. Discharge pumped from Anaheim Lake may be sent to Kraemer, Miller, La Jolla and Raymond Basins. These pumps can be operated using local control or SCADA (Appendix A-9).
- Flow spills from Anaheim Lake at elevation 224 ft. msl (Figure 6-5(E)). There is a concrete spill structure at elevation 224 feet msl, this is now an option for emergency overflow and is not used to convey water to other basins.

<u>Anaheim Lake Dewatering Pumps</u>

The pump station is located near the northwest corner of Anaheim Lake (Orangethorpe Ave. and Miller St.). The structure has a wood shake roof with the pump panels visible from the outside.

Anaheim Lake is dewatered in the spring in preparation of imported deliveries and in the fall in preparation of receiving storm water. Anaheim Lake is dewatered initially using the submersibles pumps and the vertical turbine is used to remove the last few feet of water. Once the dewatering is complete the basin is cleaned using heavy equipment. Pump preventative maintenance and repairs are performed during these down times.

Appendix A-9 contains operational instruction for the Anaheim Lake dewatering pumps.

g. Phase II Pipeline

The Phase II Pipeline runs just north of Anaheim Lake, Kraemer Basin and Miller Basin (Figure 6-5, (F)). An Accusonic flowmeter is located midway above the north shore of Anaheim Lake, seen on SCADA. Although designed for close to 250 cfs flow through this pipeline, generally flow would not exceed 200 cfs due to limitations of downstream sites and head concerns at OC-28. The current practice is to construct a temporary wall (sandbags) along the OC-28 spillway into Atwood Channel to create enough head to force more flow into the Phase II pipe.

Flow can enter the Phase II Pipeline from four places:

- Flow can come from OC-28 (the Tubs) through a 72-inch butterfly valve located at the west end of the structure (Section 6d). This 72-inch butterfly valve can be controlled locally or remotely by SCADA.
- Flow can come from the Phase I Pipeline through two 48-inch butterfly valves west of the OC-28 concrete structure. These two 48-inch butterfly valves can be controlled locally or remotely by SCADA.
- Flow can come from pumping Anaheim Lake, Miller Basin, Kraemer Basin or Miraloma Basin into the Phase II Pipeline.
- Flow can come from the GWRS Pipeline into Phase II Pipeline. ***Note***: Flow into the Phase II Pipeline from Miraloma Basin is not standard operating practice.

Flow from the Phase II Pipeline can be sent to following places:

- Flow can be sent to the Phase I Pipeline when Anaheim Lake, Miller Basin, and Kraemer Basin are pumped. Sending pump discharge from these basins into the Phase I Pipeline is not done often.
- Flow can be sent to Anaheim Lake through the Anaheim Lake return line 42-inch butterfly valve located near northwest side of Anaheim Lake (Figure 6-5, (I)). This 42-inch butterfly valve can be controlled locally or remotely by SCADA. Flow is measured using a propeller flowmeter and can be seen on SCADA.
- Flow can be sent to Carbon Diversion (Miller Forebay) through a 72-inch butterfly valve located southwest of the Orangethorpe and Miller intersection. This 72-inch butterfly valve can only be controlled locally using the controller on the actuator motor. Flow is measured by taking spot stream flow measurements using the Flow-Tracker or River Surveyor (higher flows).
- Flow can be sent to Miller Basin through the 42-inch (Miller 2) slide gate valve (Section 6(J)) at a maximum flow rate of 50 cfs. This valve can be operated using SCADA or local control.

- Flow can be sent to Carbon Creek through the Carbon Creek Turnout 42-inch butterfly valve (Section 6*h*).
- Flow can be sent to Kraemer Basin through the 48-inch butterfly valve at north end of Kraemer Basin (Section 6i). This 48-inch butterfly valve can be operated locally or remotely by SCADA. Flow is measured using a Magmeter with SCADA functionality. A maximum flow rate of 100 cfs can be achieved.
- Flow can be sent to Miller Basin through the Miller return line 42-inch butterfly valve at southwest corner of Miller Basin near pump sump (Section 6j). This 42-inch butterfly valve can be operated locally or remotely by SCADA. Flow is measured using a propeller meter with SCADA functionality. A maximum flow rate of approximately 60 cfs can be achieved.
- Flow can be sent to Kraemer Basin through the Kraemer return line 42-inch butterfly valve at east side of basin near pump sump (Section 6i). This 42-inch butterfly valve can be operated locally or remotely by SCADA. Flow is measured using a Propeller meter and can be seen on SCADA. A maximum flow rate between 50 and 60 cfs can be sustained.
- Flow can be sent to Miraloma Basin through the Miraloma inflow 42-inch butterfly valve northeast of Kraemer Basin (Section 8). The valve can be operated locally or remotely by SCADA.
- Flow can be sent to Carbon Diversion through a 42-inch butterfly valve east of Kraemer Basin (Section 6i). This 42-inch butterfly valve can be operated locally or remotely by SCADA. Flow is measured using a propeller meter with SCADA functionality. A maximum flow rate of approximately 60 cfs can be achieved.
- Flow can be sent to Miraloma Basin and the GWRS Pipeline (Section 8).

h. <u>Carbon Creek</u>

Carbon Creek serves as a conveyance channel to distribute recharge water into multiple recharge basins. The channel bottom is permeable. A maximum flow of 25 cfs can be sent down the Carbon Creek.

Flow into Carbon Creek comes from the Phase II Pipeline via a 42-inch butterfly valve located at the Kraemer 2 Site - southwest of the Orangethorpe Avenue and Miller Avenue intersection (Figure 6-6(A)). This valve can be operated locally or by SCADA. Carbon Creek flow is measured over the La Jolla dam and/or at the La Jolla inflow meter (Section 6*k*).

Figure 6-6 Kraemer 2 Site featuring: (A) Carbon Creek Turnout 42” Butterfly Valve Actuator, (B) Kraemer 48” Butterfly Valve Actuator and (C) MOV-13 Phase II Isolation Valve.

Flow from Carbon Creek can be sent to La Jolla Basin, Placentia Basin or Raymond Basin.

i. Kraemer Basin

Kraemer Basin is located northeast of the Kraemer Boulevard and Miraloma Avenue intersection (Figure 6-1(G)) (Figure 6-7). The primary function of Kraemer Basin is recharge and contains 30.8 acres of wetted area with a maximum storage capacity of 1,055 acre-feet. Percolation rates in Kraemer Basin generally range between 30-70 cfs.

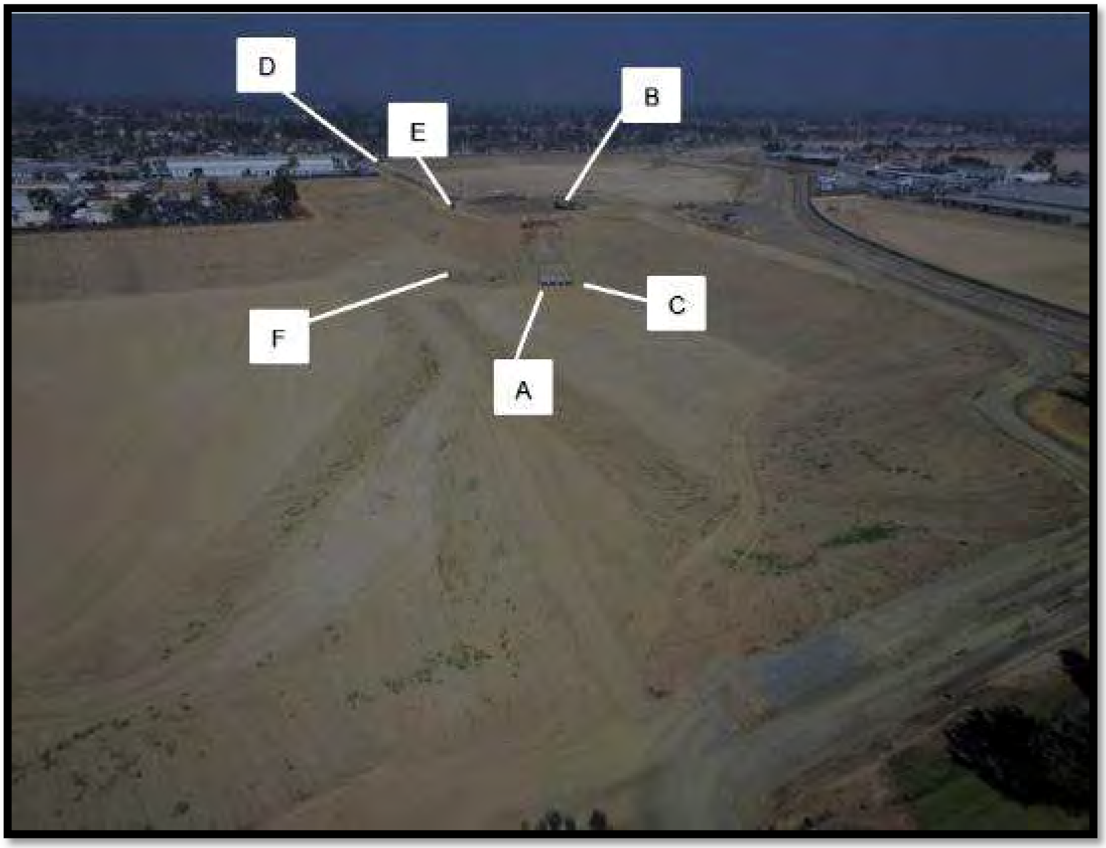


Figure 6-7 Aerial view of Kraemer Basin featuring: (A) dewatering pump sump area, (B) GWRS pipeline terminus with air gap structure, (C) GWRS entry point into the basin, (D) Kraemer 2 Site, (E) 42-inch inflow valve into the pump sump area and (F) Kraemer 48-inch inflow structure.

Flow can enter Kraemer Basin from three places:

- From the Phase II Pipeline through a 48-inch inflow butterfly valve at north end of Kraemer Basin (Figure 6-6(B)). This valve can be operated locally or remotely by SCADA. Flow is measured using a Magmeter (currently non-operational) and can be viewed on SCADA. A maximum flow rate of 100 cfs can be conveyed. Figure 6-7(A) shows where flow enters Kraemer Basin.
- From 42-inch inflow valve into the sump pump (Figure 6-8). This valve can be operated locally or remotely by SCADA. Flow is measured using a propeller flowmeter and viewed on SCADA. A maximum flow rate of approximately 60 cfs can be achieved (Figure 6-8).

Figure 6-8 Kraemer 42-inch Inflow Valve Actuator (A).

- GWRS Pipeline from 48-inch pipeline and butterfly valve at northeast end of basin (Figure 6-9). This valve is operated by operators in Fountain Valley per instruction from SRSO’s via telephone. Flow is measured using a clamp-on flowmeter with SCADA functionality. A maximum flow of approximately 125 cfs can be achieved. Downstream of the flowmeter flow breaks to atmosphere in a concrete air-gap structure, then enters Kraemer Basin via gravity into the sump pump area.

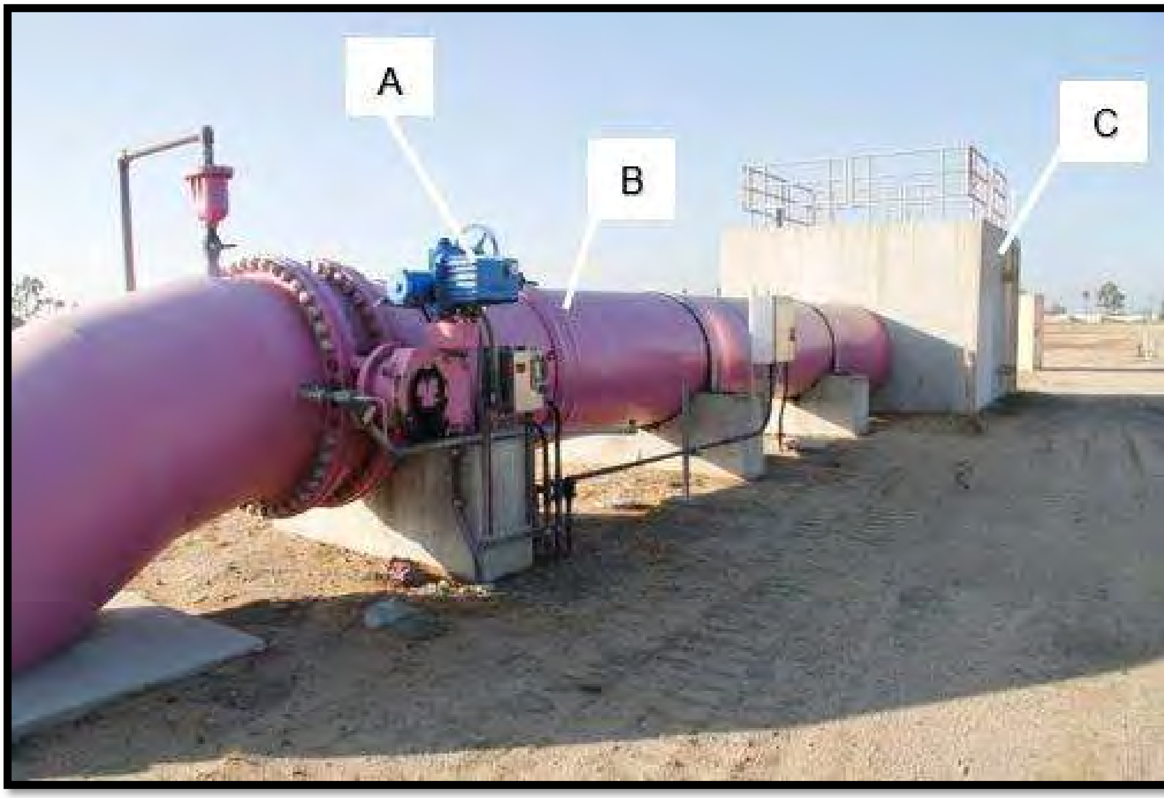


Figure 6-9 Terminus GWRS Pipeline at Kraemer Basin featuring: (A) 48-inch butterfly valve, (B) clamp on flow meter and (C) concrete air-gap structure into Kraemer Basin.

Flow can exit Kraemer Basin two ways:

- Through three dewatering pumps (see Appendix A-9). Discharge pumped from Kraemer Basin is normally sent to Miller, La Jolla and Raymond Basin. These pumps can be operated using local control or SCADA. There are no flowmeters to measure pump discharge. Usually, flow is measured at the location receiving the discharge flow. Pumping rates up to 20-35 cfs (each pump) can be achieved based on basin level.
- Flow can exit Kraemer Basin through the overflow structure located in the northeast corner of Kraemer Basin (Figure 6-10). This structure's elevation is 221 feet msl and discharges into Carbon Diversion.

Figure 6-10 Kraemer Basin overflow structure at elevation 221 ft msl discharges into the Carbon Creek Diversion Channel.

j. Miller Basin

Miller Basin is located northwest of Miraloma Avenue and Miller Street intersection (Figure 6-11). The primary function of Miller Basin is flood control. This basin is owned by OCFCD. The secondary function is recharge and contains 24.6-acres of wetted area with a maximum of 350 acre-feet of water storage. Percolation in Miller Basin generally ranges between 25-40 cfs.

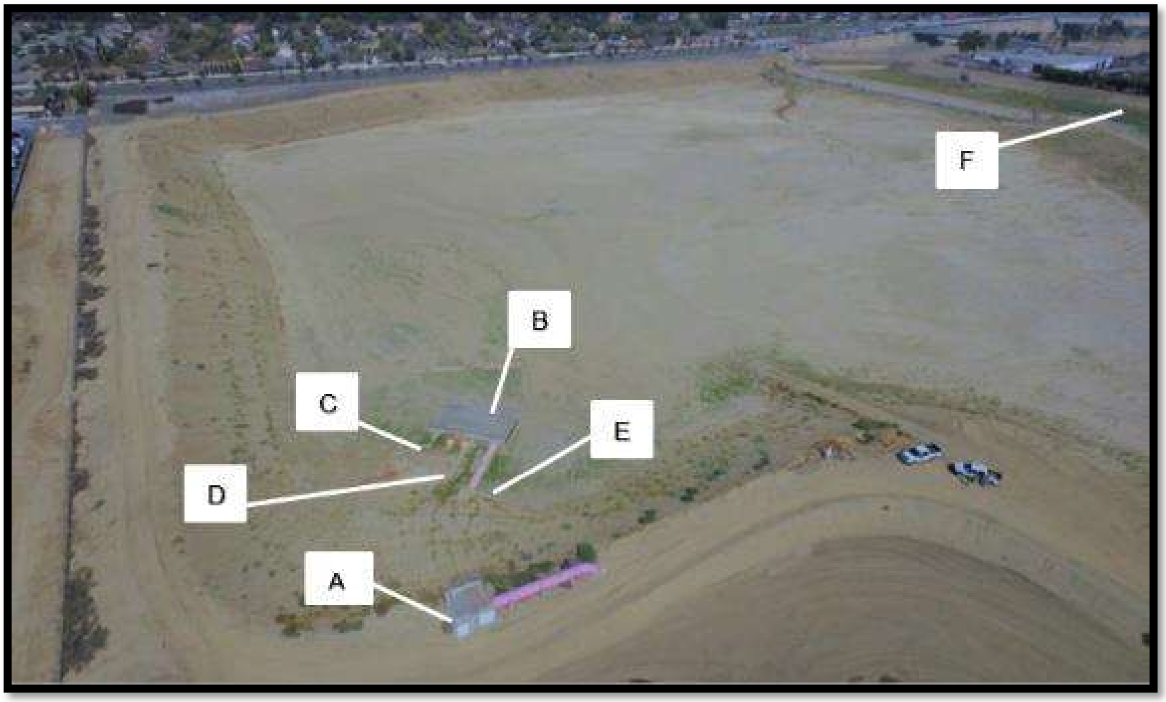


Figure 6-11 Aerial image of Miller Basin featuring: (A) terminus of GWRS pipeline with concrete air-gap structure, (B) dewatering pump sump/ flow entry structure, (C) 42-inch Miller Basin inflow line from the Phase II pipeline, (D) sump pump discharge lines, (E) GWRS delivery line and (F) Carbon Diversion.

OCWD is required to operate Miller Basin in accordance with an agreement with OCFCD. The agreement dictates basin operations levels. The agreement is presented as Appendix D of this manual.

Flow can enter Miller Basin four ways:

- From the Carbon Diversion Channel Overflow to Miller Basin. During high flows and when Carbon Diversion water level exceeds 224.9’ msl flow spill into Miller Basin (Figure 6-12).

Figure 6-12 Carbon Diversion Channel overflow into Miller Basin.

- From the Phase II Pipeline through the 42-inch Miller 2 slide gate valve (Figure 6-13).

Figure 6-13 Miller 2 Inflow Structure into Miller Basin from the Phase II Pipeline (A).

- From the 42-inch inflow butterfly valve (Figure 6-11(C)). Flow is metered using a propeller meter and seen on SCADA.
- From the GWRS Pipeline (Figure 6-11(E)). The Miller Basin GWRS 48-inch butterfly valve is controlled by GWRS Operators in Fountain Valley per instructions from SRSO's at FHQ via telephone. Flow is measured using a clamp-on flowmeter that communicates with SCADA. A maximum flow of 125 cfs can be achieved.

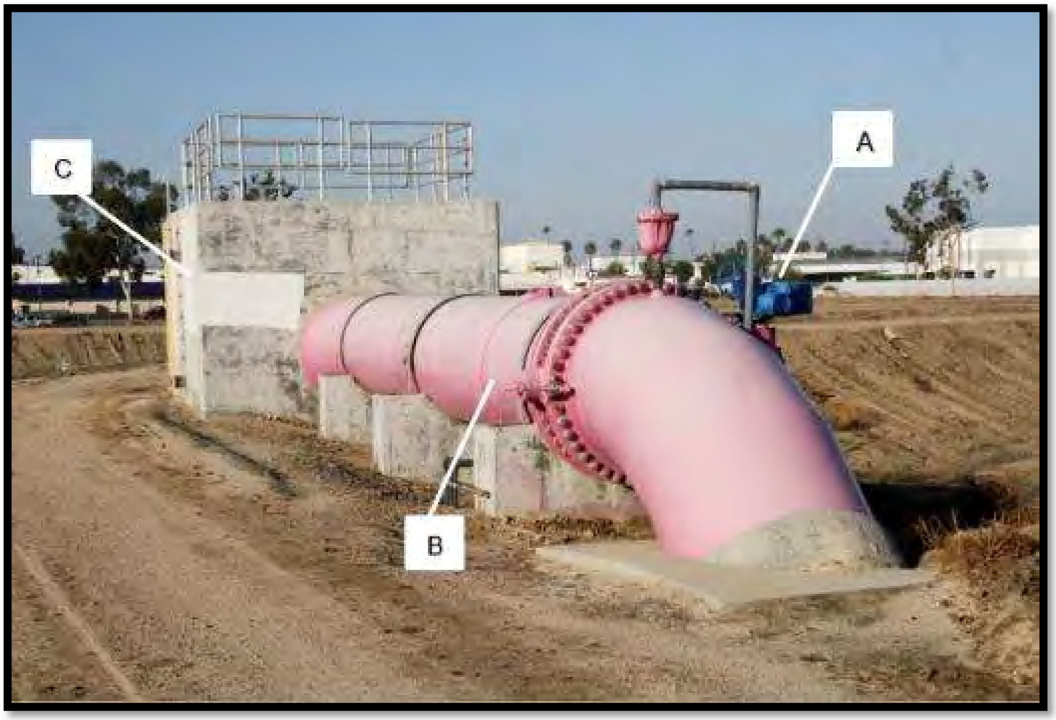


Figure 6-14 Terminus of GWRS pipeline at Miller Basin featuring: (A) 48-inch butterfly valve, (B) clamp-on flow meter and (C) concrete air-gap structure into Miller Basin.

Flow can exit Miller Basin three ways:

- Through two submersible dewatering pumps at the southwest corner of Miller Basin (Figure 6-11(B) (D)). Discharge pumped from Miller Basin is normally sent to Kraemer, La Jolla and Raymond Basin. These pumps can be operated locally or remotely by SCADA. Pumping rates up to 20-35 cfs (per pump) can be achieved depending on the basin level. For Miller Basin dewatering pump operation instructions see Appendix A-9.
- The 18-inch gate valve which connects into the Carbon Diversion Channel (Figure 6-11(H)).
- Over the spill structure at west end of Miller Basin (Figure 6-11(I)). This spillway acts as an overflow for Miller Basin and spills at elevation 226.3 ft mls.

k. La Jolla Basin

La Jolla Basin located in the city of Anaheim on East La Jolla Street between Red Gum and Hundley Street east of McFadden Park (Figure 6-1(H)) (Figure 6-15). The primary function of La Jolla Basin is recharge and has a wetted area of 6.3-acres and a maximum 19.8 acre-feet of water storage. Percolation ranges between 5 and 25 cfs in La Jolla Basin.

Figure 6-15 Aerial view of La Jolla Basin featuring: (A) Carbon Creek, (B) La Jolla Basin diversion structure (including rubber dam), (C) Control house and (D) dewatering sump area. District staff is shown cleaning La Jolla Basin with heavy equipment in this image.

La Jolla Basin primarily percolates storm flow capture in winter months and imported water during summer months. This basin can also be used to accommodate the basin cleaning schedule.

Influent flow requires inflation of the rubber dam in Carbon Creek (Figure 6-15(B)) to divert flow into La Jolla Basin. See Appendix A-13 for La Jolla Basin Rubber Dam and trash rack operations.

La Jolla basin can be dewatered by gravity or by pumping. See Appendix A-9 for La Jolla Basin dewatering pump operation instructions. Discharge pumped from La Jolla Basin is normally sent to Raymond Basin via Carbon Creek.

I. Placentia Basin

The primary function of Placentia Basin is flood control, the secondary function is recharge (Figure 6-16). This basin is owned by OCFCD. Placentia Basin has a maximum percolation rate of 10 cfs.

Figure 6-16 Aerial view of Placentia Basin featuring: (A) spillway into Placentia Basin, (B) gauge house, (C) groundwater clean-up equipment, (D) 36-inch pneumatic valve and (E) spillway into Carbon Creek.

Placentia Basin is not equipped with a dewatering pump therefore, water entering this basin must not contain quagga mussels. This basin is currently receiving treated water from OCWD's north basin groundwater cleanup project. Communication with the OCWD Geology Department is necessary to change cleanup project flow into this basin.

Flow can enter Placentia Basin two ways:

- Through the spillway on northeast side of basin (during heavy rainfall).
- Through a drain grate at bottom of channel eastside of basin with 36-inch pneumatic valve. This 36-inch pneumatic valve can only be controlled locally by opening the nitrogen cylinder and turning the pneumatic valve dial to the "open"

position, located in the gauge house. See Appendix A-14 for operational details regarding the Placentia Basin influent valve.

Flow can exit Placentia Basin by spilling through a 36-inch canal gate valve located in the northwest corner of the basin. This canal gate valve is operated manually only.

m. Raymond Basin

The primary function of Raymond Basin is flood control. This basin is owned by OCFCD. The secondary function is recharge (Figure 6-18). Maximum percolation rate achieved at Raymond Basin is approximately 10 cfs.

Figure 6-17 Aerial image of Raymond Basin featuring: (A) Carbon Creek, (B) concrete spillways and (C) general location of 36-inch canal gate valves from Carbon Creek.

Flow can enter Raymond Basin two ways:

- Flow can enter either the North and/or the South side or Raymond Basin. Each side has one 36-inch canal gate valve from Carbon Creek (concrete lined channel) boards are placed in iron tracks on channel wall just downstream of the canal gate valves to create head to force water into basins (Appendix A-15). Generally, a maximum rate of 10 cfs to each side can be sustained. There are no flow meters at Raymond Basin. There are two flow through transfer pipes connecting the basins at approximately 4-feet above the invert of the basins.

- Flow can enter both North and South sides of Raymond Basin via spillways in channel at east ends. This occurs only during heavy rains and is used by OCFCD to ease channel capacity.

Flow can exit Raymond Basin through a 36-inch slide gate valve drain that discharges to Carbon Creek. The slide gate valve is located at the northeast end of basin. Portable dewatering pumps are used if total dewatering of Raymond Basin is required.

7. LOWER OFF-RIVER SYSTEM

The Lower Off-River System extends from Upper Five Coves Basin downstream and includes the Upper and Lower Five Coves, Lincoln Basin, Burris Basin, Fletcher Basin, Riverview Basin, Upper Santiago Creek and Santiago Basins (Figure 7-1).

Figure 7-1 Aerial image of SAR, Carbon Diversion channel and the Lower-Off-River System. Visible features of the Lower-Off-River System include: (A) Upper Five Coves Basin and (B) Lower Five Coves Basin. Other important visible components of the Lower Off-River System include: (C) two 8-foot by 5-foot Five Coves diversion canal gate valves into Upper Five Coves Basin, (D) four 48-inch discharge pipes into Upper Five Coves Basin from the Upper Off-River System, (E) concrete spillway from Upper to Lower Five Coves Basins, (F) two 66-inch canal gate valves connecting Upper Five Coves to the SAR and (G) general location of 36-inch canal gate valves drain from Upper Five Coves Basin into Lower Five Coves Basin.

a. Upper Five Coves Basin

The primary function of Upper and Lower Five Coves Basins is to desilt recharge water before it enters Burris Basin and then Santiago Basin. Recharge in Upper and Lower Five Coves Basin does occur after cleaning but is short lived due to the high concentration of suspended solids in the flow coming directly from the SAR.

Flow can enter Upper Five Coves Basin from three places:

- Flow can enter from the Off-River through four 48-inch canal gate valves (Figure 7-1(D)). These four canal gate valves can be operated locally or remotely using SCADA. Flow can be measured using a weir system at the end of the Upper Off-River just upstream of these four 48-inch canal gate valves. A rating table is currently being developed for this weir system. This structure is designed for a maximum flow of 250 cfs (Figure 4-12).
- Flow can enter from behind the Five Coves Rubber Dam from two 8 ft. by 5 ft. diversion slide gate valves (SCADA and local control at actuator) (Figure 7-1(C)) (Figure 3-3). The two slide gate valves can be operated locally or remotely by SCADA. Flow is measured using Rittmeyer flow meters that communicate with SCADA. A maximum flow rate of 500 cfs can be sustained through the diversion boxes.
- Flow can enter from the SAR through two 66-inch canal gate valves located just below where the SAR and Carbon Diversion meet on the north side (Figure 7-1(F)). A sand dike can be built in the SAR channel to divert flow into Upper Five Coves Basin through the two 66-inch canal gate valves (Figure 7-2). These canal gate valve can be operated manually only by hand crank or hydraulic actuator. Flow at this location is measured manually by stream gauging. No more than 150 cfs can be diverted due to hydraulic head constraints.

Figure 7-2 Two 66-inch transfer tubes from SAR into Upper Five Coves Basin with diversion sand dike in place. USACE concrete stabilization structure in the SAR channel.

b. Lower Five Coves Basin

Flow enters Lower Five Coves Basin from Upper Five Coves Basin either by surface transfer over a concrete structure or 36-inch drain operated locally or remotely using SCADA (see Figure 7-3).

Figure 7-3 Aerial image looking southwest (downstream) of concrete spillway between Upper and Lower Five Coves Basin (left) and 36-inch canal gate valve drain from Upper Five Coves Basin into Lower Five Coves Basin (right). This drain can be controlled locally or remotely using SCADA.

c. Lincoln Basin

The primary function of Lincoln Basin is to desilt the recharge water (Figure 7-4). Percolation rates at Lincoln Basin are not monitored or recorded.

Figure 7-4 Aerial image looking southwest (downstream) showing Lower Five Coves Basin, Lincoln Avenue and Lincoln Basin. Four 48-inch transfer tubes (left) and one 36-inch canal drain (right) convey flow beneath Lincoln Avenue. The canal gate valve can be operated locally or remotely using SCADA.

Flow can enter Lincoln Basin from three places:

- The 36-inch drain valve from Lower Five Coves. This drain can be operated locally or remotely using SCADA (Figure 7-4).
- Four 48-inch transfer pipes (Figure 7-4). Maximum combined flow rate through all four 48-inch transfer tubes is 500 cfs.
- Flow can come from the SAR through two 36-inch canal gate valves. These two gate valves are controlled locally using the portable hydraulic operator or hand crank. A sand dike can be built in the SAR to divert flow into Lincoln Basin through these two 36-inch canal gate valves (Figure 7-5).

Figure 7-5 Aerial Image looking northeast (upstream) of Lincoln Basin (left) and the SAR channel (right). Two 36-inch canal gate valves connecting the SAR and Lincoln Basin can be seen with associated sand dike to divert SAR flow into Lincoln Basin.

All flow from Lincoln Basin can only be sent to Burris Basin. Flow can be surfaced transferred from Lincoln Basin to Burris Basin through a 15-foot Parshall Flume or drained through a 36-inch canal gate valve (Figure 7-6).

Level from the flume is converted to flow using a bubbler and can be viewed on SCADA.

This Lincoln Basin drain gate valve can only be controlled using the wheel crank. There is no flowmeter for the drain.

Figure 7-6 Aerial view looking downstream from Lincoln Basin. The 15-foot Parshall Flume (left) and 36-inch canal drain (right) are used to transfer flow beneath a service access road into Burris Basin.

d. Burris Basin

Burris Basin is located northwest of Ball Road and the Santa Ana River (Figure 7-7). Burris Basin is the last gravity-only fed basin of the Lower Off-River System.

The primary purpose for Burris Basin is to desilt and store water for distribution. This basin is equipped with four 1,750 hp vertical turbine pumps capable of pumping up to 200 cfs (combined) into the Santiago Basins. For instructions on the operation of the Burris Pump Station see Appendix A-9.

There is a golf concessionaire that has needs relating to level that can be problematic at times. There is a bird island that needs attention during nesting season (March 15 - September 15), level should be high enough so that predators cannot reach nests on the island. Low levels in Burris Basin can also deplete dissolved oxygen in the water and initiate a fish kill. SRSOs work closely with District Wildlife Biologist when changing levels in Burris Basin during critical time periods.

Figure 7-7 Aerial image of Burris Basin looking southwest (downstream). Water surface elevations is 155 ft. msl. The (A) Burris Pump Station is visible at the lower end of Burris Basin.

Flow can enter Burris Basin from four places:

- Flow can come from Lincoln Basin through a 15-foot Parshall Flume (Figure 7-7). Flow through the flume is measured with a pressure transducer converting level to flow and can be viewed on SCADA. Look up tables for this flume are included in Appendix A-8
- Flow can come from the manually operated and unmetered Lincoln Basin drain canal gate valve (Figure 7-7).
- Flow can come from the Burris/Santiago Pipeline while pumping Bond Basin through a 42-inch butterfly return line valve. This valve can be operated manually or remotely by SCADA.
- The GWRS pipeline through a 12-inch pipe spur and butterfly valve. This valve is operated locally only using T-handle. This connection is unmetered and rarely used.

Flow can be sent from of Burris Basin to two places:

- Flow can be pumped to the 66-inch Burris-Santiago Pipeline using the Burris Pump Station (Figure 7-8). The Burris-Santiago Pipeline can deliver flow to Riverview Basin, Fletcher Basin, Bond Basin and Santiago Creek for recharge. For Burris Pump Station operations see Appendix A-9.
- Flow can be sent to Ball Road Basin by surface spilling through an engineered spillway from Burris Basin when the level is above 172.4 feet msl (not preferred). Flow entering Ball Road Basin from Burris Basin spills into SAR through an engineered concrete structure. OCWD does not own Ball Road Basin and an agreement with the new owner allows spillage from Burris Basin when necessary. This option is used for emergency purposes only.

Figure 7-8 Inside the Burris Pump Station. The four 1,750 hp electric motors that power vertical turbine pumps used to pressurize the Burris-Santiago Pipeline. Motors for Pumps #1 through #4 are visible from right to left.

e. Riverview Basin

Riverview Basin is located northeast of the SAR and Ball Road (Figure 7-9). The primary function of Riverview Basin is recharge. Riverview basin has a maximum storage of 7.5 acre-feet. The maximum percolation rate through Riverview Basin is 12 cfs.

Figure 7-9 Riverview Basin looking south. The inlet structure and drain are in the upper (north) end of Riverview Basin.

Flow enters Riverview Basin from a 24-inch pipeline spur off the Burris-Santiago Pipeline that serves Riverview Basin and Fletcher Basin. Flow through the 24-inch spur is controlled using a 24-inch ball valve located south of Riverview Basin (Figure 7-10). This 24-inch ball valve communicates with SCADA.

Figure 7-10 Riverview Basin 24-inch inflow ball valve and Auma actuator with local controls at valve. This valve communicates with SCADA.

The flow control valve is operated by imputing a flow set-point value in SCADA. Flow is measured with a Magmeter and can be viewed on SCADA. A maximum flow of approximately of 12 cfs can be sustained, although normally flow is 3-5 cfs.

There are additional valves along the 24-inch pipeline spur that are used for maintenance purposes and are operated manually. These valves are described in the Water Atlas found in Section 9 of this manual.

Level in Riverview Basin is measured by transducer and viewed on SCADA.

Figure 7-11 Riverview Basin inlet (left) and drain valve/actuator (local control only) with catwalk. Mounted to the catwalk railing are the level transducer controls.

Riverview Basin can be drained by manually opening a 36-inch canal gate valve which sends flow to Fletcher Channel and into the SAR (Figure 7-11).

f. <u>Fletcher Basin</u>

Fletcher Basin is located southeast of the Fletcher Street and Batavia Avenue intersection (Figure 7-9). The primary function of Fletcher is flood control, secondary function is recharge. Use for recharge is mostly during spring to fall or non-storm season. Maximum percolation rate is 3 cfs.

Figure 7-12 Aerial Image of Fletcher Basin showing (A) box culvert inlet structure from Fletcher Channel, (B) Inlet from Fletcher 12-inch Inflow Pipeline, (C) outlet to Fletcher Channel at elevation 188 msl and (D) dewatering pump intake. Just out of view is (E) the location of the Fletcher Basin dewatering pump controls.

Flow can enter Fletcher Basin two ways:

- From Fletcher channel during rainfall or a local flow event.
- Flow can enter Fletcher Basin from a 12-inch automated globe valve using SCADA and lateral pipeline off the Burris-Santiago Pipeline. This flow control valve is operated by imputing a flow set-point value in SCADA. Flow is measured with a Magmeter and can be viewed on SCADA. A maximum flow of approximately 3 cfs can be sustained.

Additionally, there is a 24-inch isolation valve located between the tee at the Burris-Santiago Pipeline and the flow control valve. The isolation valve is used for maintenance only and operated manually only by using a T-handle. For location see the Water Atlas in Section 9 of this manual.

Level is monitored in Fletcher Basin using a bubbler system and available on SCADA (Figure 7-13).

Figure 7-13 Fletcher Basin pump sump inlet structure and valve are at the bottom of the stairs. The Waterlog bubbler level sensor control box is seen at the top of the stairs.

Flow can exit Fletcher Basin two ways:

- Flow exits the basin from the downstream side when maximum elevation is approximately 190 ft. above msl.
- Flow can be pumped out of Fletcher Basin into Fletcher Channel and the SAR (Appendix A-9).

g. <u>Santiago Basins</u>

(Santiago Basins = Bond Basin + Blue Diamond Basin + Smith Basin)

Santiago Basins are located northeast of Collins Avenue and Bond Street intersection in the City of Orange, approximately 3.5 miles east of the Santa Ana River (Figure 7-14). These basins are used primarily for recharge. This is OCWD largest surface water reservoir with 13,561 acre-feet of storage. Percolation rates in Santiago Basins range from 0-120 cfs depending on the water level. When full, these basins serve as a flow through feature of Santiago Creek. Blue Diamond Basin and Bond Basin join at approximately elevation 220 feet msl. Smith Basin joins Bond and Blue Diamond at elevation 260 feet msl.

Figure 7-14 Aerial image of Santiago Basins from the South-East corner of Bond Basin. Water surface elevation is at 210 feet msl. Visible features include: (A) Bond Basin, (B) Blue Diamond Basin, (C) general location of Smith Basin, (D) floating pump station barge and (E) floating pump discharge pipeline.

Flow can enter Santiago Basin from the following three places:

- From the Upper Santiago Creek into Smith Basin
- Flow can enter Bond Basin from Burris Basin while pumping Burris Basin and discharging into the 66-inch Burris-Santiago Pipeline through 66-inch butterfly valve located east of Collins Street and north of Bond Street. Flow entering Bond Basin is controlled using this 66-inch butterfly valve. The 66-inch butterfly valve can be controlled locally or remotely by SCADA. Pumped flow entering Bond Basin is measured using an Accusonic flow meter and viewed on SCADA.
- Numerous storm drains discharge into Santiago Basin. Storm drain flow is unmetered.

Flow leaves Santiago Basin two ways:

- Surface spilling from Blue Diamond Basin when the elevation is above 285.3 feet msl. This occurs when Santiago Basin is full.
- Flow can be pumped out of Bond Basin into the Burris-Santiago 66-inch Pipeline. To achieve pumping to the following four locations the 66-inch butterfly valve on the Burris-Santiago Pipeline needs to be throttled or closed. This valve can be operated locally or remotely via SCADA.

Flow can be sent into:

- Burris Basin through a 42-inch butterfly valve.
- Riverview Basin through 24-inch ball valve.
- Fletcher Basin through 24-inch globe valve (pressure reducing globe valve) controlled using SCADA.
- Lower Santiago Creek through 42-inch butterfly valve.
  Note: Water Atlas in Section 9 of this manual shows a distribution diagram

Santiago Floating Pump Station operation procedures are presented in Appendix A-9.

h. Lower Santiago Creek

The primary purpose of Lower Santiago Creek is flood control, recharge is secondary. This channel is managed by the OCFCD. The Lower Santiago Creek channel extends to just above Hart Park. Sustained percolation rates up to 15 cfs have been observed at Lower Santiago Creek. Pumped flow into Lower Santiago Creek is measured at the 42-inch discharge via Accusonic meter and viewed on SCADA. Pumped flow must be managed so that water does not flow too far downstream and onto the Hart Park parking lot pavement, which is located in the stream bed.

Flow can enter Lower Santiago Creek from two places:

- Flow can enter Lower Santiago Creek by surface spilling Santiago Basins through Blue Diamond when level is above 285.3 feet msl.
- Flow can come from Burris-Santiago 66-inch pipeline when either Bond or Burris is being pumped through the 42-inch butterfly valve. This 42-inch butterfly valve can be controlled locally or remotely by SCADA.

8. GROUND WATER REPLENISHMENT SYSTEM RECHARGE SYSTEM

a. The GWRS Pipeline

The GWRS pipeline starts at the GWRS treatment plant in Fountain Valley. This pipeline is a 13.5-mile cement mortar lined mild steel pipeline that follows the west bank for the SAR then the west bank of the Carbon Diversion Channel and terminates near Kraemer and Miller Basins. This Pipeline ranges in diameter from 78-inches at its origin to 60-inches before reducing to feed recharge basins dedicated or partially dedicated to receiving recycled water from the GWRS treatment plant. The GWRS Pipeline has three butterfly valves that separate the Pipeline into three units. Valve positions and flow are controlled by treatment plant operators at the GWRS control room in Fountain Valley. Routine monitoring and maintenance of the GWRS Pipeline is performed by Injection Recharge System Operators from Fountain Valley. Five injection wells in Santa Ana inject flow from this pipeline.

Flows in this pipeline can reach up to 125 cfs. Flow can fluctuate based on GWRS treatment plant inflows from the Orange County Sanitation District (OCSD) and coastal groundwater levels. The first priority of GWRS flow is to supply the Talbert Seawater Intrusion Barrier. The second priority is surface recharge.

All GWRS flow changes are made by GWRS operators in Fountain Valley. Surface Recharge System Operators need to be in communication with the GWRS System Operators continually. GWRS operations staff provides planning/scheduling e-mails to all recharge operators. The GWRS control room can be reached by telephone at extension 3240 or (714) 378-3240.

b. The GWRS Basins

Various basins are dedicated or partially dedicated to recharge GWRS water under permit.

The GWRS Pipeline can deliver flow to four recharge basins:

- Flow can go to La Palma Basin through a 48-inch diameter lateral pipe with a 48-inch isolation butterfly valve and then a 48-inch ball valve used for throttling. These valves are operated by GWRS operators in Fountain Valley per instructions from SRSOs at Forebay (FHQ). Flow is measured using a

Magmeter, this flowmeter can be seen on SCADA. A maximum flow of 100 cfs can be delivered.

- Flow can go to Miraloma Basin through a 36-inch pipe and 36-inch butterfly valve. This valve is controlled by GWRS Operators in Fountain Valley per instruction from SRSOs at Forebay (FHQ) via telephone. Flow is measured using a Magmeter. This flowmeter is seen on SCADA. A maximum flow of 70 cfs can be delivered.
- Flow can go to Miller basin through a 48-inch pipe and 48-inch butterfly valve. This valve is controlled by GWRS Operators in Fountain Valley per instruction from SRSOs at Forebay (FHQ) via telephone. Flow is measured using a clamp-on flow meter and viewed on SCADA. A maximum flow of 125 cfs can be delivered.
- Flow can go to Kraemer Basin through a 48-inch pipe and 48-inch butterfly valve. This valve is operated by GWRS operators in Fountain Valley per instruction from SRSOs at Forebay. Flow is measured using a Clamp-on flowmeter. This flowmeter is seen on SCADA. A maximum flow of 125 cfs can be delivered.

c. La Palma Basin

La Palma Basin is dedicated to receiving 100% GWRS (recycled) water. The primary function of La Palma Basin is recharge. On-line in November 2016, La Palma Basin is OCWD's most recent recharge basin. This is a shallow basin capable of storing up to 101 acre-feet. A maximum percolation rate of 100 cfs has been observed. La Palma Basin is located along the eastern bank of the Carbon Diversion Channel at the intersection of Coronado Street (Figure 8-1).

Flow enters this basin through a 48-inch pipe, 48-inch butterfly valve and 48-inch ball valve, operated by GWRS operators in Fountain Valley per instructions from SRSO's at FHQ. Flow is measured using a Magmeter and is viewed on SCADA.

La Palma Basin is divided by a berm into two sub-basins (north and south) each equipped with their own delivery channel, inflow slide gate valve and wet well isolation slide gate valve at the base of the concrete airgap "waterfall". The two basins share a common wet well equipped with a single submersible dewatering pump and level sensor. The 36-inch inflow slide gate valves are controlled by GWRS operators in Fountain Valley and viewed on SCADA (Figure 8-2). This sub-basin design provides the option to clean one sub-basin while recharging the other sub-basin.

Flow exits La Palma Basin by percolation or dewatering pump. The pump can be controlled manually or remotely by SCADA. See Appendix A-9 for La Palma Basin dewatering pump operation instructions.

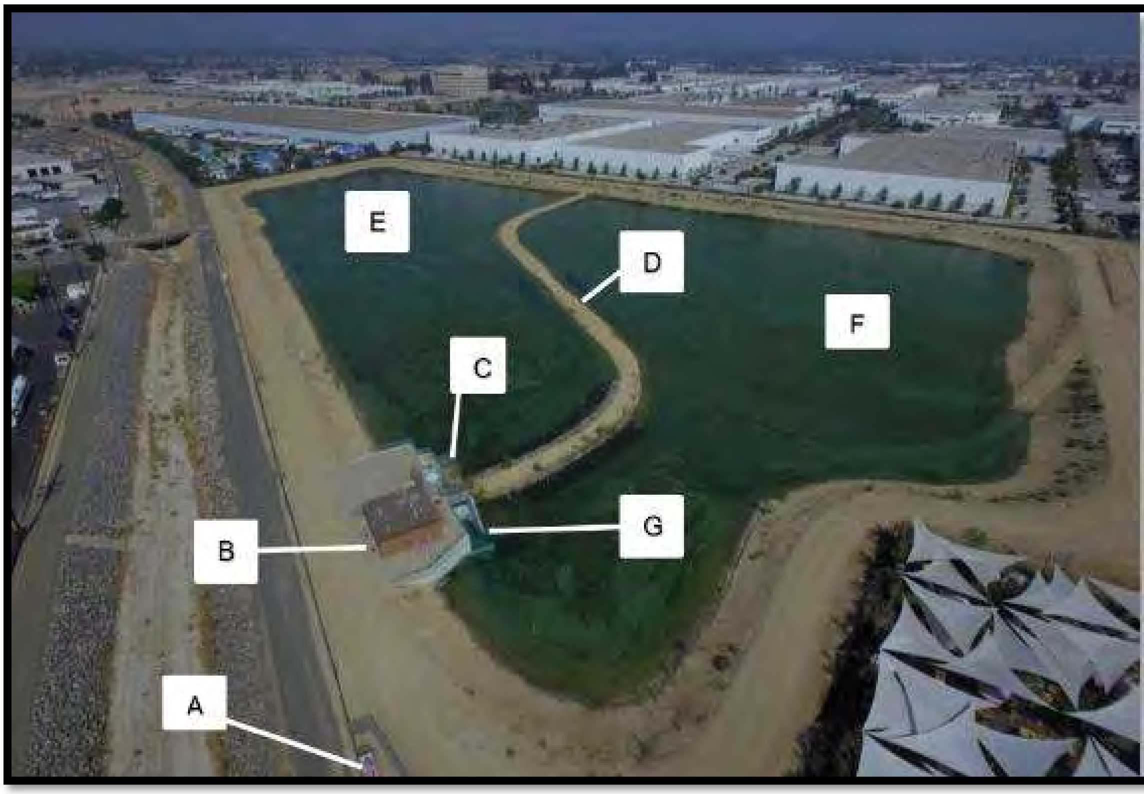


Figure 8-1 Aerial image of La Palma Basin looking north with water surface elevation 214 msl. Miraloma Basin (dry) is visible higher up along the Carbon Diversion Channel. Important features of La Palma Basin visible in this image include: (A) 48-inch pipe and 48-inch ball valve from the GWRS Pipeline, (B) La Palma Basin control building, (C) La Palma Basin entry structure “waterfall”, (D) partition berm, (E) La Palma North Sub Basin, (F) La Palma South Sub Basin and (G) portal into La Palma South Sub Basin.

Level is measured in La Palma Basin using a down looking level sensor and viewed on SCADA.

Figure 8-2 Aerial image showing the (A) La Palma Basin control building, (B) concrete air gap delivery structure “waterfall” within plexiglass panels and (C) concrete distribution channel and gate valve into the La Palma South Sub Basin.

d. Miraloma Basin

Miraloma Basin is plumbed to receive GWRS water, imported water from MWD, and flow from the SAR. The primary function of Miraloma Basin is recharge and has 52.6 acre-feet of storage (Figure 8-3). A maximum percolation rate of 70 cfs has been observed. Miraloma Basin is located along the eastern bank of the Carbon Canyon Diversion channel east of Kraemer Basin.

Water from the main GWRS pipeline flows through a 36-inch lateral pipeline and 36-inch isolation butterfly valve. The lateral pipeline is upsized to a 42-inch pipe and 42-inch butterfly valve used for throttling flow into the concrete air-gap structure. The valves are operated by GWRS operators in Fountain Valley per instruction from SRSOs at FHQ. Flow is measured using a Magmeter. Flow can be viewed on SCADA.

Flow exits Miraloma Basin by percolation or dewatering pumps. The pumps can be controlled manually or remotely by SCADA.

Figure 8-3 Aerial image of (A) Miraloma Basin looking downstream (South) along the Carbon Diversion Channel. Kraemer Basin is visible on the other side of the Carbon Creek Diversion Channel. A small portion of Miller Basin is barely visible along the lower right margin of this frame. County of Orange heavy equipment and rock piles lie between the three OCWD basins. Important visible features of Miraloma Basin include: (B) the concrete air gap and inlet structure, (C) Miraloma Basin control building and (D) over excavated area in the southern portion for recreational tenant.

The primary purpose of the basin is for recharge of GWRS water. However, the southern portion of the basin is being leased for recreation. Recreation activities have not commenced at the time of this writing. OCWD Property Management Department can provide a copy of the lease explaining the operational conditions for this basin. Over 100 metal anchors have been placed into the basin bottom in the southern portion of Miraloma basin and needs to be considered when developing a cleaning plan.

Miraloma Basin is equipped with a submersible dewatering pump. Pump operations are explained in Appendix A-9.

Level in Miraloma Basin is measured by a down-looking levels sensor and viewed on SCADA.

e. Kraemer Basin

Kraemer Basin receives GWRS flow when Miraloma and La Palma basins are unavailable.

Flow enters this basin through an air-gap structure at the end of the 48-inch GWRS pipeline (See Section 6i). The 48-inch pipeline butterfly valve is controlled by GWRS operators in Fountain Valley per instructions from SRSOs at FHQ.

Flow is measured using a clamp-on flowmeter with SCADA functionality. A maximum flow of approximately 125 cfs can be achieved. Downstream of the flowmeter, flow breaks to atmosphere in a concrete air-gap structure, then enters Kraemer Basin via gravity.

Flow exits Kraemer Basin using dewatering pump(s). These pumps can be controlled manually or remotely by SCADA (Appendix A-9).

f. Miller Basin

Miller Basin receives GWRS flow when Miraloma and La Palma Basins are unavailable.

Flow enters this basin through an air-gap structure at the end of the 48-inch GWRS pipeline (See Section 6(J)). The 48-inch pipeline butterfly valve is controlled by GWRS operators in Fountain Valley per instructions from Recharge Operators at FHQ.

Flow is measured using a clamp-on flowmeter with SCADA functionality. A maximum flow of approximately 125 cfs can be achieved. Downstream of the flowmeter, flow breaks to atmosphere in a concrete air-gap structure, then enters Miller Basin via gravity.

Flow exits Miller Basin using dewatering pump(s). These pumps can be controlled manually or remotely by SCADA (Appendix A-9).

9. Conclusion

The Orange County Water District Surface Recharge System is very dynamic presenting the SRSO with many options to efficiently recharge base flow, storm flow, recycled water, and imported water.

To assist the SRSO a comprehensive water atlas is presented as Plates 1 through 7. This water atlas provides locations and details for all valves, flowmeters, level sensors, and supporting appurtenances for the entire recharge system.

Additionally, to assist the SRSO, Plates 8 through 11 present drafted flow schematics for the recharge system.

ACRONYMS

Acronyms	Meaning
AF	Acre-Feet (325,850 gallons)
Basin	Orange County Groundwater Basin
cfs	Cubic Feet per Second
FHQ	Field Headquarters
GWRS	Groundwater Replenishment System
MOV	Motor Operated Valve
MWD	Metropolitan Water District
OCFCD	Orange County Flood Control District
PZF	Point of Zero Flow
SAR	Santa Ana River
SCADA	Supervisory Control and Data Acquisition
SRS	Surface Recharge System
SRSO	Surface Recharge System Operator
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

Recharge Manual Appendix List

Imperial Dam & Diversion, Weir pond system and Warner System

SCADA Master Computer and components housed at Field Headquarters Building – communicates with Imp. Control house, Weir Pond 4, weir pond 3 via Fiber Optics.
Weir 2 communicates with Imperial Control house via hard wire.
FHQ Buiding communicates with Conrock and Warner houses via radios.

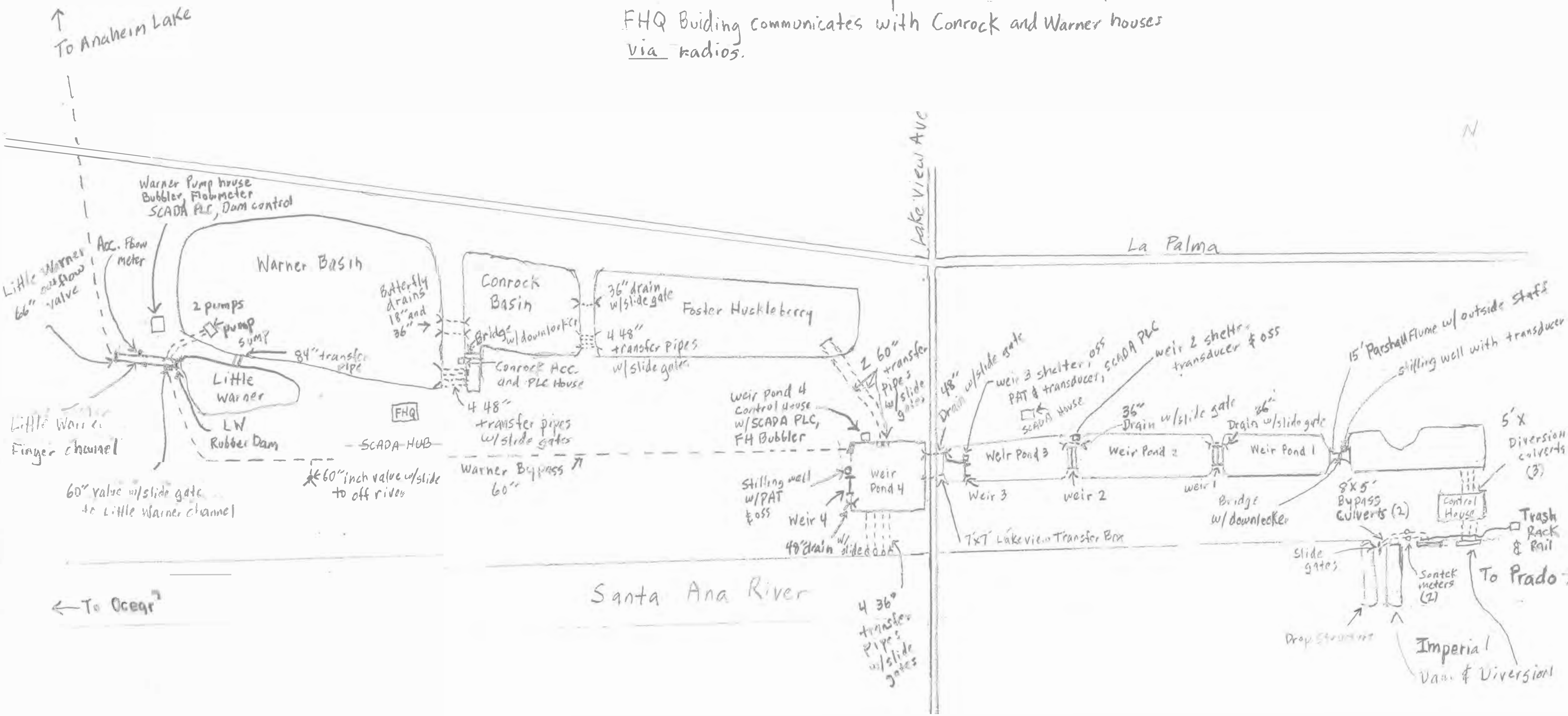


PLATE 1

Anaheim, Kraemer and Miller System

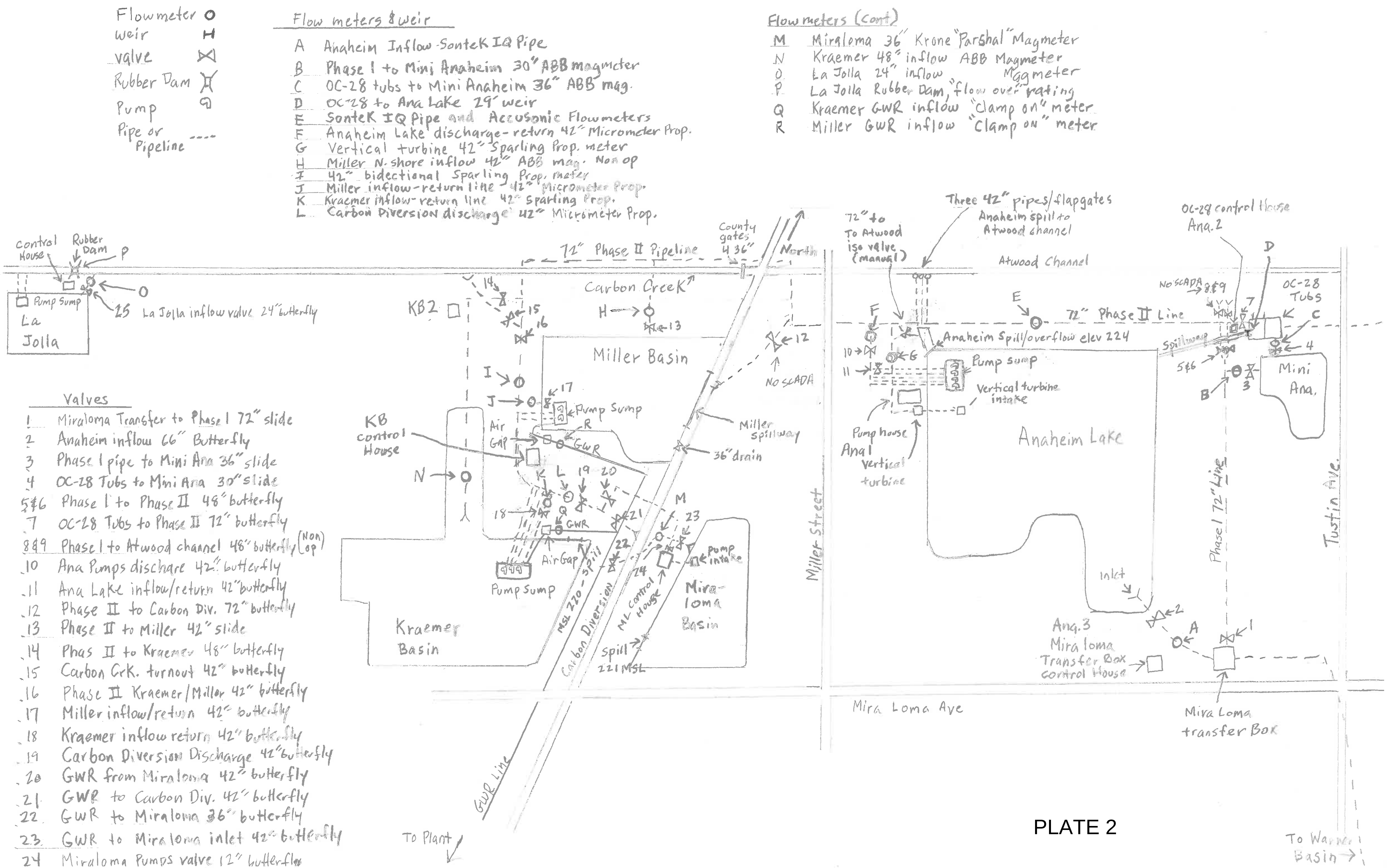


PLATE 2

Kraemer and Miller System

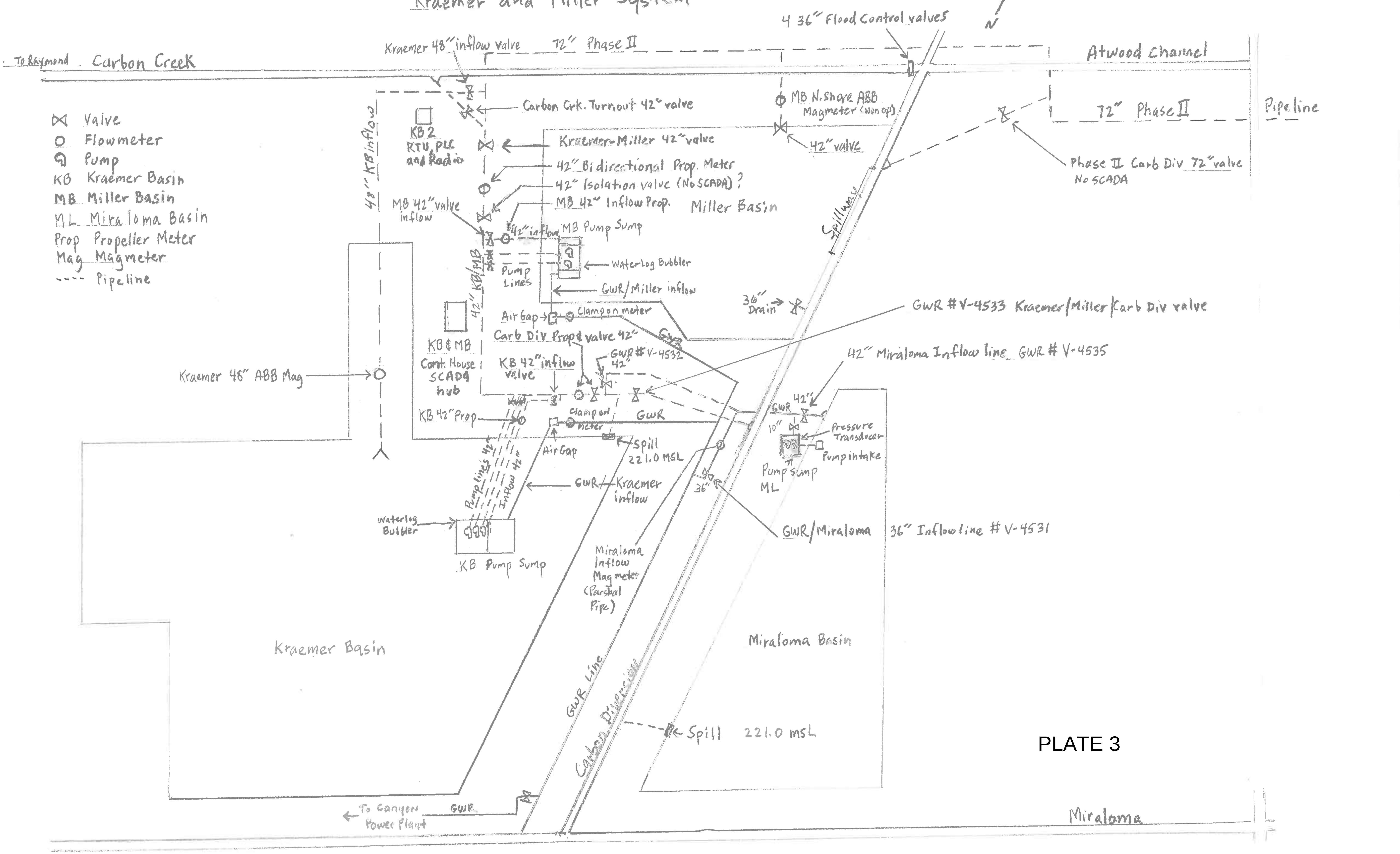


PLATE 3

Five Coves, Burris and Riverview Basins

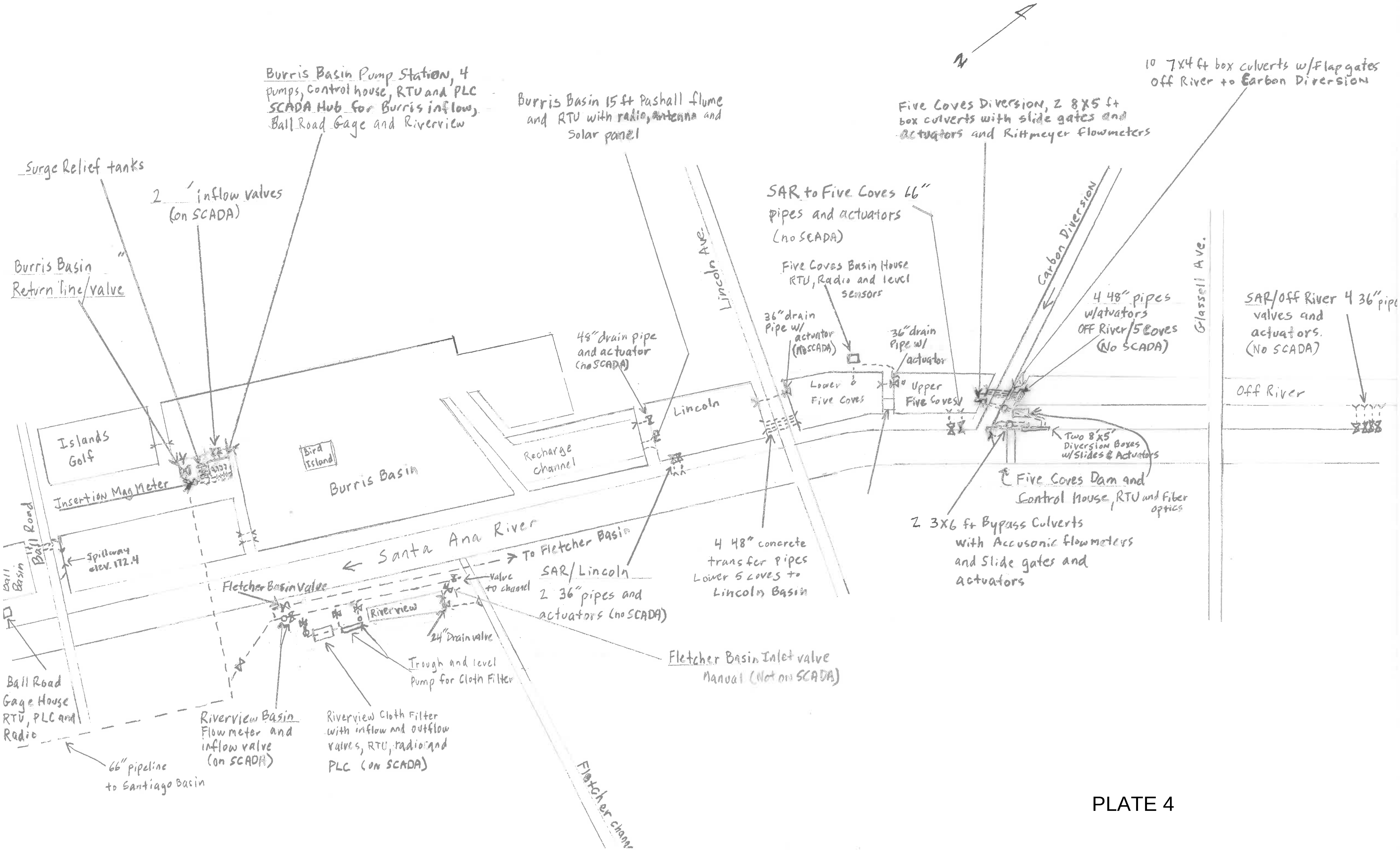


PLATE 4

Santa Ana River, Carbon Diversion and Five Coves Basins (enlarged view)

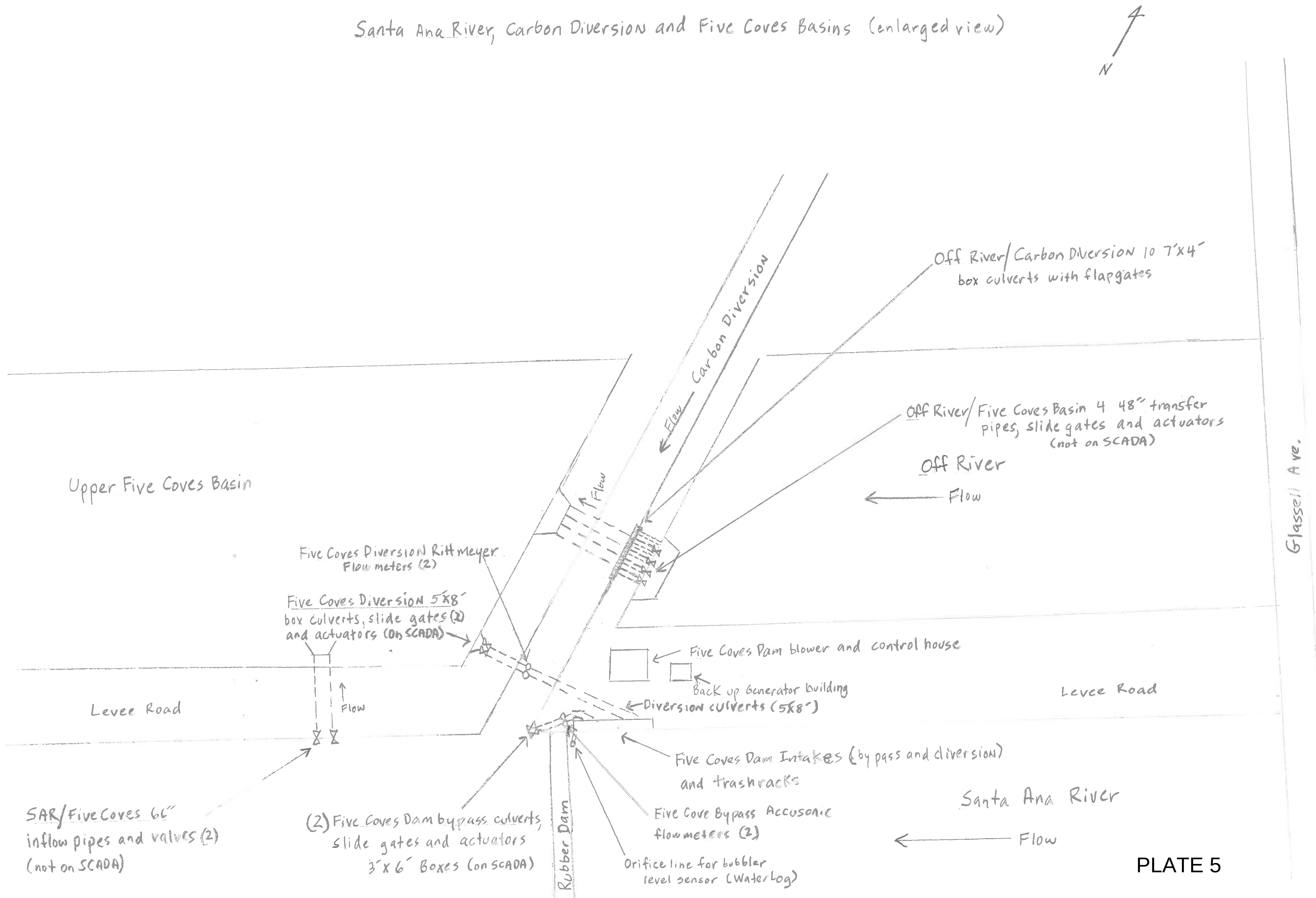


PLATE 5

Riverview and Fletcher Basin System

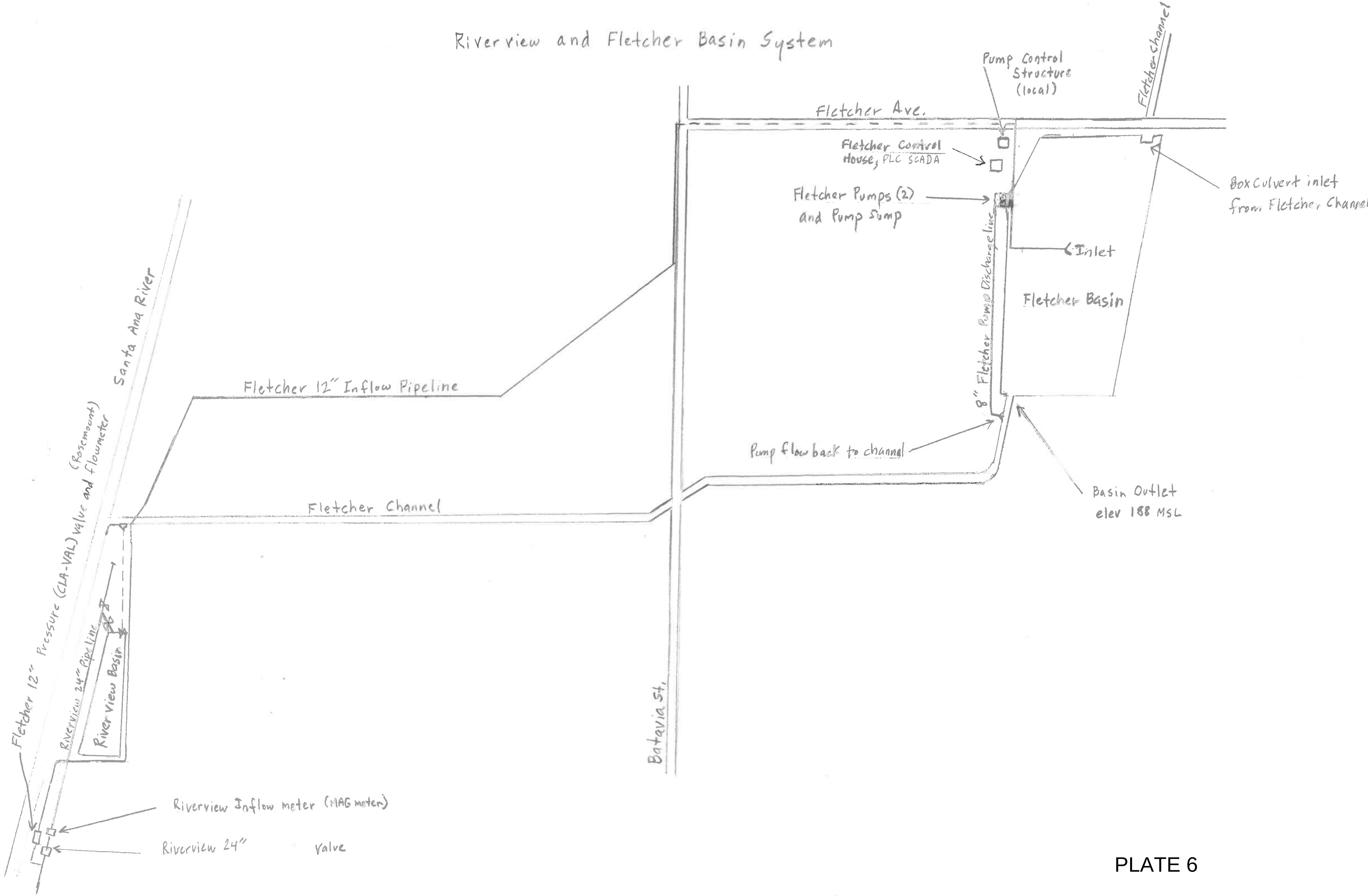


PLATE 6

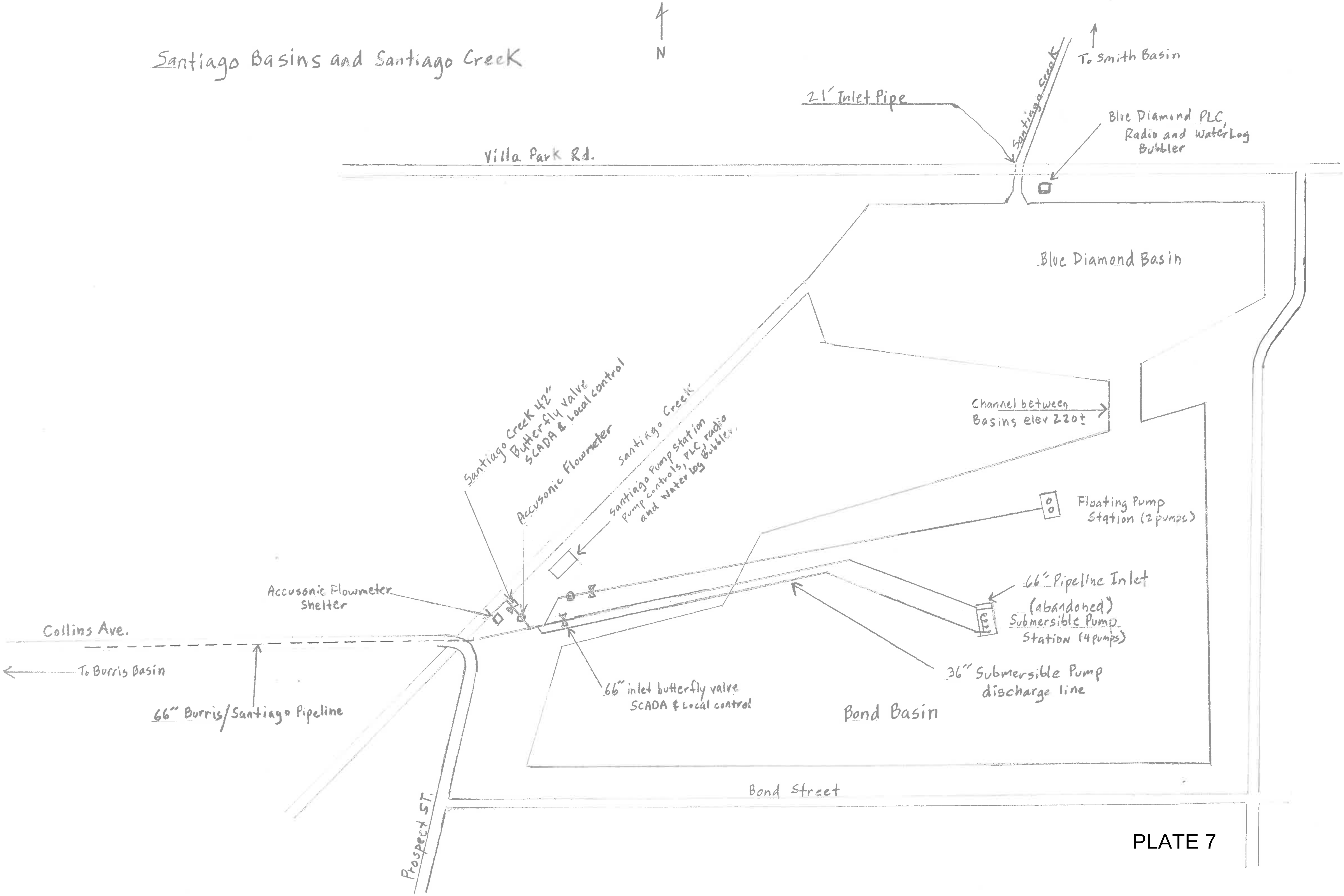
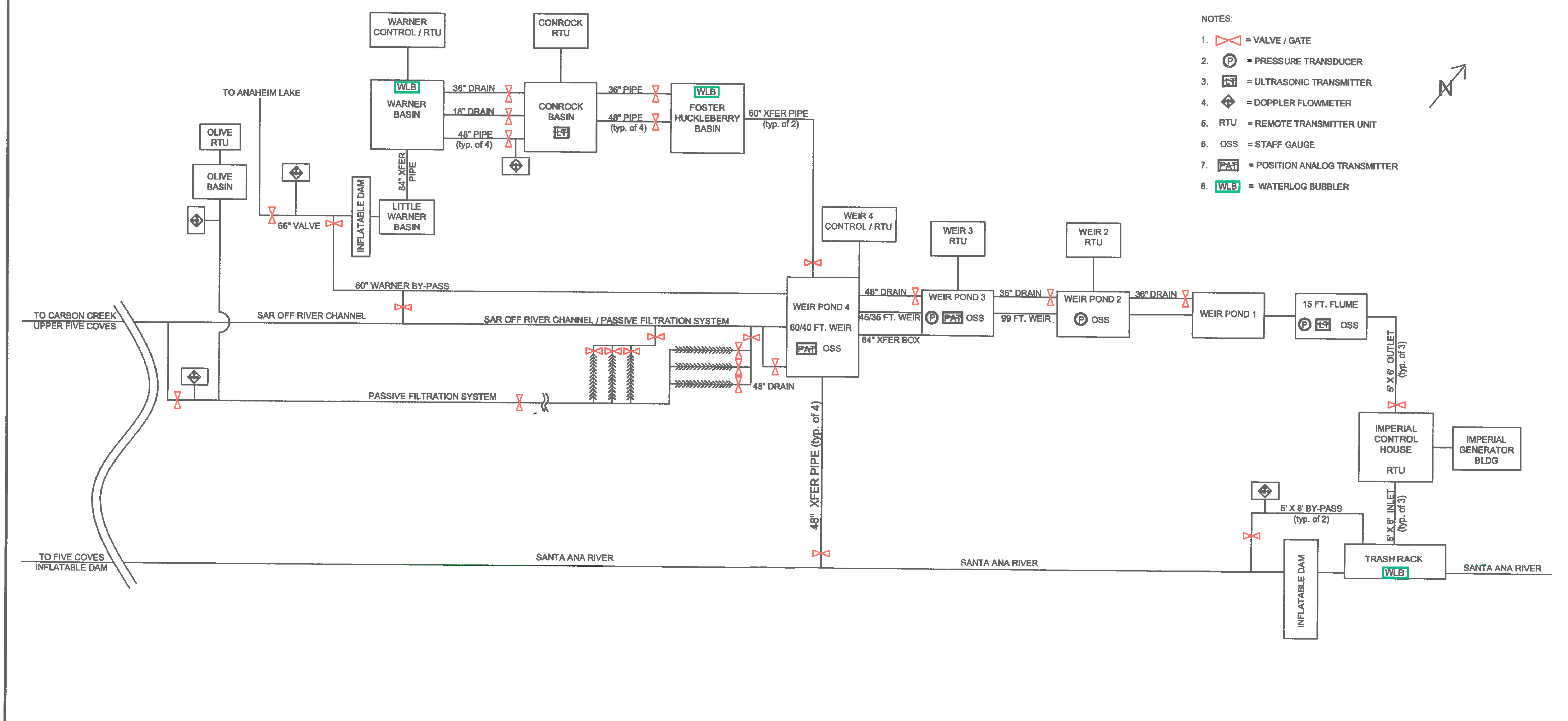

Santiago Basins and Santiago Creek
N
To Smith Basin
Santiago Creek
21' Inlet Pipe
Blue Diamond PLC, Radio and WaterLog Bubbler
Villa Park Rd.
Blue Diamond Basin
Channel between Basins elev 220±
Santiago Creek 42" Butterfly valve SCADA & Local control
Accusonic Flowmeter
Santiago Creek
Santiago Pump Station Pump controls, PLC, radio and Water log Bubbler.
Floating Pump Station (2 pumps)
66" Pipeline Inlet (abandoned)
Submersible Pump Station (4 pumps)
Accusonic Flowmeter Shelter
Collins Ave.
To Burris Basin
66" Burris/Santiago Pipeline
66" inlet butterfly valve SCADA & Local control
36" Submersible Pump discharge line
Bond Basin
Bond Street
Prospect St.

PLATE 7

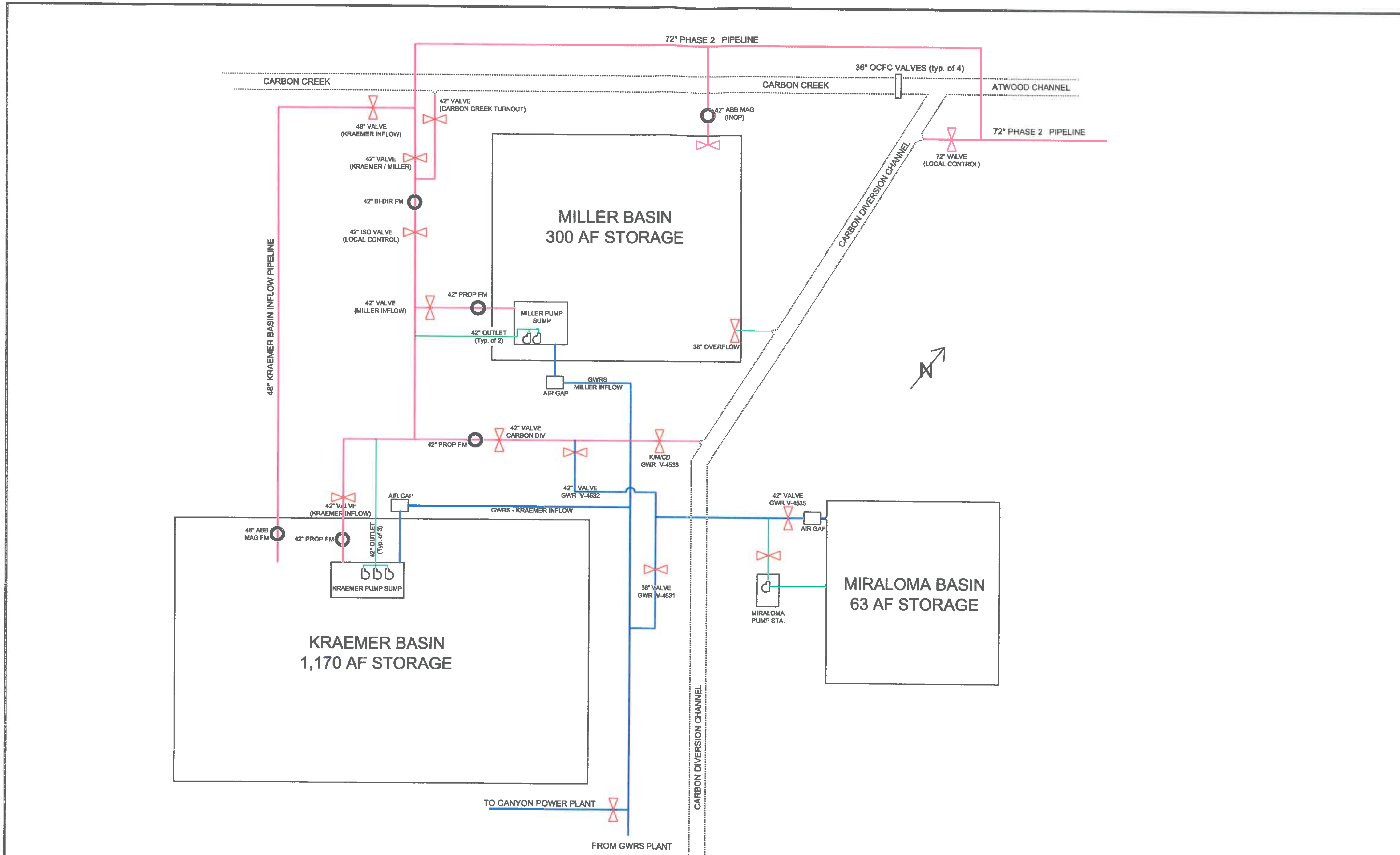


	11/2017	IMPERIAL SYSTEM SCHEMATIC		DESIGN	DATE
				DRAWN SN	JOB NO.
				CHECKED DH/JV	DRAWING
REV.	DATE	DESCRIPTION	APP.		

Santa Ana River – Imperial Distribution System

ORANGE COUNTY WATER DISTRICT
4060 E. LA PALMA
ANAHEIM, CALIFORNIA 92706
TELEPHONE (714) 378–3200

PLATE 8

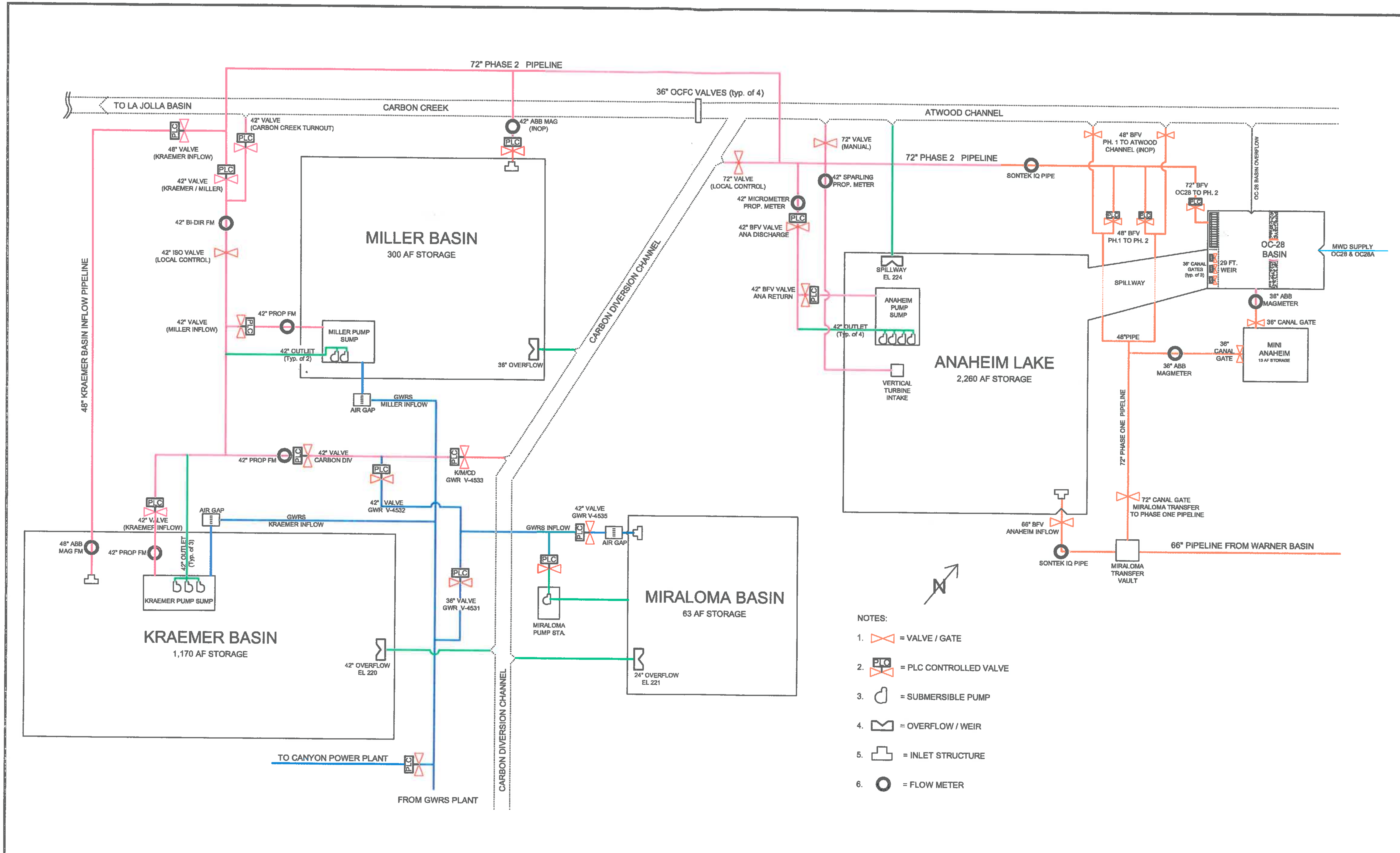


REV.	DATE	DESCRIPTION	APP.	DESIGN / DRAWN / CHECKED	DATE / JOB NO. / DRAWING
	4/2018	Kraemer/Miller/Miraloma		SN / DH/JV	

Kraemer / Miller / Miraloma Distribution System

ORANGE COUNTY WATER DISTRICT
4060 E. LA PALMA
ANAHEIM, CALIFORNIA 92706
TELEPHONE (714) 378–3200

PLATE 9



REV.	DATE	DESCRIPTION	APP.
	4/2018	OC-28 System	
	4/2018	Anaheim System Added	

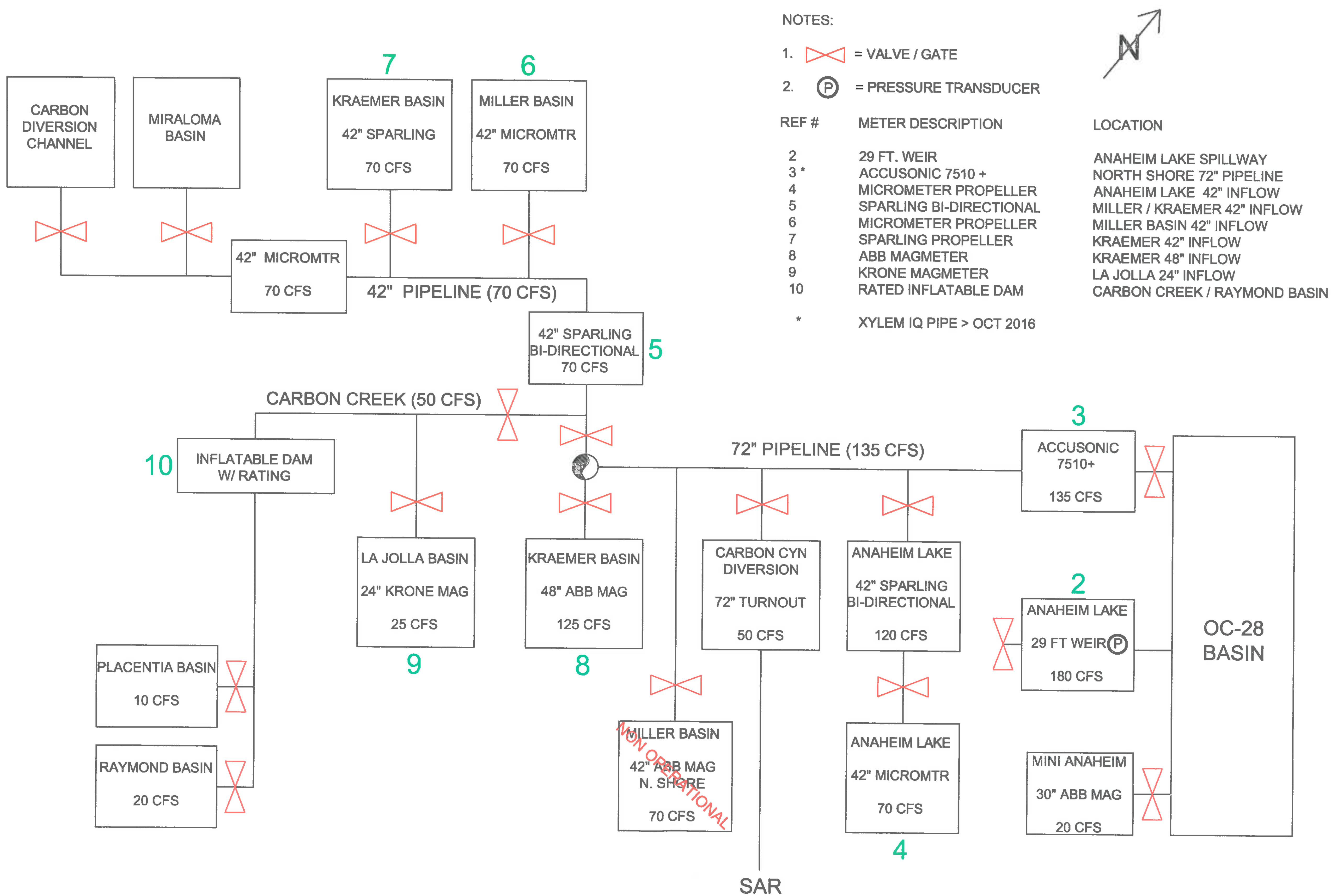
DESIGN:
DRAWN: SN
CHECKED: DH/JV
DATE:
JOB NO.:
DRAWING:

Anaheim Lake, Kraemer, Miller, & Miraloma Basins
Distribution System

ORANGE COUNTY WATER DISTRICT
4060 E. LA PALMA
ANAHEIM, CALIFORNIA 92706
TELEPHONE (714) 378-3200

PLATE 10

4/23/2018 11:49 AM



REV.	DATE	DESCRIPTION	APP.
	4/2018	OC-28 System	

DESIGN / DRAWN: SN / CHECKED: DH/JV

OC-28
DISTRIBUTION SYSTEM

ORANGE COUNTY WATER DISTRICT
4060 E. LA PALMA
ANAHEIM, CALIFORNIA 92706
TELEPHONE (714) 378-3200

PLATE 11

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Appendix A-1

Imperial Rubber Dam Operation

How to Operate the Imperial Rubber Dam

Local Mode – Inflate the Dam

1. Inside the Imperial control house locate the Imperial Rubber Dam control panel mounted on the South wall (Figure 1).
2. Place the Panel Control Mode dial in “Manual”. The green “auto mode” light on the panel will start blinking.
3. Place the Dam Inflate Valve dial to the “open” position; place the dam deflate dial to “close”.
4. Once the valve actuator wheels completely open, turn the dam inflate blower valve to “Start”
5. When the desired psi is reached, turn the blower valve to stop.
6. To allow remote control once dam is inflated, turn the Panel Control Mode dial to “SCADA”.
   <u>**Note:**</u> Once the dam is inflated, if you would like to have remote control of this dam, the Control Mode Dial must be switched to “SCADA” and the SCADA screen must also have “inflate” selected. To prevent deflation of the dam via SCADA, select “inflate” on the SCADA screen “Local Panel”.

Local Mode – Notch the Dam

1. Inside the Imperial control house locate the Imperial Rubber Dam control panel mounted on the South wall (Figure 1).
2. Place the Panel Control Mode dial in “Manual”. The green “auto mode” light on the panel will start blinking.
3. Place the Dam Deflate Valve dial to the “open” position.
4. Once the valve actuator wheels completely open, air will release from the dam.
5. Visually look for a depression to develop in the dam.
6. Once the desired depression is reached, turn the Dam Deflate Valve to “close”.
7. The notch is created to remove debris or rapidly drop the pool level. Once the notch is no longer desired, switch the Panel Control Mode back to “SCADA” and the dam will reflate.

Local Mode – Deflate the Dam

1. Inside the Imperial control house locate the Imperial Rubber Dam control panel mounted on the South wall (Figure 1).
2. Place the Panel Control Mode dial in “Manual”. The green “auto mode” light on the panel will start blinking.
3. Place the Dam Deflate Valve dial to the “open” position.

4. Once the valve actuator wheels completely open, air will release from the dam.
5. Visually look for the dam to completely deflate.
6. To allow remote control once dam is deflated, turn the Panel Control Mode dial to "SCADA".
   Note: Once the dam is deflated, if you would like to have remote control of this dam, the Control Mode Dial must be switched to "SCADA" and the SCADA screen must also have "inflate" selected. To prevent reinflation of the dam via SCADA, select "deflate" SCADA screen on the "Local Panel" dial.
7. Close the Bypass gates when dam is deflated.

Remote Mode - Inflate Dam

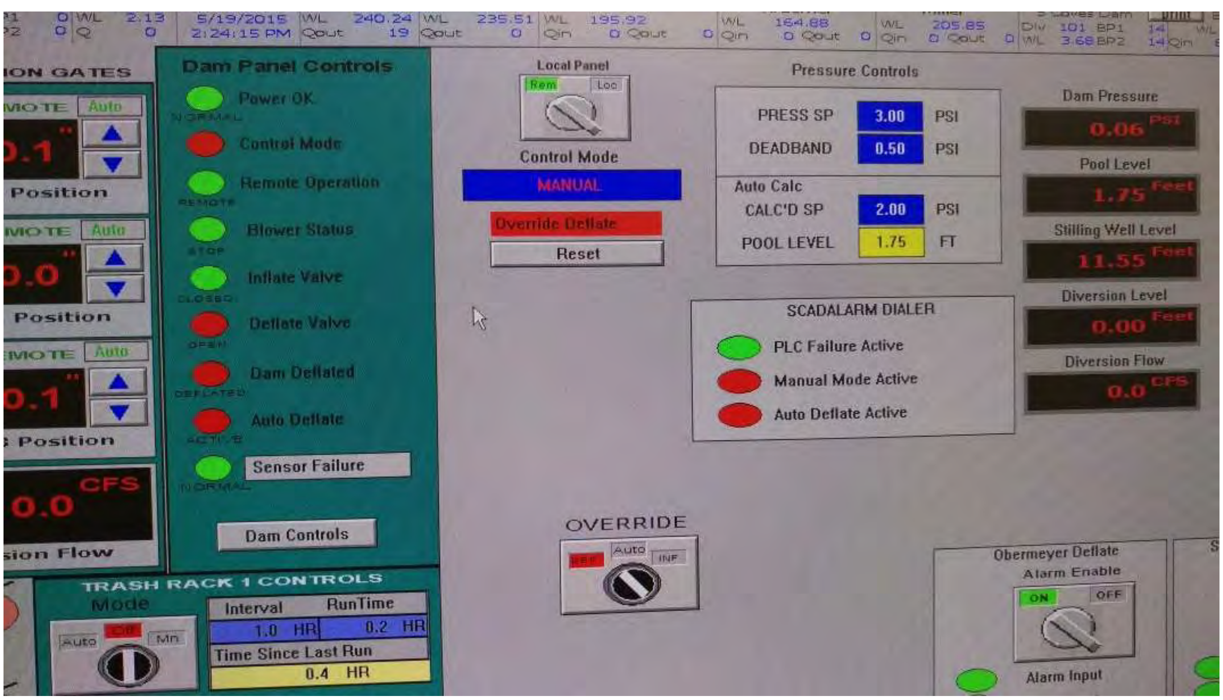
1. Select the "Imperial" screen from the SCADA menu.
2. Select "Dam Control".
3. Verify the control mode is in "Remote"
4. Within the SCADA screen locate the "local panel" in the upper center of the page and select "Inflate". The control mode is displayed as pressure (psi) and located just below the "local panel". The preferred mode of operation is "auto calc". This mode does not require any pressure set point entries by the operator. The software calculates and shuts off at the correct pressure automatically.
5. Deadband setpoints can be set to compensate for environmental changes to the dam pressure. To set dead band set points click the "deadband" value box in blue and select desired pressure from the pop-up screen.
6. The dam will inflate to the auto calc pressure setpoint and the blower will stop inflating.
7. The deadband will regulate the pressure inside the dam by controlling the blower and pressure relief valves automatically as air temperature and pool levels affect the dam bladder pressure.

Remote Mode - Inflate Dam

1 Select the "Imperial" screen from the SCADA menu.
2 Select "Dam Control".
3 Verify the control mode is in "Remote"
4 Within the SCADA screen locate the "local panel" in the upper center of the page and select "deflate" and the dam will deflate.
5 Close the Bypass gates when dam is deflated.

Figure 1 Imperial Rubber Dam Control Panel

Figure 2 Imperial Rubber Dam Control Scada Screen



Appendix A-2

Imperial Trash Rack Operation

IMPERIAL TRASH RACK OPERATIONS

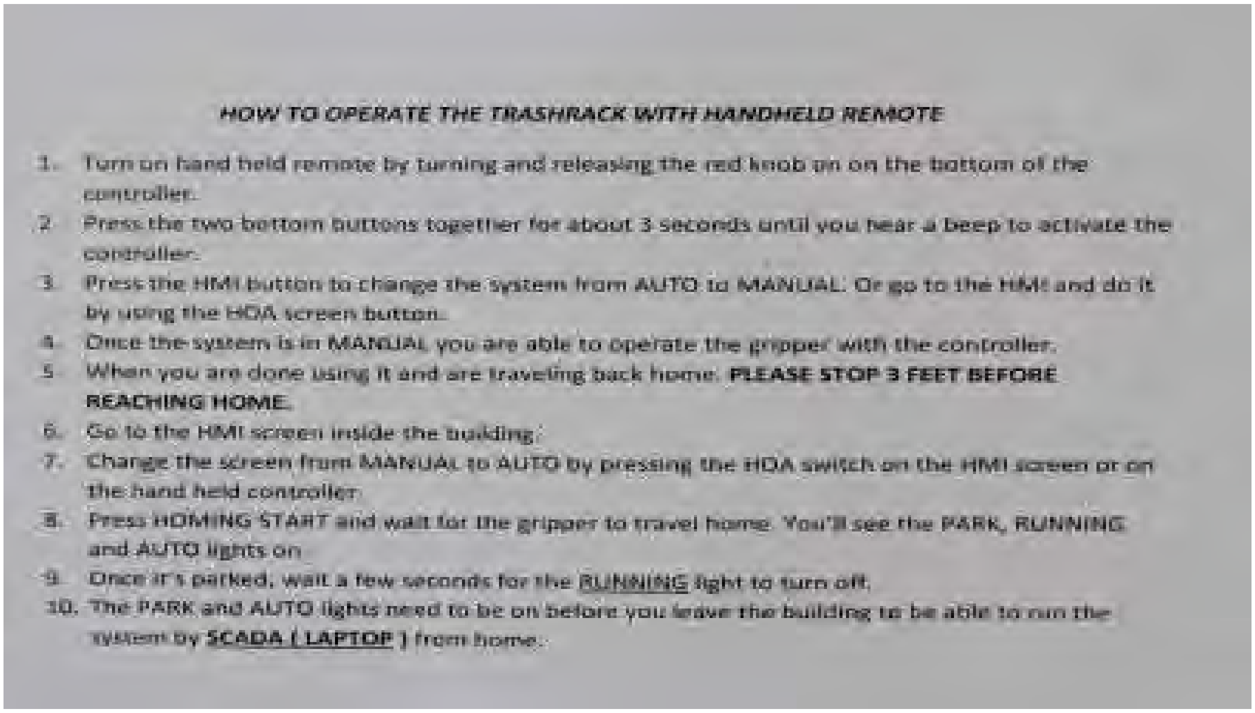
The Imperial Trash Rack system is relatively new and utilizes state of the art technology. This technology involves an above ground monorail (Figure 1). An articulating mechanical grabber travels along the monorail and set frequencies and is lowered into the water at various stations. Once submerged, the grabber automatically closed it's jaws, lifts the grabber back to the monorail. The grabber filled with debris travels back to the upstream side end of the monorail when it is automatically lowered, and the jaws open to release the debris. Heavy equipment operators will clear the debris piles with a backhoe periodically.

Local Operation

This system is operated in the field using a hand-held remote controller. Figure 2 provides operational instructions. Figure 3 shows the control panel and hand-held controller found inside the Imperial Control house.

Figure 1. Imperial Trash Rack System

Figure 2. Imperial Trash Rack Operation Local Operation Instructions



HOW TO OPERATE THE TRASHRACK WITH HANDHELD REMOTE

1. Turn on hand held remote by turning and releasing the red knob on on the bottom of the controller.
2. Press the two bottom buttons together for about 3 seconds until you hear a beep to activate the controller.
3. Press the HMI button to change the system from AUTO to MANUAL. Or go to the HMI and do it by using the HOA screen button.
4. Once the system is in MANUAL you are able to operate the gripper with the controller.
5. When you are done using it and are traveling back home. **PLEASE STOP 3 FEET BEFORE REACHING HOME.**
6. Go to the HMI screen inside the building.
7. Change the screen from MANUAL to AUTO by pressing the HOA switch on the HMI screen or on the hand held controller.
8. Press HOMING START and wait for the gripper to travel home. You'll see the PARK, RUNNING and AUTO lights on.
9. Once it's parked, wait a few seconds for the RUNNING light to turn off.
10. The PARK and AUTO lights need to be on before you leave the building to be able to run the system by **SCADA (LAPTOP)** from home.

Figure 3 Imperial Trash Rack Control Panel with hand-held controller

Modifications to The Imperial Trash Rack system can be made using the SCADA system. SCADA can be used to change the location of the pick up stations and the frequency of the pick ups.

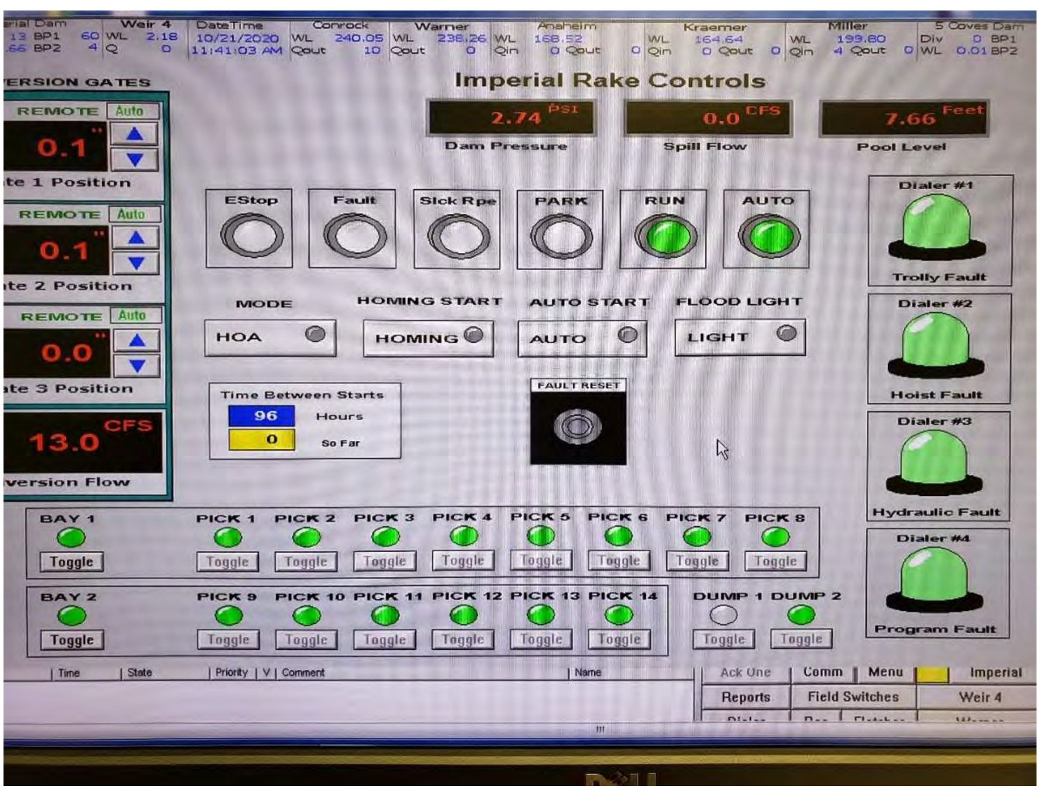
To change the Imperial Trash Rack pick up location:

1. On the SCADA system select the Imperial Dam screen
2. Select Trash Rack from the lower right side of screen
3. The screen “Imperial Rake Control” (Figure 3) will appear
4. The Bay 1 and Bay 2 pick locations are shown near the bottom of the screen
5. Click the locations desired. Once selected the toggle will appear green on the screen.

To change the timing between starts (frequency)

1. Locate the “time between starts” field (yellow and blue boxes) on the SCADA screen.
2. Click on the blue box and a pop-up box will appear, then values can be changes. The yellow box “so far” indicated how much time has elapsed since the last trash rack operation.

Figure 4 Imperial Trash Rack SCADA Screen



Appendix A-3

Motor Operated Valve Actuator Operation

How to Operate a Motor Operated Valve Actuator

1. Open lock on the Motor Operator Valve (Figure 2).
2. Turn the dial from “Remote” to “Off” to “Local”
3. Hit the Open button until it reaches desired height.
4. Now hit the close button until it completely closes.
5. Turn dial from “Local” to “Off” to “Remote”
6. Close and lock the Motor Operator Valve (MOV)

Figure 1 Motor Operated Valve Actuator

The preceding instruction apply to all motor operated valves (MOV’s) throughout the OCWD Recharge System, however, the gate valves into Huckleberry Pond require additional steps due to the presence of a large metal trash screen (Figure 2). The procedures below describe how to operate the Huckleberry MOVs.

Figure 2 Huckleberry Trash screen and Lift System

How to Operate Huckleberry Gates at Pond 4

1. Unhook chain from pole than put hook on eye of trash rack to get ready to lift it up.
2. Use boom controller to pull gate up by pushing the “UP” button (Figure 2).
3. Raise bar a couple inches over water or until the trash moves underneath the gate.
4. Open lock on the Motor Operator Valve (Figure 2).
5. Turn the dial from “Remote” to “Off” to “Local”
6. Hit the Open button until it reaches desired height.
7. Now hit the close button until it completely closes.
8. Turn dial from “Local” to “Off” to “Remote”
9. Close and lock the Motor Operator Valve (MOV)
10. Use boom controller to lower the gate (trash rack) by hitting the “Down” button until completely closed
11. Unhook chain from eye and place back on pole

Figure 3 Control to Move the Trash Rack

Appendix A-4

Portable Hydraulic Valve Operator Operation

How to use the Portable Hydraulic Operator Unit to open valves not equipped with actuators

1) Unwind the hydraulic hoses with the drive from the hydraulic operator unit (unit) (Figure 1) and place the drive (located at the end of the hydraulic hoses) on the valve gear drive (on the top of the valve stem) (Figure 2).
2) Put the hydraulic unit to “On” position (on the back of the unit below the gas tank).
3) Turn the gas and choke to the “On” position (on the side of the unit below the gas tank).
4) Make sure the valve body lever is in the “Neutral” position.
5) Pull starter string and once the motor starts turn the choke to “off” position.
6) While standing behind the hydraulic operator unit, pull the valve body handle back to open the valve or push the valve body handle forward to close valve (Figure 4).
7) When valve is closed, put the hydraulic operator to the “off” position.
8) Turn the gas to the “off” position.

Figure 1 Portable Hydraulic Operator Unit

Figure 2 Drive on valve stem

Figure 3 Operator-drive assembled correctly

Locations that do not have valve actuators and need the portable hydraulic operator (figure 1) to open/close are Weir Ponds 1-4 drains, Warner Bypass to Off-River, Warner Bypass to Warner Outflow Channel, SAR to Pond 4, SAR to Off-River, *SAR to Upper Five Coves, SAR to Lincoln.

*The SAR to Upper Five coves has a gear box adaptor (figure 6) that the hydraulic operator hoses connect to. The hydraulic driver is removed from the end of the hoses for this site (figure 5).

Figure 3 motor on the gear drive at Weir Pond 4 drain

Figure 4 SRSO moving the valve body position

How to Open/Close the SAR to Upper Five Coves Canal Gates

1. Unwind the hydraulic hoses with the drive from the unit and disconnect the drive from the hoses (figure 5).
2. Connect hydraulic hoses to the fittings inside the hydraulic connection box (figure 6).
3. Turn the unit power to “On” position (on the back of the unit below the gas tank).
4. Turn the gas and choke to the “On” position (on the side of the unit below the gas tank).
5. Make sure the valve body lever is in the “Neutral” position (middle).
6. Pull starter string and once the motor starts turn the choke to “Off” position.
7. While standing behind the hydraulic operator unit, pull the valve body handle to open the valve or push the valve body handle to close valve.
8. When the canal gate is in the desired position, place the valve body handle to the neutral position.
9. Place the hydraulic operator power to the “Off” position.
10. Turn the gas to the “Off” position.

Figure 5 removing the motor from the hydraulic operator hoses

Figure 6 Hydraulic Connection Box Located above Canal Gates

Appendix A-5

Five Coves Rubber Dam Operation

How to Operate the Five Coves Rubber Dam

Local Mode – Inflate the Dam

7. Inside the Five Coves Rubber Dam control house locate the Five Coves Rubber Dam control panel mounted on the West wall (Figure 1).
8. Place the Deflation Valve dial to the closed position.
9. Pull the Dam Inflate Blower knob and hold it open, the dam will start inflating.
10. Once the desired dam inflation is reached, release the Dam Inflation Blower knob and the inflation blower will stop.
    Note: Once the dam is inflated, if you would like to have remote control of this dam, the Programmable Controller Dial must be switched to "SCADA" and the SCADA screen must also have "inflate" selected. To prevent deflation of the dam via SCADA, select "Auto" on the Five Coves Dam SCADA screen "Dam Control" dial.

Local Mode – Notch the Dam

8. Inside the Five Coves control house locate the Five Coves Rubber Dam control panel mounted on the West wall.
9. Place the Programmable Controller dial in the "Local" position.
10. Place the dam Deflate Valve dial to the "open" position.
11. Once the valve actuator wheels completely open, the dam will begin to deflate.
12. Visually look for a depression to develop in the dam.
13. Once the desired depression is reached, turn the Dam Deflate Valve to "close".
14. The notch is created to remove debris or rapidly drop the pool level. Once the notch is no longer desired, switch the Programmable Controller dial to "SCADA" and the dam will reflate.

Local Mode – Deflate the Dam

1 Inside the Five Coves control house locate the Five Coves Rubber Dam control panel mounted on the West wall.
2 Place the Programmable Controller dial in the "Local" position.
3 Place the dam Deflate Valve dial to the "open" position.
4 Once the valve actuator wheels completely open, the dam will deflate.
5 Visually look for the dam to completely deflate. The dam may not completely deflate until there is enough external pressure.
6 To allow remote control once dam is deflated, turn the Programmable Controller dial to "SCADA".
Note: Once the dam is deflated, if you would like to have remote control of this dam, the Control Mode Dial must be switched to "SCADA" and the SCADA screen must also have "deflate" selected. To prevent reinflation of the dam via SCADA, select "deflate" on the SCADA screen "Dam Control" dial.
7 Close the Bypass gates when dam is deflated.

Remote Mode - Inflate Dam

8. Select the “Five Coves Dam” screen from the SCADA menu.
9. Select “Dam Control”. (Figure 2)
10. Verify the remote status light is “green”
11. Locate the “Dam Control” dial in the upper center of the page and select “Auto”. This mode does not require any pressure set point entries by the operator. This dam is programmed to auto calculate the pressure setpoint. The software calculates and shuts off at the correct pressure automatically.
12. The dam will inflate to the auto calc pressure setpoint and the blower will stop inflating.
13. The internal pressure of this dam is self-regulating.

Remote Mode - Deflate Dam

6 Select the “Five Coves Dam” screen from the SCADA menu.
7 Select “Dam Control”.
8 Verify the remote status light is “green”
9 Locate the “Dam Control” dial in the upper center of the page and select “DEF” and the dam will deflate.

Figure 1 Five Coves Rubber Dam Control Panel

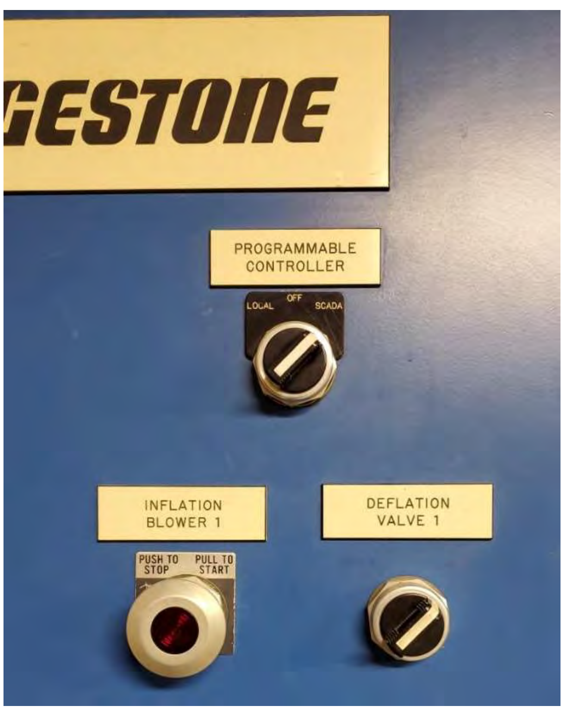
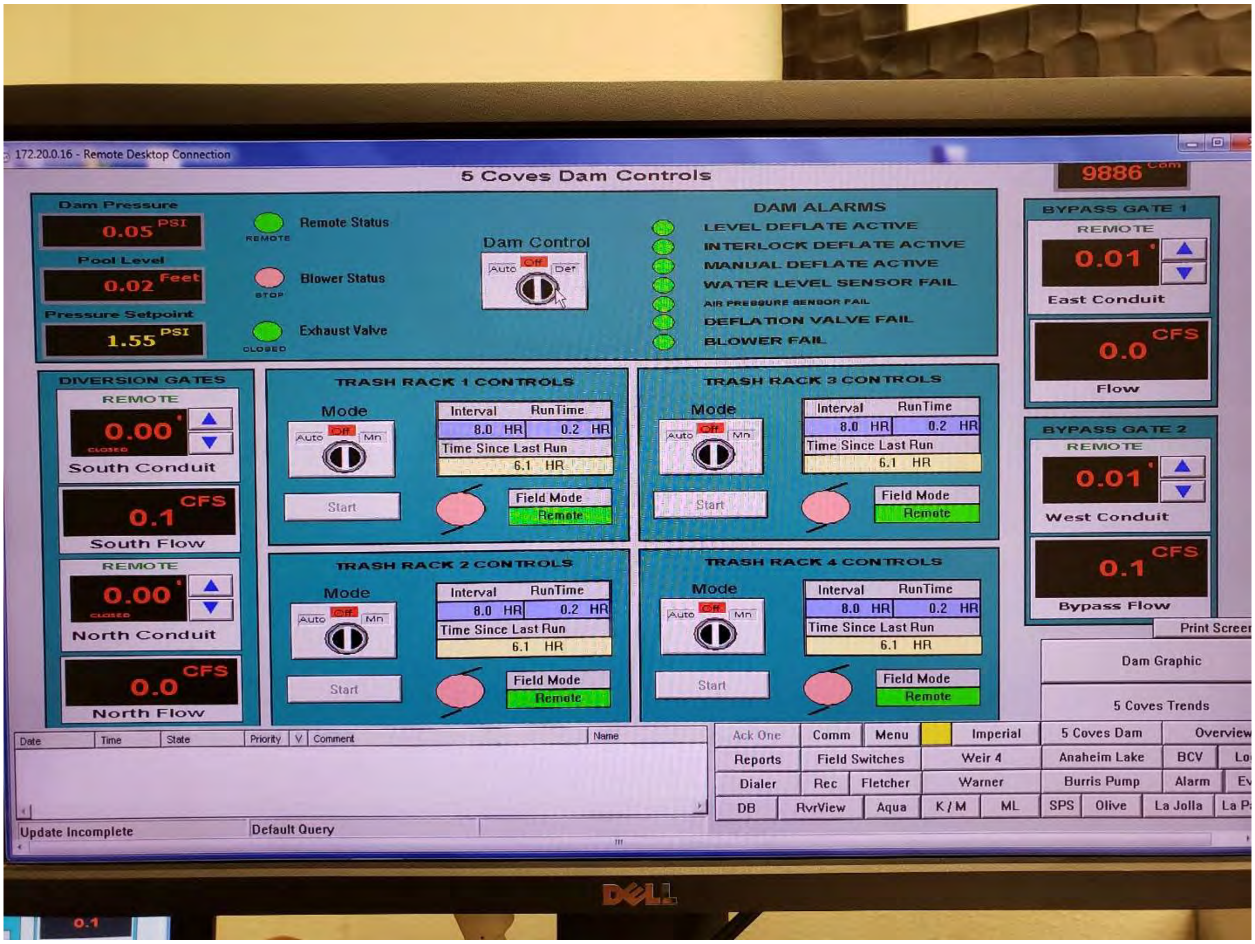


Figure 2 Five Coves Rubber Dam Scada Screen



Appendix A-6

Five Coves Trash Rack Operation

FIVE COVES TRASH RACK OPERATIONS

The Five Coves Trash Rack is a hydraulic motor operated system that utilizes rotating chains and perpendicular metal rods (cars and tines) attached to the chains that lift debris out of the water and carries the material up to ground surface where it is released by gravity and forms a pile (Figure 1). Heavy equipment operators will clear the debris piles with a backhoe periodically.

The trash racks can be run locally or remotely. The normal operation is remotely in the "Auto" setting.

Figure 1. Five Coves Trash Rack System with debris falling to the ground.

To operate the trash rack system Locally:

1.) Locate the trash rack controls on the Southwest wall on the inside of the Dam Control building (Figure 2).
2.) There are four bar screen dials that control 10 chains each. Turn the bar screen dial to the "Hand" position and then go to the outside of the building and open the trash rack control box on the wall (figure 3).
3.) On the outside panel turn the Bar Screen dial to "Forward" and push the "Start" button. The "reverse" option is used only when the trash racks fails to release stuck cars or remove debris.

4.) To stop the trash rack, turn the Bar Screen dial to “Off” on the outside panel. Place the Bar Screen dial back to the “Auto” position on the panel inside the building before you leave the site.

Figure 2. Five Coves Trash Rack Control Panel inside the Dam Control building.

Figure 3. Five Coves Trash Rack Control Panel outside the Dam Control building.

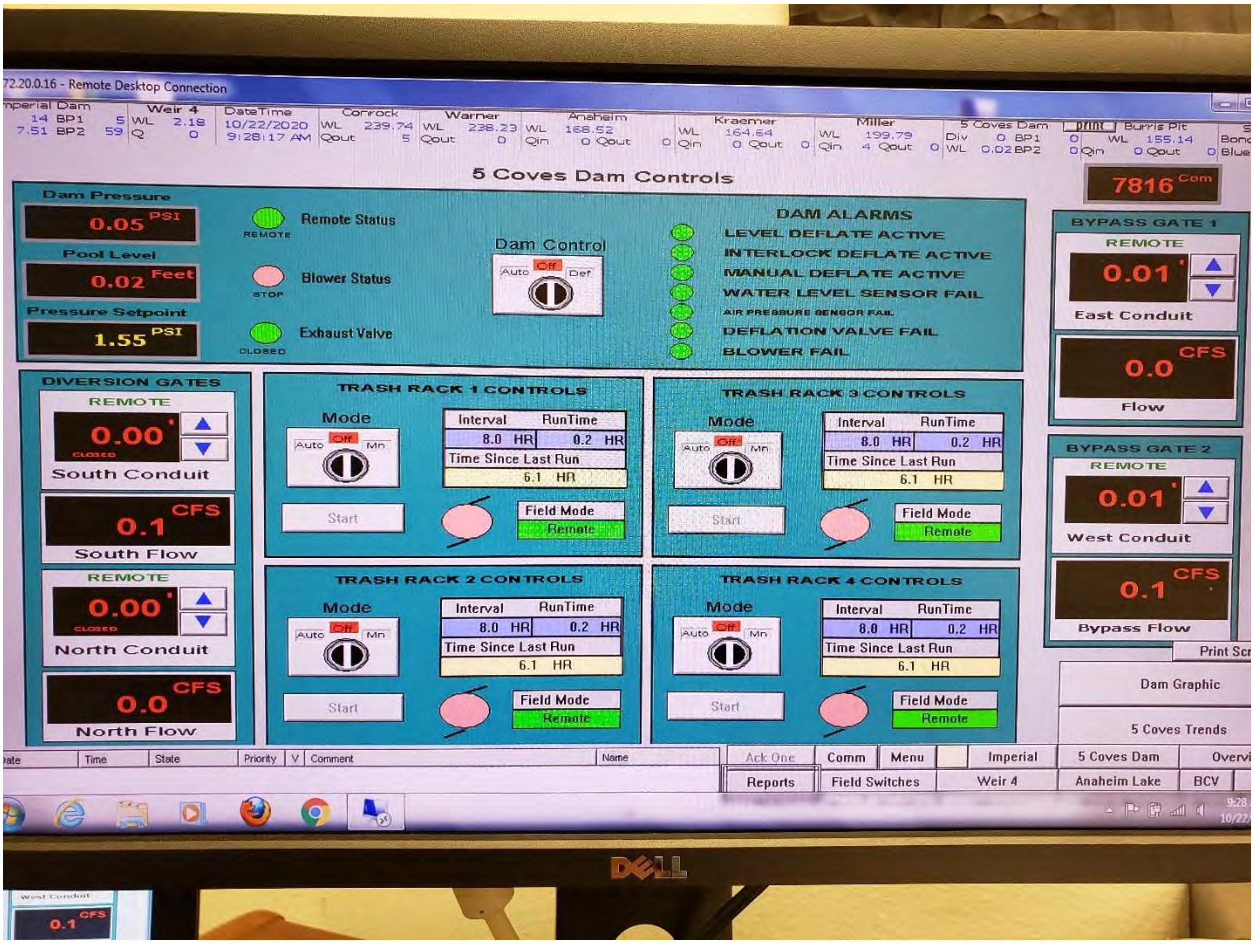
To operate the trash rack system Remotely:

1.) Select the Five Coves trash rack SCADA screen and select the Dam Control" at the lower right side of the screen. This will take you to a screen that looks like Figure 4.

2.) There are four Trash Rack Controls in the middle of the screen. Each control has an HOA dial, "Start" button, Interval and runtime setting and the local control status. The local control status on the screen needs to be in "Remote" (in green). The Mode dial in "Auto" will turn the trash racks on an off automatically accordingly to the Interval and Runtime setting values. These values can be changed by clicking on the numbers in the blue boxes to the right of the HOA dial.

3.) Press "Start" and the trash racks will start immediately. The Mode dial in "Mn" (manual) will run the trash racks continually until the Mode dial is placed in "Off".

Figure 4 Imperial Trash Rack SCADA Screen



How to clear Five Coves Trash Rack Failure

When the trash rack fails in "auto" the SRSO must visit the site and push the reset button (blue button with the letter "R" on the inside control panel (Figure 2)) switch the dial on the inside control panel to " hand". Then the SRSO must select "manual" on the outside panel and switch the dial to "reverse". If the chains do not move in reverse, call the Maintenance Department for assistance. If the chains do go into reverse and the blockage is clear, then place the outside panel dial to the "off" position, then go to the inside control panel and place the dial back into "auto".

Appendix A-7

Ball Road Gauging Station Look Up Table

10/13/97 11:17
ORANGE COUNTY WATER DISTRICT

#R-6 SANTA ANA RIVER AT BALL RD 1997

Rating Table 297 from 01/12/97 14:00 Scale Offset = 4.10

DIKES OUT BASED ON MEAS. 155-156.
Note: Table is expanded rectilinearly from 4.10 to 4.15 feet

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
4.1	0*	.044	.088	.132	.176	.220*	.328	.460*	.627	.823	1.05	
4.2	1.05*	1.30	1.59	1.90	2.25*	2.65	3.09	3.58	4.10*	4.66	4.21	3.16
4.3	5.26	5.91	6.60*	7.33	8.11	8.93	9.80*	10.7	11.7	12.7	8.49	4.28
4.4	13.8	14.9	16.0	17.2	18.5*	19.8	21.2	22.6	24.1	25.6	13.4	4.91
4.5	27.2	28.8	30.5	32.2	34.0*	35.9	37.8	39.7	41.8	43.8	18.8	5.44
4.6	46.0	48.2	50.5	52.8	55.2	57.6	60.1	62.7	65.3	68.0*	24.8	5.94
4.7	70.8	73.6	76.5	79.4	82.5	85.6	88.7	91.9	95.2	98.6	31.2	6.46
4.8	102.0	105.5	109.0	112.7	116.4	120.1	124.0	127.9	131.8	135.9	38.0	6.77
4.9	140.0*	144.1	148.4	152.6	157.0	161.4	165.9	170.5	175.1	179.8	44.6	6.57
5.0	184.6	189.4	194.3	199.3	204.4	209.5	214.7	220.0	225.4	230.8	51.8	7.20
5.1	236.3	241.9	247.6	253.3	259.1	265.0*	271.0	277.1	283.2	289.5	59.5	7.70
5.2	295.8	302.2	308.7	315.2	321.9	328.6	335.4	342.2	349.2	356.2	67.5	8.08
5.3	363.4	370.5	377.8	385.2	392.6	400.2	407.9	415.5	423.2	431.1	75.7	8.13
5.4	439.0	447.1	455.2	463.4	471.6	480.0*	489.1	498.4	507.7	517.1	87.6	12.0
5.5	526.7	536.3	546.1	555.9	565.9	576.0	586.2	596.5	606.9	617.4	101.4	13.7
5.6	628.0	638.8	649.6	660.6	671.7	682.8	694.1	705.5	717.1	728.7	112.4	11.0
5.7	740.4	752.3	764.3	776.4	788.6	800.9	813.4	825.9	838.6	851.4	123.3	11.4
5.8	864.3	877.3	890.5	903.8	917.1	930.6	944.3	958.0	971.9	985.9	135.7	11.8
5.9	1,000*	1,015	1,030	1,045	1,060	1,075	1,091	1,106	1,122	1,138	153.8	18.1
6.0	1,154	1,170	1,186	1,203	1,219	1,235	1,253	1,270	1,287	1,304	167.7	13.9
6.1	1,321	1,339	1,357	1,374	1,392	1,411	1,429	1,447	1,466	1,485	182.0	14.4
6.2	1,503	1,522	1,542	1,561	1,580	1,600*	1,621	1,642	1,664	1,686	[illegible]	21.9
[illegible]	[illegible]	1,722	1,752	1,774	1,797	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.5
6.4	[illegible]	[illegible]	1,984	2,008	2,032	2,057	2,082	2,107	2,132	2,158	247.3	18.9
6.5	2,183	2,209	2,235	2,261	2,288	2,314	2,341	2,368	2,395	2,422	266.9	19.5
6.6	2,450*	2,477	2,505	2,533	2,560	2,589	2,617	2,645	2,674	2,703	292.0	15.1
6.7	2,732	2,761	2,791	2,820	2,850	2,880	2,911	2,941	2,972	3,003	301.3	20.0
6.8	3,034	3,065	3,097	3,128	3,160	3,193	3,225	3,257	3,290	3,323	322.5	20.5
6.9	3,356	3,390	3,423	3,457	3,491	3,526	3,560	3,595	3,630	3,665	343.6	21.1
7.0	3,700*	3,758	3,817	3,876	3,936	3,997	4,058	4,121	4,184	4,247	612.0	268.4
7.1	4,312	4,377	4,443	4,510	4,578	4,646	4,715	4,785	4,856	4,928	688.0	76.1
7.2	5,000*	5,015	5,030	5,045	5,060	5,075	5,090	5,105	5,120	5,135	150.5	-537.6
7.3	5,150	5,165	5,181	5,196	5,211	5,226	5,241	5,256	5,271	5,286	150.1	-.311
7.4	5,301	5,316	5,331	5,346	5,361	5,376	5,391	5,406	5,421	5,435	149.8	-.301
7.5	5,450	5,465	5,480	5,495	5,510	5,525	5,540	5,555	5,570	5,585	149.5	-.292
7.6	5,600*	5,630	5,660	5,691	5,721	5,752	5,782	5,813	5,843	5,874	304.9	155.4
[illegible]	5,905	5,936	5,967	5,998	6,029	6,060	6,092	6,123	6,154	6,186	312.5	7.56
[illegible]	6,217	[illegible]	6,281	[illegible]	6,345	6,376	6,409	6,441	6,473	6,505	[illegible]	7.54
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6,766	[illegible]	[illegible]	[illegible]	[illegible]

07/30/12 15:46

ORANGE COUNTY WATER DISTRICT

#R-6 SANTA ANA RIVER AT BALL RD 2012 WY

Rating Table 197 from 04/10/2011 14:30 Scale Offset = 4.10

DIKE IN BASED ON MEAS.57-159.

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
4.1	0*	.039	.078	.117	.156	.195*	.281	.382	.499	.632	.780	
4.2	.780*	.939	1.11	1.30*	1.52	1.75	2.00*	2.25	2.52	2.80	2.32	1.54
4.3	3.10*	3.41	3.74	4.08	4.44	4.81	5.20*	5.60	6.01	6.44	3.78	1.46
4.4	6.88	7.33	7.80*	8.28	8.77	9.27	9.79	10.3	10.9	11.4	5.12	1.35
4.5	12.0*	12.6	13.3	13.9	14.6	15.3	16.0	16.7	17.5	18.2	7.00	1.88
4.6	19.0*	19.8	20.5	21.3	22.1	23.0	23.8	24.6	25.5	26.4	8.28	1.28
4.7	27.3	28.2	29.1	30.0	31.0*	32.0	33.0	34.1	35.1	36.2	9.98	1.71
4.8	37.3	38.4	39.5	40.6	41.8	42.9	44.1	45.3	46.5	47.8	11.7	1.76
4.9	49.0*	50.2	51.4	52.7	53.9	55.2	56.5	57.8	59.1	60.4	12.8	1.03
5.0	61.8	63.1	64.5	65.9	67.3	68.7	70.1	71.6	73.0	74.5	14.2	1.45
5.1	76.0*	77.5	79.0	80.5	82.1	83.6	85.2	86.8	88.4	90.0	15.6	1.42
5.2	91.6	93.3	94.9	96.6	98.3	100.0*	101.6	103.2	104.8	106.4	16.4	.771
5.3	108.1	109.7	111.4	113.0	114.7	116.4	118.1	119.8	121.5	123.3	16.9	.534
5.4	125.0*	127.0	129.0	131.0	133.1	135.1	137.2	139.3	141.4	143.5	20.7	3.74
5.5	145.7	147.8	150.0	152.2	154.4	156.6	158.9	161.1	163.4	165.7	22.3	1.64
5.6	168.0*	170.2	172.4	174.7	176.9	179.2	181.5	183.8	186.1	188.4	22.8	.469
5.7	190.8	193.1	195.5	197.9	200.3	202.7	205.1	207.6	210.0	212.5	24.2	1.43
5.8	215.0*	217.6	220.2	222.8	225.5	228.1	230.8	233.5	236.2	239.0	26.7	2.49
5.9	241.7	244.5	247.2	250.0	252.8	255.6	258.5	261.3	264.2	267.1	28.3	1.60
6.0	270.0*	272.8	275.6	278.4	281.3	284.1	287.0	289.9	292.8	295.7	28.6	.291
6.1	298.6	301.5	304.5	307.4	310.4	313.4	316.4	319.4	322.5	325.5	30.0	1.41
6.2	328.6	331.7	334.8	337.9	341.0	344.1	347.3	350.4	353.6	356.8	31.4	1.41
6.3	360.0*	362.9	365.8	368.7	371.7	374.6	377.6	380.5	383.5	386.5	29.5	-1.91
6.4	389.5	392.5	395.5	398.5	401.6	404.6	407.7	410.7	413.8	416.9	30.5	1.01
6.5	420.0*	423.8	427.7	431.5	435.4	439.3	443.2	447.1	451.1	455.1	39.1	8.55
6.6	459.1	463.1	467.1	471.1	475.2	479.3	483.4	487.5	491.7	495.8	40.9	1.89
6.7	500.0*	503.7	507.5	511.3	515.0	518.8	522.6	526.4	530.3	534.1	38.0	-2.96
6.8	538.0	541.9	545.7	549.6	553.6	557.5	561.4	565.4	569.3	573.3	39.3	1.35

Rating #: 197
Page 2

BALL RIO

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
6.9	577.3	581.3	585.3	589.4	593.4	597.5	601.6	605.6	609.7	613.9	40.7	1.34
7.0	618.0	622.1	626.3	630.5	634.6	638.8	643.0	647.3	651.5	655.7	42.0	1.34
7.1	660.0*	664.1	668.2	672.4	676.5	680.7	684.8	689.0	693.2	697.4	41.6	-.364
7.2	701.6	705.9	710.1	714.4	718.6	722.9	727.2	731.5	735.8	740.1	42.8	1.18
7.3	744.5	748.8	753.2	757.6	761.9	766.3	770.7	775.2	779.6	784.0	44.0	1.18
7.4	788.5	792.9	797.4	801.9	806.4	810.9	815.4	820.0	824.5	829.1	45.2	1.17
7.5	833.7	838.2	842.8	847.4	852.1	856.7	861.3	866.0	870.6	875.3	46.3	1.17
7.6	880.0*											

* skeletal rating point

Appendix A-8

Look Up Tables for Off-River System

ORANGE COUNTY WATER DISTRICT

#OR-1 SANTA ANA RIVER SPREADING DIVERSION 2007 WY

Rating Table 2 from 07/01/2002 00:00 Scale Offset = 0.00

15ft PARSHALL FLUME use with new 2016 flume

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
0.0	0*	.031	.063	.094	.126	.157*	.238	.338	.459*	.725	1.09	
0.1	1.09*	1.18	1.27	1.36	1.45	1.54	1.63*	1.94	2.29	2.68	2.02	.929
0.2	3.11	3.58*	3.91	4.25	4.61	4.98*	5.38	5.79	6.22	6.66	4.00	1.99
0.3	7.11	7.58	8.07*	8.44	8.82	9.21	9.59	9.99	10.4	10.8	4.09	.082
0.4	11.2*	11.6	12.0	12.4	12.8	13.2	13.6*	14.1	14.7	15.2	4.55	.461
0.5	15.7	16.3	16.9	17.4	18.0	18.6	19.2	19.8	20.4	21.1	5.95	1.40
0.6	21.7*	22.3	22.9	23.5	24.2	24.8	25.4	26.1	26.7	27.4	6.32	.366
0.7	28.0	28.7	29.4	30.0	30.7	31.4	32.1	32.8	33.5	34.2	6.94	.624
0.8	35.0	35.7	36.4	37.2	37.9	38.7	39.4	40.2	40.9	41.7	7.54	.596
0.9	42.5*	43.3	44.0	44.8	45.6	46.4	47.2	48.0	48.8	49.6	7.89	.351
1.0	50.4	51.2	52.0	52.9	53.7	54.5	55.4	56.2	57.1	57.9	8.39	.502
1.1	58.8	59.6	60.5	61.4	62.3	63.2	64.0	64.9	65.8	66.7	8.88	.484
1.2	67.7	68.6	69.5	70.4	71.3	72.3	73.2	74.1	75.1	76.0	9.34	.468
1.3	77.0*	77.9	78.9	79.8	80.8	81.7	82.7	83.6	84.6	85.6	9.56	.213
1.4	86.6	87.5	88.5	89.5	90.5	91.5	92.5	93.5	94.5	95.5	9.96	.403
1.5	96.5	97.5	98.6	99.6	100.6	101.6	102.7	103.7	104.8	105.8	10.4	.392
1.6	106.9	107.9	109.0	110.0	111.1	112.2	113.3	114.3	115.4	116.5	10.7	.381
1.7	117.6*	118.7	119.8	120.9	122.1	123.2	124.3	125.5	126.6	127.7	11.3	.562
1.8	128.9	130.0	131.2	132.4	133.5	134.7	135.9	137.0	138.2	139.4	11.7	.386
1.9	140.6	141.8	143.0	144.2	145.4	146.6	147.8	149.0	150.2	151.4	12.1	.378
2.0	152.6	153.9	155.1	156.3	157.6	158.8	160.0	161.3	162.5	163.8	12.4	.370
2.1	165.1	166.3	167.6	168.9	170.1	171.4	172.7	174.0	175.3	176.6	12.8	.363
2.2	177.9	179.2	180.5	181.8	183.1	184.4	185.7	187.0	188.3	189.7	13.1	.356
2.3	191.0*	192.3	193.7	195.0	196.3	197.7	199.0	200.4	201.7	203.1	13.4	.283
2.4	204.4	205.8	207.2	208.5	209.9	211.3	212.7	214.0	215.4	216.8	13.8	.338
2.5	218.2	219.6	221.0	222.4	223.8	225.2	226.6	228.0	229.5	230.9	14.1	.333
2.6	232.3*	233.8	235.2	236.7	238.1	239.6	241.1	242.5	244.0	245.5	14.7	.559
2.7	247.0	248.4	249.9	251.4	252.9	254.4	255.9	257.4	258.9	260.4	15.0	.341
2.8	262.0	263.5	265.0	266.5	268.1	269.6	271.1	272.7	274.2	275.8	15.3	.337
2.9	277.3*	278.8	280.2	281.7	283.2	284.7	286.1	287.6	289.1	290.6	14.8	-.536
3.0	292.1	293.6	295.1	296.6	298.1	299.6	301.1	302.6	304.1	305.7	15.1	.266
3.1	307.2	308.7	310.2	311.7	313.3	314.8	316.3	317.9	319.4	321.0	15.3	.262
3.2	322.5*	323.9	325.2	326.6	328.0	329.3	330.7	332.1	333.4	334.8	13.7	-1.65
3.3	336.2	337.6	338.9	340.3	341.7	343.1	344.5	345.8	347.2	348.6	13.8	.146
3.4	350.0*	351.9	353.9	355.8	357.7	359.7	361.6	363.6	365.6	367.5	19.5	5.68
3.5	369.5	371.5	373.5	375.5	377.4	379.4	381.4	383.4	385.5	387.5	20.0	.491
3.6	389.5*	391.3	393.1	394.9	396.7	398.6	400.4	402.2	404.0	405.9	18.2	-1.79
3.7	407.7	409.5	411.4	413.2	415.1	416.9	418.8	420.6	422.5	424.4	18.5	.331
3.8	426.2	428.1	430.0	431.9	433.7	435.6	437.5	439.4	441.3	443.2	18.9	.328
3.9	445.1	447.0	448.9	450.8	452.7	454.6	456.6	458.5	460.4	462.3	19.2	.325
4.0	464.3	466.2	468.2	470.1	472.0	474.0	475.9	477.9	479.9	481.8	19.5	.323
4.1	483.8	485.8	487.7	489.7	491.7	493.7	495.6	497.6	499.6	501.6	19.8	.320
4.2	503.6	505.6	507.6	509.6	511.6	513.7	515.7	517.7	519.7	521.7	20.1	.317
4.3	523.8	525.8	527.8	529.9	531.9	534.0	536.0	538.1	540.1	542.2	20.5	.315
4.4	544.2	546.3	548.4	550.4	552.5	554.6	556.7	558.7	560.8	562.9	20.8	.313
4.5	565.0*	567.0	569.1	571.1	573.1	575.2	577.2	579.3	581.3	583.4	20.5	-.322
4.6	585.5	587.5	589.6	591.6	593.7	595.8	597.9	599.9	602.0	604.1	20.7	.277
4.7	606.2	608.3	610.4	612.5	614.5	616.6	618.7	620.9	623.0	625.1	21.0	.274
4.8	627.2	629.3	631.4	633.5	635.7	637.8	639.9	642.0	644.2	646.3	21.3	.272
4.9	648.5	650.6	652.7	654.9	657.0	659.2	661.4	663.5	665.7	667.8	21.5	.270

12/29/15 07:58

ORANGE COUNTY WATER DISTRICT

#W2 Weir 2 2016 WY

Rating Table 2 from 07/01/2016 00:00

Scale Offset = 261.16

To 1929 datum

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
261.1							0*	1.05	2.10	3.15		
261.2	4.20	5.25	6.30	7.35	8.40	9.45	10.5*	12.1	13.8	15.6	13.2	
261.3	17.4	19.3	21.3	23.3	25.4	27.6	29.8*	32.1	34.4	36.7	21.7	8.52
261.4	39.2	41.6	44.2	46.7	49.3	52.0	54.7	57.5	60.3	63.1	26.8	5.10
261.5	66.0	68.9	71.9	74.9	78.0	81.1	84.2*	87.4	90.6	93.9	31.2	4.32
261.6	97.2	100.5	103.9	107.3	110.7	114.2	117.7	121.3	124.9	128.5	35.0	3.83
261.7	132.1	135.8	139.6	143.3	147.1	150.9	154.8*	158.7	162.6	166.6	38.4	3.40
261.8	170.5	174.5	178.6	182.7	186.8	190.9	195.1	199.3	203.5	207.7	41.5	3.09
261.9	212.0	216.3	220.7	225.0	229.4	233.8	238.3*	242.8	247.3	251.8	44.4	2.90
262.0	256.4	261.0	265.6	270.2	274.9	279.6	284.3	289.1	293.9	298.7	47.1	2.72
262.1	303.5	308.3	313.2	318.1	323.1	328.0	333.0*	338.0	343.0	348.1	49.7	2.57
262.2	353.2	358.3	363.4	368.6	373.7	378.9	384.2	389.4	394.7	400.0	52.1	2.45
262.3	405.3	410.6	416.0	421.4	426.8	432.2	437.7*	443.2	448.7	454.2	54.5	2.35
262.4	459.8	465.3	470.9	476.6	482.2	487.9	493.6	499.3	505.0	510.7	56.7	2.26
262.5	516.5	522.3	528.1	534.0	539.8	545.7	551.6*	557.5	563.5	569.4	58.9	2.15
262.6	575.4	581.4	587.4	593.5	599.5	605.6	611.7	617.9	624.0	630.2	61.0	2.06
262.7	636.4	642.6	648.8	655.0	661.3	667.6	673.9*	680.2	686.6	693.0	63.0	2.03
262.8	699.3	705.8	712.2	718.6	725.1	731.6	738.1	744.6	751.2	757.7	65.0	1.98
262.9	764.3	770.9	777.5	784.2	790.8	797.5	804.2*	810.9	817.6	824.4	66.9	1.89
263.0	831.2	837.9	844.7	851.6	858.4	865.3	872.1	879.0	886.0	892.9	68.7	1.82
263.1	899.8	906.8	913.8	920.8	927.8	934.8	941.9*					

* skeletal rating point

Top of wing wall at stilling well
269.90 msL (1988)
266.66 msL (1929) district uses

measure down to water to
get current level.

[redacted]

02/28/11 11:11

ORANGE COUNTY WATER DISTRICT

[redacted] WEIR-3

Rating Table 2 from 07/01/2009 00:00 Scale Offset = 257.74

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
257.7					0*	.473	.946	1.42	1.89	2.37		
257.8	2.84	3.31	3.78	4.26	4.73*	5.43	6.16	6.91	7.70	8.51	6.50	
257.9	9.34	10.2	11.1	12.0	12.9*	13.9	15.0	16.1	17.2	18.4	10.2	3.75
258.0	19.6	20.8	22.0	23.3	24.6*	25.8	27.1	28.4	29.7	31.0	12.7	2.46
258.1	32.3	33.6	35.0	36.4	37.8*	39.2	40.7	42.2	43.6	45.1	14.4	1.65
258.2	46.7	48.2	49.7	51.3	52.9*	54.5	56.1	57.7	59.4	61.0	16.0	1.66
258.3	62.7	64.4	66.1	67.8	69.5*	71.2	73.0	74.8	76.5	78.3	17.5	1.43
258.4	80.1	82.0	83.8	85.6	87.5*	89.4	91.3	93.2	95.1	97.1	18.9	1.45
258.5	99.0	101.0	103.0	105.0	107.0*	109.0	111.1	113.2	115.2	117.3	20.4	1.50
258.6	119.4	121.6	123.7	125.8	128.0*	130.1	132.1	134.2	136.3	138.4	21.0	.634
258.7	140.5	142.6	144.7	146.9	149.0*	151.2	153.5	155.8	158.1	160.4	22.2	1.15
258.8	162.7	165.0	167.3	169.7	172.0*	174.4	176.7	179.1	181.5	183.9	23.6	1.42
258.9	186.3	188.7	191.1	193.6	196.0*	198.5	201.1	203.7	206.3	208.9	25.2	1.58
259.0	211.5	214.1	216.7	219.3	222.0*	225.0	228.1	231.1	234.2	237.3	28.9	3.74
259.1	240.4	243.5	246.7	249.8	253.0*	256.2	259.5	262.7	266.0	269.3	32.2	3.27
259.2	272.6	275.9	279.3	282.6	286.0*	289.5	293.0	296.6	300.2	303.8	34.8	2.58
259.3	307.4	311.0	314.6	318.3	322.0*	323.8	325.6	327.4	329.2	331.0	25.4	-9.33
259.4	332.8	334.6	336.4	338.2	340.0*	342.0	344.0	346.0	348.0	350.0	19.2	-6.26
259.5	352.0	354.0	356.0	358.0	360.0*	363.9	367.8	371.8	375.8	379.7	31.8	12.6
259.6	383.8	387.8	391.8	395.9	400.0*	404.0	408.0	412.1	416.2	420.3	40.6	8.86
259.7	424.4	428.5	432.6	436.8	441.0*	445.3	449.6	454.0	458.4	462.7	42.8	2.16
259.8	467.2	471.6	476.0	480.5	485.0*	489.4	493.8	498.3	502.8	507.3	44.6	1.83
259.9	511.8	516.3	520.8	525.4	530.0*	534.5	539.1	543.6	548.2	552.8	45.6	.997
260.0	557.4	562.0	566.7	571.3	576.0*	580.6	585.3	589.9	594.6	599.3	46.6	.998
260.1	604.0	608.7	613.5	618.2	623.0*							

* skeletal rating point

08/07/03 23:28

ORANGE COUNTY WATER DISTRICT

#FIBS-1 BURRIS PIT INFLOW

2000 WY

Rating Table 3 from 10/01/1999 00:00

Scale Offset = 3.20

RATING SOURCE IS USGS, TWRI

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
3.2									0*	.280		
3.3	.560	.840	1.12	1.40	1.68	1.96	2.24	2.52	2.80	3.08	2.80	
3.4	3.36	3.64	3.92	4.20	4.48	4.76	5.04	5.32	5.60	5.88	2.80	-0
3.5	6.16	6.44	6.72	7.00	7.28	7.56	7.84	8.12	8.40*	8.84	3.13	.332
3.6	9.29	9.75	10.2	10.7	11.2	11.7	12.2	12.8	13.3*	13.8	5.09	1.96
3.7	14.4	14.9	15.5	16.1	16.7	17.3	17.9	18.5	19.1*	19.7	5.93	.845
3.8	20.3	20.9	21.6	22.2	22.8	23.5	24.2	24.8	25.5*	26.2	6.56	.629
3.9	26.9	27.6	28.3	29.0	29.7	30.5	31.2	31.9	32.7*	33.4	7.31	.746
4.0	34.2	34.9	35.7	36.5	37.2	38.0	38.8	39.6	40.4*	41.2	7.86	.551
4.1	42.0	42.9	43.7	44.6	45.4	46.3	47.1	48.0	48.9*	49.8	8.60	.746
4.2	50.6	51.5	52.4	53.3	54.2	55.1	56.0	57.0	57.9*	58.8	9.09	.482
4.3	59.7	60.7	61.6	62.5	63.5	64.4	65.4	66.3	67.3	68.3	9.53	.441
4.4	69.3	70.2	71.2	72.2	73.2	74.2	75.3	76.3	77.3*	78.3	10.1	.578
4.5	79.4	80.4	81.5	82.5	83.6	84.6	85.7	86.8	87.9	89.0	10.7	.579
4.6	90.1	91.2	92.3	93.4	94.5	95.6	96.7	97.9	99.0*	100.1	11.2	.545
4.7	101.3	102.4	103.6	104.8	105.9	107.1	108.3	109.4	110.6	111.8	11.7	.513
4.8	113.0	114.2	115.4	116.7	117.9	119.1	120.3	121.6	122.8*	124.0	12.2	.466
4.9	125.2	126.5	127.7	128.9	130.2	131.4	132.7	133.9	135.2	136.4	12.5	.252
5.0	137.7	139.0	140.2	141.5	142.8	144.1	145.4	146.7	148.0*	149.3	12.9	.489
5.1	150.6	152.0	153.3	154.7	156.0	157.3	158.7	160.1	161.4	162.8	13.5	.561
5.2	164.2	165.5	166.9	168.3	169.7	171.1	172.5	173.9	175.3*	176.7	13.9	.424
5.3	178.1	179.5	180.9	182.3	183.7	185.1	186.6	188.0	189.4	190.9	14.2	.286
5.4	192.3	193.8	195.2	196.7	198.1	199.6	201.1	202.5	204.0*	205.5	14.7	.483
5.5	207.0	208.5	210.1	211.6	213.1	214.6	216.2	217.7	219.3	220.8	15.4	.662
5.6	222.4	223.9	225.5	227.1	228.7	230.2	231.8	233.4	235.0*	236.6	15.7	.374
5.7	238.1	239.7	241.3	242.8	244.4	246.0	247.6	249.2	250.8	252.4	15.9	.139
5.8	254.0	255.6	257.2	258.9	260.5	262.1	263.7	265.4	267.0*	268.6	16.2	.369
5.9	270.3	271.9	273.5	275.2	276.8	278.5	280.1	281.8	283.4	285.1	16.5	.265
6.0	286.8	288.4	290.1	291.8	293.5	295.2	296.9	298.6	300.3	302.0	16.9	.376
6.1	303.7	305.4	307.1	308.8	310.5	312.2	314.0	315.7	317.4	319.2	17.3	.372
6.2	320.9	322.7	324.4	326.2	327.9	329.7	331.5	333.2	335.0*	336.8	17.7	.396
6.3	338.6	340.4	342.2	344.0	345.8	347.6	349.4	351.2	353.1	354.9	18.1	.484
6.4	356.7	358.6	360.4	362.2	364.1	365.9	367.8	369.6	371.5	373.4	18.5	.369
6.5	375.2	377.1	379.0	380.9	382.7	384.6	386.5	388.4	390.3	392.2	18.9	.365
6.6	394.1	396.0	397.9	399.8	401.8	403.7	405.6	407.5	409.5	411.4	19.2	.361
6.7	413.4	415.3	417.2	419.2	421.1	423.1	425.1	427.0	429.0*	431.0	19.6	.327
6.8	432.9	434.9	436.8	438.8	440.8	442.8	444.8	446.7	448.7	450.7	19.8	.227
6.9	452.7	454.7	456.7	458.7	460.7	462.7	464.7	466.8	468.8	470.8	20.1	.341
7.0	472.8	474.9	476.9	478.9	481.0	483.0	485.1	487.1	489.2	491.3	20.5	.337
7.1	493.3	495.4	497.4	499.5	501.6	503.7	505.8	507.8	509.9	512.0	20.8	.334
7.2	514.1	516.2	518.3	520.4	522.5	524.6	526.8	528.9	531.0*	533.1	21.1	.323
7.3	535.2	537.4	539.5	541.6	543.8	545.9	548.1	550.2	552.4	554.5	21.4	.295
7.4	556.7	558.8	561.0	563.2	565.3	567.5	569.7	571.9	574.0	576.2	21.7	.323
7.5	578.4	580.6	582.8	585.0	587.2	589.4	591.6	593.8	596.0	598.3	22.1	.320
7.6	600.5	602.7	604.9	607.2	609.4	611.6	613.9	616.1	618.4	620.6	22.4	.318
7.7	622.9	625.1	627.4	629.6	631.9	634.2	636.4	638.7	641.0*	643.3	22.7	.321
7.8	645.6	647.9	650.2	652.5	654.8	657.1	659.4	661.7	664.0	666.3	23.0	.338
7.9	668.6	670.9	673.3	675.6	677.9	680.3	682.6	684.9	687.3	689.6	23.4	.311
8.0	692.0	694.3	696.7	699.0	701.4	703.8	706.1	708.5	710.9	713.3	23.7	.309
8.1	715.6	718.0	720.4	722.8	725.2	727.6	730.0	732.4	734.8	737.2	24.0	.307

08/07/03 23:28

ORANGE COUNTY WATER DISTRICT

#FIBS-1 BURRIS PIT INFLOW (Flume) 2000 WY

Rating Table 3 from 10/01/1999 00:00 Scale Offset = 3.20

RATING SOURCE IS USGS, TWRI

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
3.2									0*	.280		
3.3	.560	.840	1.12	1.40	1.68	1.96	2.24	2.52	2.80	3.08	2.80	
3.4	3.36	3.64	3.92	4.20	4.48	4.76	5.04	5.32	5.60	5.88	2.80	-0
3.5	6.16	6.44	6.72	7.00	7.28	7.56	7.84	8.12	8.40*	8.84	3.13	.332
3.6	9.29	9.75	10.2	10.7	11.2	11.7	12.2	12.8	13.3*	13.8	5.09	1.96
3.7	14.4	14.9	15.5	16.1	16.7	17.3	17.9	18.5	19.1*	19.7	5.93	.845
3.8	20.3	20.9	21.6	22.2	22.8	23.5	24.2	24.8	25.5*	26.2	6.56	.629
3.9	26.9	27.6	28.3	29.0	29.7	30.5	31.2	31.9	32.7*	33.4	7.31	.746
4.0	34.2	34.9	35.7	36.5	37.2	38.0	38.8	39.6	40.4*	41.2	7.86	.551
4.1	42.0	42.9	43.7	44.6	45.4	46.3	47.1	48.0	48.9*	49.8	8.60	.746
4.2	50.6	51.5	52.4	53.3	54.2	55.1	56.0	57.0	57.9*	58.8	9.09	.482
4.3	59.7	60.7	61.6	62.5	63.5	64.4	65.4	66.3	67.3	68.3	9.53	.441
4.4	69.3	70.2	71.2	72.2	73.2	74.2	75.3	76.3	77.3*	78.3	10.1	.578
4.5	79.4	80.4	81.5	82.5	83.6	84.6	85.7	86.8	87.9	89.0	10.7	.579
4.6	90.1	91.2	92.3	93.4	94.5	95.6	96.7	97.9	99.0*	100.1	11.2	.545
4.7	101.3	102.4	103.6	104.8	105.9	107.1	108.3	109.4	110.6	111.8	11.7	.513
4.8	113.0	114.2	115.4	116.7	117.9	119.1	120.3	121.6	122.8*	124.0	12.2	.466
4.9	125.2	126.5	127.7	128.9	130.2	131.4	132.7	133.9	135.2	136.4	12.5	.252
5.0	137.7	139.0	140.2	141.5	142.8	144.1	145.4	146.7	148.0*	149.3	12.9	.489
5.1	150.6	152.0	153.3	154.7	156.0	157.3	158.7	160.1	161.4	162.8	13.5	.561
5.2	164.2	165.5	166.9	168.3	169.7	171.1	172.5	173.9	175.3*	176.7	13.9	.424
5.3	178.1	179.5	180.9	182.3	183.7	185.1	186.6	188.0	189.4	190.9	14.2	.286
5.4	192.3	193.8	195.2	196.7	198.1	199.6	201.1	202.5	204.0*	205.5	14.7	.483
5.5	207.0	208.5	210.1	211.6	213.1	214.6	216.2	217.7	219.3	220.8	15.4	.662
5.6	222.4	223.9	225.5	227.1	228.7	230.2	231.8	233.4	235.0*	236.6	15.7	.374
5.7	238.1	239.7	241.3	242.8	244.4	246.0	247.6	249.2	250.8	252.4	15.9	.139
5.8	254.0	255.6	257.2	258.9	260.5	262.1	263.7	265.4	267.0*	268.6	16.2	.369
5.9	270.3	271.9	273.5	275.2	276.8	278.5	280.1	281.8	283.4	285.1	16.5	.265
6.0	286.8	288.4	290.1	291.8	293.5	295.2	296.9	298.6	300.3	302.0	16.9	.376
6.1	303.7	305.4	307.1	308.8	310.5	312.2	314.0	315.7	317.4	319.2	17.3	.372
6.2	320.9	322.7	324.4	326.2	327.9	329.7	331.5	333.2	335.0*	336.8	17.7	.396
6.3	338.6	340.4	342.2	344.0	345.8	347.6	349.4	351.2	353.1	354.9	18.1	.484
6.4	356.7	358.6	360.4	362.2	364.1	365.9	367.8	369.6	371.5	373.4	18.5	.369
6.5	375.2	377.1	379.0	380.9	382.7	384.6	386.5	388.4	390.3	392.2	18.9	.365
6.6	394.1	396.0	397.9	399.8	401.8	403.7	405.6	407.5	409.5	411.4	19.2	.361
6.7	413.4	415.3	417.2	419.2	421.1	423.1	425.1	427.0	429.0*	431.0	19.6	.327
6.8	432.9	434.9	436.8	438.8	440.8	442.8	444.8	446.7	448.7	450.7	19.8	.227
6.9	452.7	454.7	456.7	458.7	460.7	462.7	464.7	466.8	468.8	470.8	20.1	.341
7.0	472.8	474.9	476.9	478.9	481.0	483.0	485.1	487.1	489.2	491.3	20.5	.337
7.1	493.3	495.4	497.4	499.5	501.6	503.7	505.8	507.8	509.9	512.0	20.8	.334
7.2	514.1	516.2	518.3	520.4	522.5	524.6	526.8	528.9	531.0*	533.1	21.1	.323
7.3	535.2	537.4	539.5	541.6	543.8	545.9	548.1	550.2	552.4	554.5	21.4	.295
7.4	556.7	558.8	561.0	563.2	565.3	567.5	569.7	571.9	574.0	576.2	21.7	.323
7.5	578.4	580.6	582.8	585.0	587.2	589.4	591.6	593.8	596.0	598.3	22.1	.320
7.6	600.5	602.7	604.9	607.2	609.4	611.6	613.9	616.1	618.4	620.6	22.4	.318
7.7	622.9	625.1	627.4	629.6	631.9	634.2	636.4	638.7	641.0*	643.3	22.7	.321
7.8	645.6	647.9	650.2	652.5	654.8	657.1	659.4	661.7	664.0	666.3	23.0	.338
7.9	668.6	670.9	673.3	675.6	677.9	680.3	682.6	684.9	687.3	689.6	23.4	.311
8.0	692.0	694.3	696.7	699.0	701.4	703.8	706.1	708.5	710.9	713.3	23.7	.309
8.1	715.6	718.0	720.4	722.8	725.2	727.6	730.0	732.4	734.8	737.2	24.0	.307

Appendix A-9

Dewatering Pump Operations

Basin Dewatering Pump Operation

When and Why: Basins are dewatered in the spring in preparation of imported water deliveries and in the fall in preparation of receiving Santa Ana River storm water. Basins are drained using dewatering pumps and cleaned using heavy equipment. Pump preventative maintenance and repairs are also completed during these down times.

There is a possibility of fish die-off when a basin water level is lowered substantially. Certain fish die-off will occur at Warner, Burris, and Santiago basins when basin levels are lowered substantially or completely. Likely, a fish die-off will occur at Anaheim Lake and Kraemer Basin when basins are dewatered. A dead fish removal plan is needed and the Public Relations Department should be notified.

Basin dewatering pumps can be operated locally from a control panel located in the basins control house or remotely (except La Jolla Basin) using SCADA. In the control house each pump has a designated panel containing a HOA dial, pump alarm indicator lights, hour meter and power disconnect switch. This document contains pictures of each basins pump panels and specific instructions of how to operate each pump station.

If you turn a HOA dial from the “Hand” position while the pump is running, the pump will stop. Before you leave the pump panel the HOA dial needs to be placed in the “Auto” position if you want to have control of the pump remotely. If you leave the panel with the pump running in “Hand” you will have to return to the pump control panel to stop the pump.

Before starting a pump, make sure downstream valves are open to receive the pumped flow.

To run a pump locally, turn the HOA dial to the “Hand” position (also referred to as Local or Manual). Press the “Start” button. In “Hand” the pump will not stop running until the HOA dial is turned to the “OFF” position. Do not use the E-STOP button to stop the pump unless an emergency. If the E-STOP is pressed, the pump stops abruptly and the MOV for the pump will not close which will cause a water hammer. Water hammer could damage the pipe and pump.

Each pump has its own discharge valve that opens after the pump starts and closes before the pump stops. The valve operates automatically and is there to prevent the pump impeller from spinning in reverse and flow from re-entering the basin. There are no check valves on discharge lines so the water column between the pump at the bottom of the basin (pump sump) and the discharge valve at the top of slope will re-enter the sump when pump is stopped.

To run a pump remotely, turn the HOA dial on the pump panel to the “Auto” position (also referred as Remote or SCADA). You can start and stop the pump using SCADA from a designated laptop or the SCADA Room computer in the FHQ office. On the computer select the basin site and go to the control screen. The control screen will indicate the position of the HOA dial. There you will see the pumps available to run indicated by the word “Remote” in green. Pumps that are in “Local” blinking in red or “Failed” in yellow are unavailable to control using SCADA. The pump controls on SCADA will have a “Start” and “Stop” button, low level setpoint and pump status display. The status displays indicates if the pump is in “Local” (Hand, Manual) in red or “Remote” (Auto, SCADA) in green and if the pump is Running (in green), “Stopped” (in red) or “Failed” (in yellow).

Warner Basin

Warner Basin is equipped with two identical 295 horsepower submersible pumps capable of removing approximately 25-40 cfs per pump. The pump sump is located at the invert of the basin across from the control house. The pump discharge flow is piped into the Little Warner Channel through flap gate valves. There are no check valves or MOV on the discharge lines. The downstream valving can be arranged to send flow to either the Off-River or the Miraloma Transfer Box (Anaheim Lake, Phase II Pipeline).

<u>Warner Basin Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the control house pump panel.

To start a pump, turn the HOA dial to “Hand” and press the “Start” button.

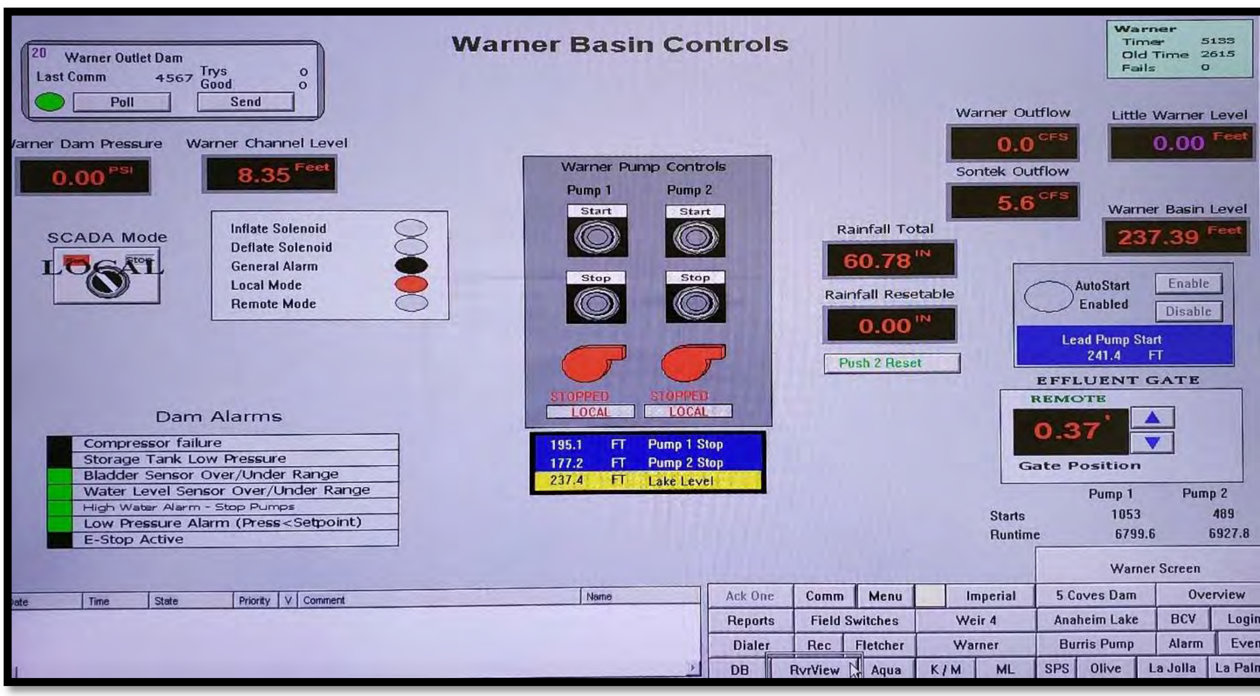
To stop a pump, press the “Stop” button.

Warner Basin Pump Control Panel

Warner Basin Dewatering Pump Operations: Remote Mode

For remote (Auto, SCADA) operations use the Warner Basin SCADA control screen. Before starting the pump in remote mode, verify the HOA is in “Remote” as indicated on the SCADA control screen. Make sure the low level setpoint (in blue) for the pump you want to run is below the current basin level (in yellow). The low level can be changed by clicking on the level and a pop-up box will appear. Enter the basin level you want the pump to shut off and press “OK”. You can either stop the pump by pressing the “Stop” button or you can set the level you wish to have the pump to stop at. Once the level reaches the low level setpoint the pump will shut off.

Warner Basin SCADA Control Screen



Anaheim Lake

Anaheim Lake is equipped with four identical 295 horsepower submersible pumps and one 300 horsepower vertical turbine pump capable of removing approximately 25–40 cfs per pump. The downstream valving can be arranged to send flow to Kraemer Basin, Miller Basin, Carbon Diversion and Carbon Creek. Each dewater pump discharge line has its own MOV that opens and closes automatically when the pump starts and stops. There are no check valves on these discharge lines.

The four submersible pumps discharge into the 42-inch pipe discharge line (manifold). The flow travels through the Anaheim Lake discharge valve and propeller flow meter then enters the 72-inch Phase 2 Pipeline. The Anaheim Lake Discharge valve must be opened (manually or using SCADA) prior to starting a pump. Before starting a second submersible pump, make sure the pipeline is full and stable. To check this, verify the discharge flow meter adds up to downstream metered flow.

The vertical turbine pump discharge line is independent of the submersible discharge line manifold and does not have a discharge valve. Discharged flow is metered by a propeller meter before it enters the 72-inch Phase 2 Pipeline. There is a maintenance butterfly valve on the vertical turbine discharge line that remains open for regular operations. The valve can be operated manually by using a “T” handle water valve key (for maintenance purposes only). The vertical turbine pump is operated when submersible pump dewatering is complete. The Heavy Equipment Operators build a sand dike between the submersible pump sump and the vertical turbine intake cage. Maintenance uses a trash pump to dewater the sump into the vertical turbine intake. When pumping this flow remotely you must have a person onsite to notify you when to stop the pump. The basin level sensor is located at the submersible pump sump and is not representative of the water level at the vertical turbine intake structure.

<u>Anaheim Lake Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the control house pump panel for the pump you want to run.

To start a submersible pump, turn the HOA dial to “Hand” and press the “Start” button.

To start the vertical turbine pump, place the HOA dial to “Hand” and the pump will start immediately.

To stop a pump, turn the HOA dial to “Off”. To prevent water hammer, do not use the “E-STOP” button to stop a pump unless an EMERGENCY!!! Submersible

Anaheim Lake Dewatering Pump Control Panels

Pump 1-3 (similar) | Pump 4 | Vertical Turbine

Pump Panel 4 has a master “Reset” button (black) used to reset all four-submersible pumps in conjunction with the individual pump “Reset" buttons (green) when power is restored.

<u>Anaheim Lake Dewatering Pump Operations: Remote Mode</u>

For remote (Auto, SCADA) operations use the Anaheim Lake SCADA control screen.

Before starting a pump in remote, verify the HOA is in “Remote” as indicated on the SCADA Control Screen. Make sure the low level setpoint (in blue) for the pump you want to run is below the current basin level (in yellow). The low level can be changed by clicking on the level (in blue) for the pump you want to run then a pop-up box will appear. Enter the basin level you want the pump to shut off at and press “OK”. In remote you can either stop the pump by pressing the “Stop” button or wait till the low level setpoint is reached. Before starting a second submersible pump, make sure the pipeline is full and stable. To check this, verify the discharge flow meter adds up to downstream metered flow.

Anaheim Lake SCADA Control Screen

Miller Basin

Miller Basin is equipped with two identical 100 horsepower submersible pumps capable of removing approximately 25-35 cfs per pump. The pump discharge flow is piped into the 42-inch Anaheim Pipeline (APL) and valves can be arranged to send flow to Kraemer Basin, Carbon Diversion, Carbon Creek and Anaheim Lake. Each dewater pump discharge line has it's a own MOV that opens and closes automatically when the pump starts and stops. There are no check valves on these discharge lines.

<u>Miller Basin Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the control house pump panel for the pump you want to run.

To start a pump, turn the HOA dial to "Hand" and press the "Start" button.

To stop a pump, place the HOA dial to "Off". To prevent water hammer, do not use the "E-STOP" to stop a pump unless an EMERGENCY!!!

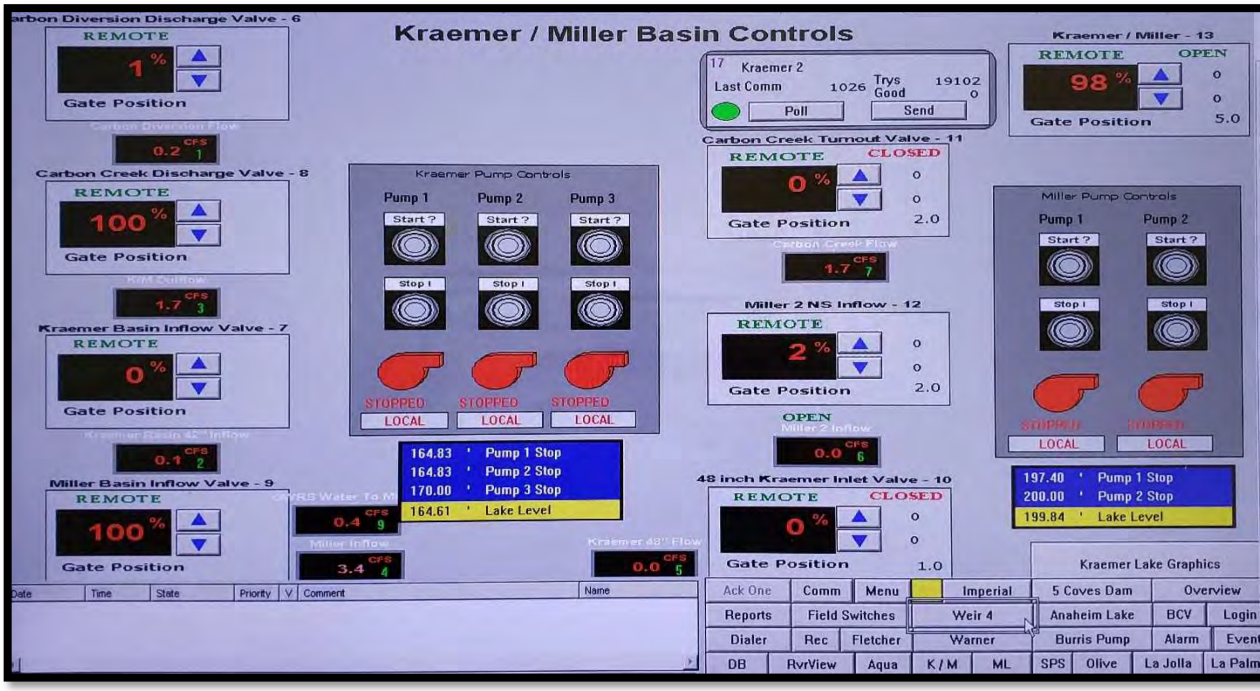
Miller Basin Pump Control Panel

Miller Basin Dewatering Pump Operations: Remote Mode

For remote (Auto, SCADA) operations use the Kraemer/Miller Basin SCADA control screen.

Before starting a pump in remote, verify the HOA is in “Remote” as indicated on the SCADA control screen. Make sure the low level setpoint (in blue) for the pump you want to run is below the current basin level (in yellow). The low level can be changed by clicking on the level (in blue) for the pump you want to run, then a pop-up box will appear. Enter the basin level you want the pump to shut off at and press “OK”. In remote you can either stop the pump by pressing the “Stop” button or wait till the low level setpoint is reached. Before starting a second submersible pump, make sure the pipeline is full and stable. To check this, verify the discharge flow meter adds up to downstream metered flow.

Kraemer/Miller Basin SCADA Control Screen



Kraemer Basin

Kraemer Basin is equipped with three identical 295 horsepower submersible pumps capable of discharging between 25-40 cfs per pump. The pump discharge flow is piped into the 42-inch APL (Anaheim Pipeline) and valves can be arranged to send flow to Miller Basin, Carbon Diversion, Carbon Creek and Anaheim Lake. Each dewater pump discharge line has its own MOV that opens and closes automatically when the pump starts and stops. There are no check valves on these discharge lines.

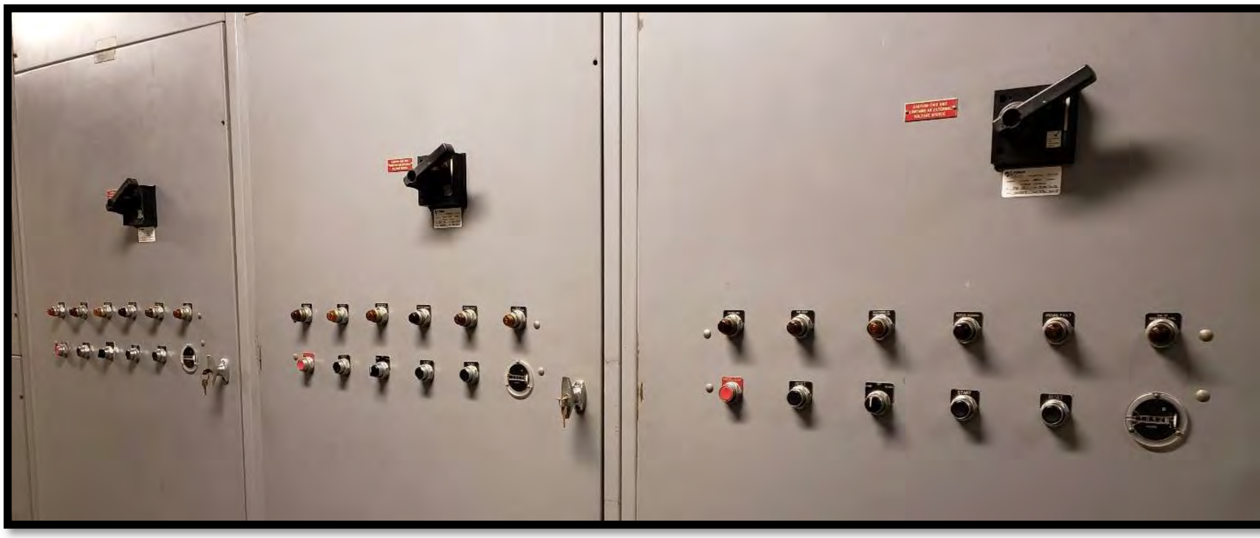
<u>Kraemer Basin Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the control house pump panel for the pump you want to run.

To start a pump, switch the HOA dial to “Hand” and press the “Start” button.

To stop a pump, place the HOA dial to “Off”. To prevent water hammer, do not use the “E-STOP” to stop a pump unless an EMERGENCY!!!

Kraemer Basin Pump Control Panel



Kraemer Basin Dewatering Pump Operations: Remote Mode

For remote (Auto, SCADA) operations use the Kraemer/Miller Basin SCADA control screen as discussed in the previous section focusing on remote mode operation of Miller Basin.

La Jolla Basin

La Jolla Basin is equipped with one small non-clog submersible pump located at the NW corner of the basin in the outlet structure capable of discharging less than 1 cfs. The pump discharge flow is piped to Carbon Creek through a flap gate valve.

There is a 10–inch gate valve that can be opened at the sump by manually turning the wheel or using the actuator controls by turning the HOA dial to “Local” and turn the dial to the “Open” position. Controls for the valve and the pump are located in the pump control box above outlet structure. Opening this 10-inch valve will evacuate water from the basin under gravity.

Although the pump status is visible on SCADA, remote functions are not available for the La Jolla pump operation.

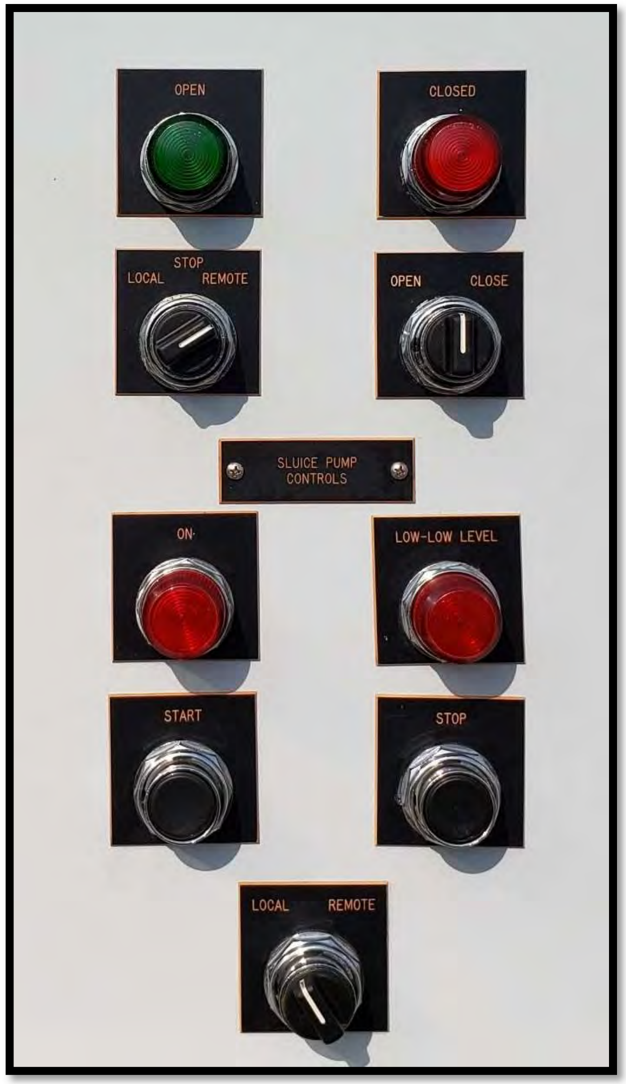
La Jolla Basin Dewatering Pump Operations: Local Mode (Only)

For local (Hand, Manual) operations use the pump panel located at the pump sump.

To start the pump, switch the dial to “Hand” and press the “Start” button.

To stop the pump, press the “Stop” button.

La Jolla Basin Pump Control Panel



Olive Basin

Olive Basin is equipped with one 30 horsepower submersible pump capable of removing approximately 5 cfs. The pump is in a concrete box with a metal grating lid located at the bottom of the basin. Pump discharge flow into the Off-River above the train bridge. There are no valves on the discharge line. The water column will return into the basin once the pump is stopped.

Olive Basin Dewatering Pump Operations: Local Mode

For local (Hand, Manual) operations use the pump panel located at the pump sump.

To start the pump, place the HOA dial either “Hand” or “Auto” and the pump will start immediately.

To stop the pump, turn the HOA dial to “Off”.

Olive Basin Pump Control Panel

Olive Basin Dewatering Pump Operations: Remote Mode

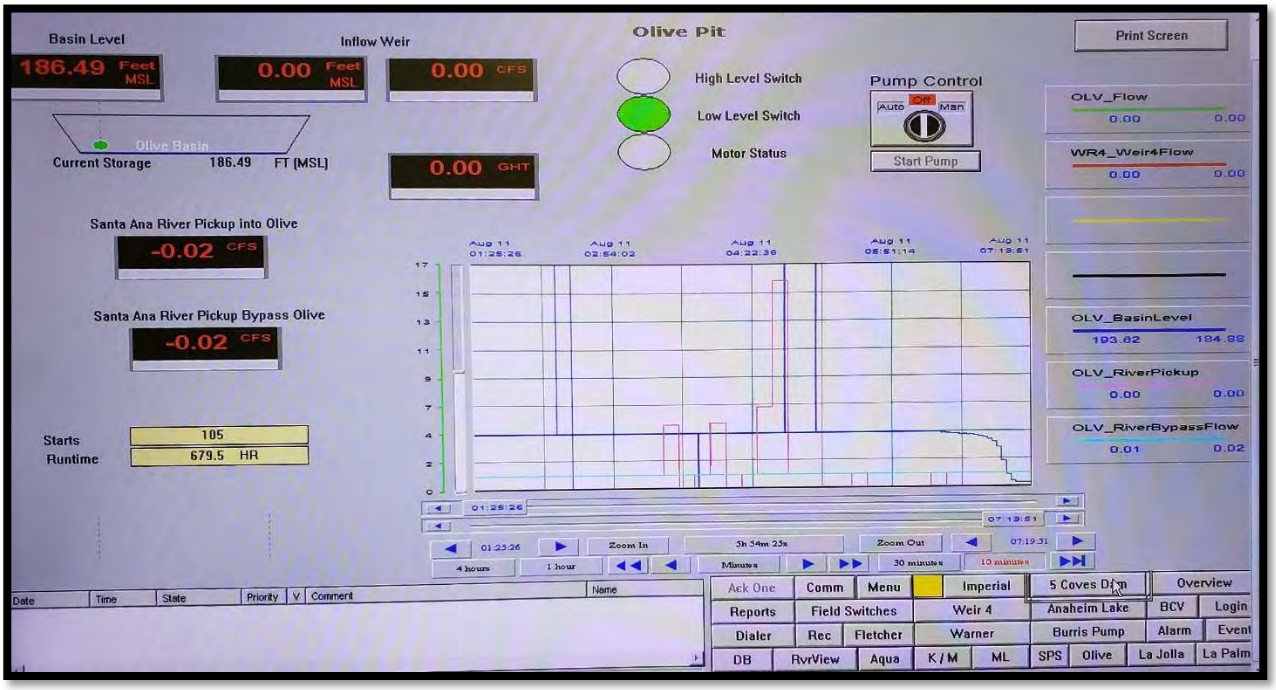
For remote (Auto, SCADA) operations use the Olive Basin SCADA Control Screen.

To start the pump, place the HOA dial in “Auto” and press the “Start” button or place the HOA dial to “Man” the pump will start immediately.

To stop the pump, turn the HOA dial to “Off”.

There are “high” and “low” level floats in the concrete box that will stop and start the pump automatically. To prevent the pump from continuously stopping and starting, monitor the level and stop the pump when the box is empty.

Olive Basin SCADA Control Screen



Burris Basin

Burris Basin is equipped with four 1750 hp vertical turbine pumps, two are equipped with soft start (pumps 1 & 4) and with two variable frequency drive (VFD) (pumps 2 & 3).

Before you start pumping confirm that the Santiago pumps are not operating, then verify that the Santiago 66-inch inflow valve is open to a minimum of 50%.

Prior to starting an additional pump, open the Santiago 66-inch inflow valve more to ensure the flow has no restriction into Santiago Basin.

The VFD pumps are used to start the pump station pumping and for stopping the pumping. Use either pump 2 or 3 to start the pumping. Check the discharge line pressure before starting a VFD pump. If the discharge line pressure is less than 45 psi the VFD must be started with the pump speed between 60 and 70. Once the line pressure reaches 45 psi, the VFD pump speed can be increased to 90. If the discharge line pressure is above 45 psi you can start a VFD at a speed of 70 to 90. With only one VFD running, the default top speed is 90. When a second pump is started and is running the VFD will increase its speed to 100. Once the VFD is running at a speed of 90 you can start a second pump. Once the second pump is running you can start another pump. Once the third pump is running you can start the fourth pump. After the first VFD is running the type (VFD or Soft Start) or order (#1, #2, #3, #4) of the following pumps does not matter.

Stopping Burris Pump Station Pumps

The pumps are to be stopped one at a time and waiting 5 minutes between stopping allows the surge tanks to readjust and the surge in the line pressure to dissipate. The line pressure can be observed on the SCADA trend screen remotely, locally on the discharge line pressure gauge. Surge tank levels can also be viewed in the field via looking glass on each surge tank. The only order that matters when stopping pumps is the *last pump to be stopped must be a VFD*.

Burris Basin Dewatering Pump Operations: Local Mode

The Burris Pump Station cannot operate while the Santiago Pump Station is running!

For local (Hand, Manual) operations use the control house pump panel.

To start a pump, turn the HOA dial to “Hand” and press the “Start” button.

To stop a pump, press the “Stop” button.

Soft Start Pump Control Panel

VFD Pump Control Panel

Burris Basin Dewatering Pump Operations: Remote Mode

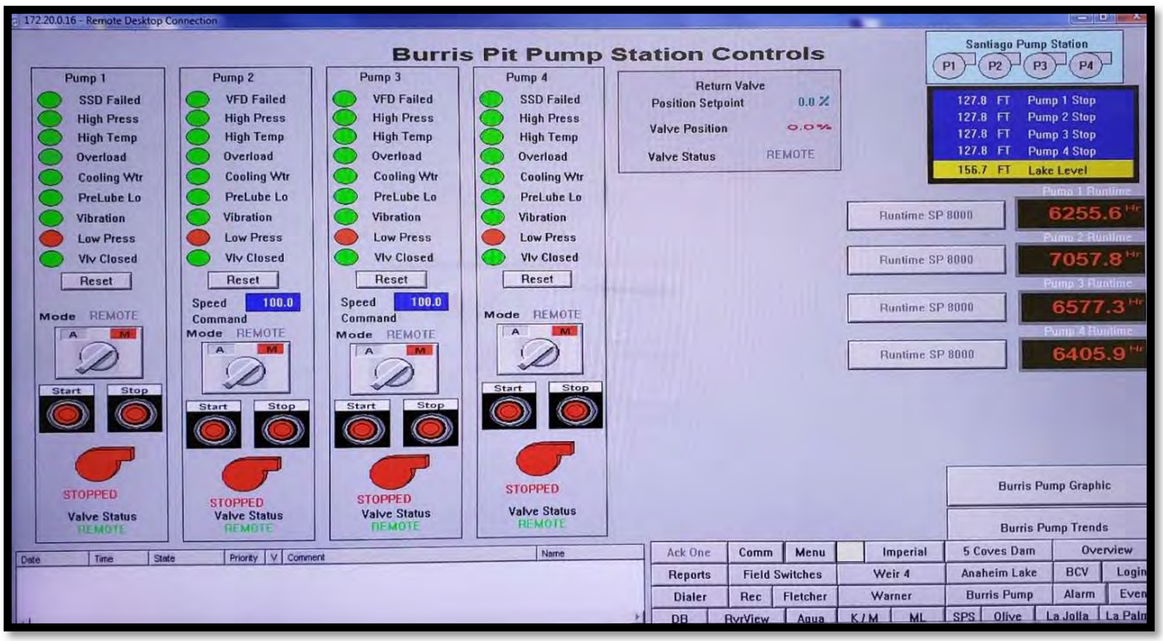
The Burris Pump Station cannot operate while the Santiago Pump Station is running!

For remote (Auto, SCADA) operations use the Burris Basin SCADA control screen. Look at the top right corner of the SCADA screen and confirm that the Santiago pumps are not operating. Before starting a pump in remote, verify the HOA is in “Auto (A)” as indicated on the SCADA Control Screen. Make sure the low level setpoint (in blue) for the pump you want to run is below the current basin level (in yellow). The low level can be changed by clicking on the level (in blue) for the pump you want to run then a pop-up box will appear. Enter the basin level you want the pump to shut off at and press “OK”. In remote you can either stop the pump by pressing the “Stop” button or wait till the low level setpoint is reached.

To start a pump, press the “Start” button. The pump will start immediately.

To stop the pump, press the “Stop” button.

Burris Basin SCADA Control Screen



Fletcher Basin

Fletcher Basin is equipped with two identical 7 horsepower submersible pumps capable of removing approximately 1 cfs per pump. The wet well has a manually operated (handwheel) slide gate valve located at the bottom of the stairs. This valve connects the basin to the wet well and it must remain open while pumps are running. The pump discharge flow is piped through a 12-inch PVC pipe to the Fletcher Channel at the south end of the basin and has no discharge valve. This is also where the basin overflows during high flow rain events.

<u>Fletcher Basin Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the Fletcher Basin pump control panel located in the green enclosure.

To start a pump, turn either pump dial to the “ON” position then place the HOA dial to “Local” and the pump will start immediately.

To stop the pump, turn the pump dial to the “Off” position.

Fletcher Basin Pump Control Panel (green enclosure)

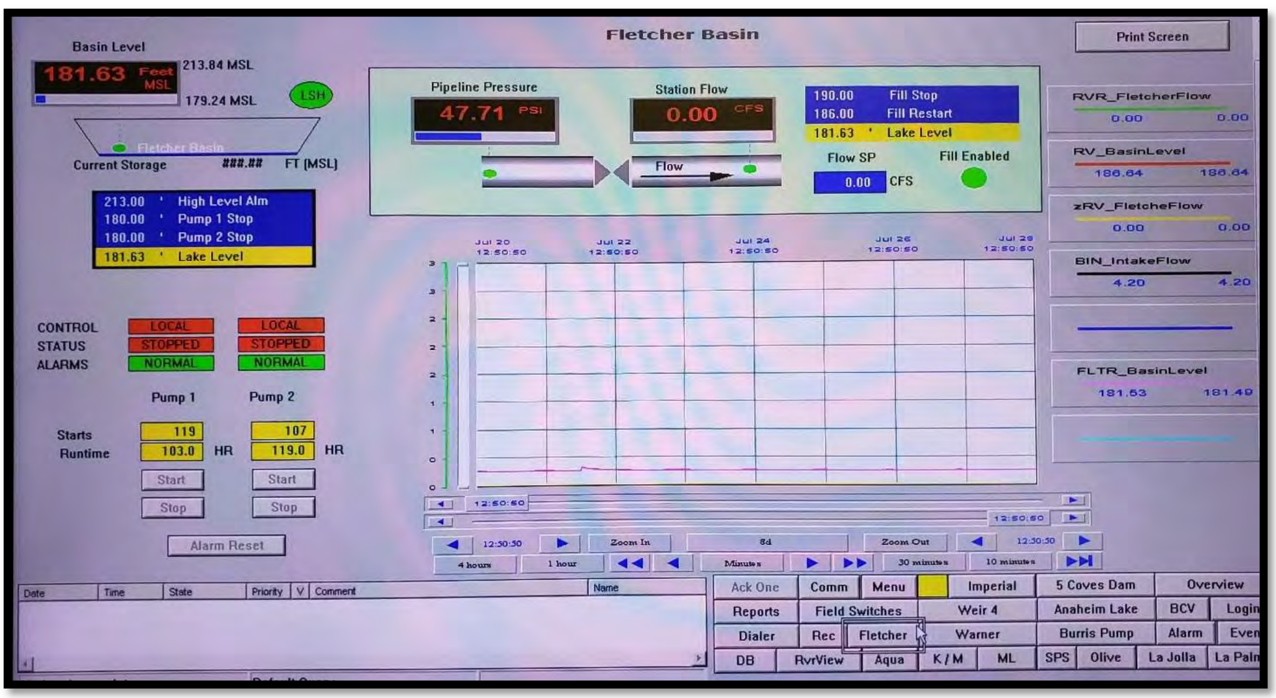
Fletcher Basin Dewatering Pump Operations: Remote Mode

For remote (Auto, SCADA) operations use the Fletcher Basin SCADA control screen. Before starting a pump in remote, verify the pump control is in "Remote" as indicated on the left side of the SCADA control screen. Make sure the low level setpoint (in blue) for the pump you want to run is below the current basin level (in yellow). The low level can be changed by clicking on the level (in blue) for the pump you want to run, then a pop-up box will appear. Enter the basin level you want the pump to shut off at and press "OK".

To start a pump, press the "Start" button. The pump will start immediately.

To stop the pump, press the "Stop" button or wait until the low level setpoint is reached and the pump will stop running.

Fletcher Basin SCADA Control Screen



Santiago Basin

Santiago pump station cannot operate while the Burris Pump Station is running!

Santiago Basin is equipped with two identical 450 horsepower vertical turbine pumps located on the floating pump station in the Bond Basin. Each pump is capable of removing approximately 15-30 cfs. The pump discharge flow is piped through a 36-inch HDPE pipe and into the 66-inch Burris/Santiago Pipeline. There is a 36-inch maintenance butterfly valve that must remain open during pumping. The valve is manually operated (handwheel) and located in a vault at the east side of the Santiago pump control building.

<u>Santiago Basin Dewatering Pump Operations: Local Mode</u>

Santiago pump station cannot operate while the Burris Pump Station is running!

For local (Hand, Manual) operations use the pump panel located in the Santiago Basin pump control building.

To start the pump, place the HOA dial to “Hand” and the pump will start immediately.

To stop the pump, turn the HOA dial to “Off”.

Santiago Basin Pump Control Panel

Santiago Basin Dewatering Pump Operations: Remote Mode

Santiago pump station cannot operate while the Burris Pump Station is running!

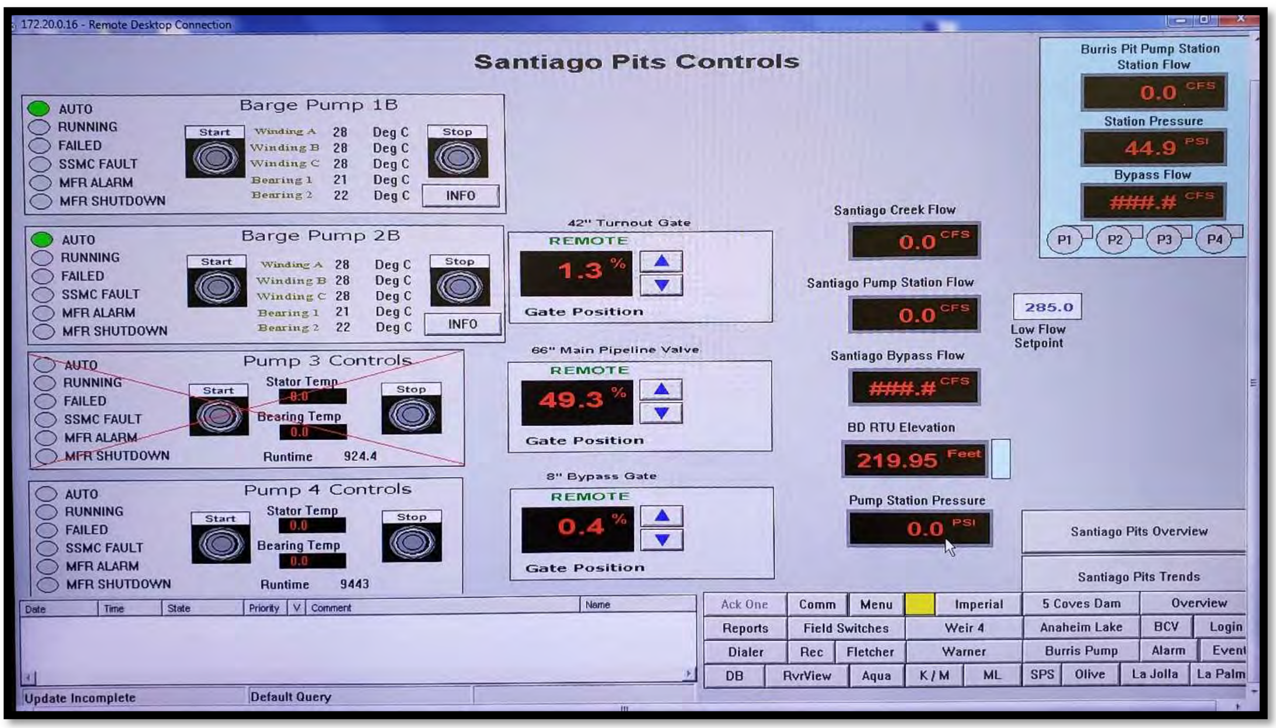
For remote (Auto, SCADA) operations use the Santiago Basin SCADA control screen. Check the upper right-hand corner (station flow box) and ensure that the Burris Pump Station is not pumping. Before starting a Santiago pump in remote, verify the pump control is in “Remote” as indicated on the SCADA control screen. There are no low level setpoints for these pumps.

To start a pump, press the “Start” button. The pump will start immediately.

To stop the pump, press the “Stop” button.

To clear alarms prior to starting a pump, press the “INFO” button and a pop-up window will appear. Press the “Reset” button and close the window.

Santiago Basin SCADA Control Screen



Miraloma Basin

Miraloma Basin is equipped with two identical 30 horsepower vertical turbine pumps capable of removing approximately 2-5 cfs per pump. The pump discharge flow is piped through a 12-inch pipe and remote operated butterfly valve into the GWRS supply pipeline or the Anaheim Lake Pipeline.

<u>Miraloma Basin Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the pump panel located in the Miraloma Basin pump control building.

To start the pump, switch the HOA dial to “Hand” and the pump will start immediately.

To stop the pump, switch the HOA dial to “Off”.

Miraloma Basin Pump Control Panel

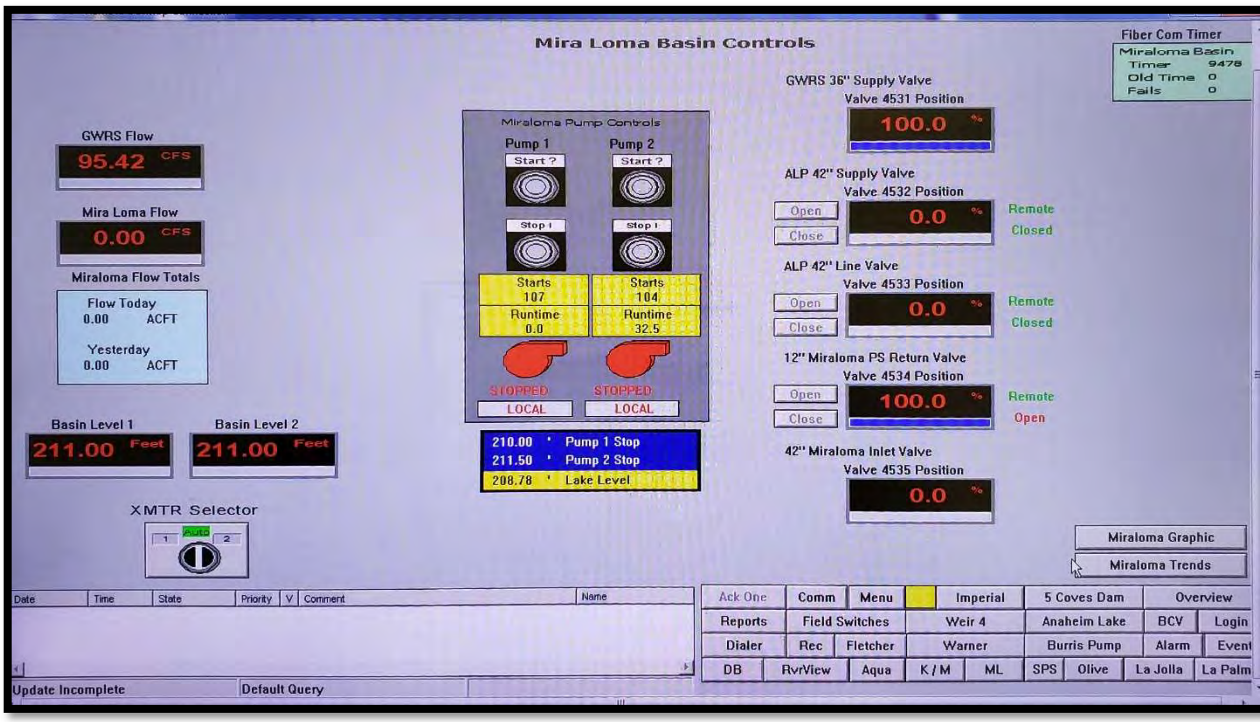
<u>Miraloma Basin Dewatering Pump Operations: Remote Mode</u>

For remote (Auto, SCADA) operations use the Miraloma Basin SCADA control screen. Before starting a pump in remote, verify the pump control is in “Remote” as indicated on the SCADA control screen. Make sure the low level setpoint (in blue) for the pump you want to run is below the current basin level (in yellow). The low level can be changed by clicking on the level (in blue) for the pump you want to run, then a pop-up box will appear. Enter the basin level you want the pump to shut off and press “OK”.

To start a pump, press the “Start” button. The pump will start immediately.

To stop the pump, press the “Stop” button or wait till the low level setpoint is reached and the pump will stop running.

Miraloma Basin SCADA Control Screen



La Palma Basin

La Palma Basin is equipped with one 60 horsepower vertical turbine pump capable of removing approximately 5-10 cfs per pump. The pump discharge flows through a 16-inch pipe and remotely operated plug valve into the GWRS supply pipeline.

<u>La Palma Basin Dewatering Pump Operations: Local Mode</u>

For local (Hand, Manual) operations use the pump panel located in the La Palma Basin pump control building.

To start the pump, place the HOA dial to “Hand” and the pump will start immediately.

To stop the pump, turn the HOA dial to “Off”.

La Palma Basin Pump Control Panel

Current Pump Control Panel Future Pump Control Panel

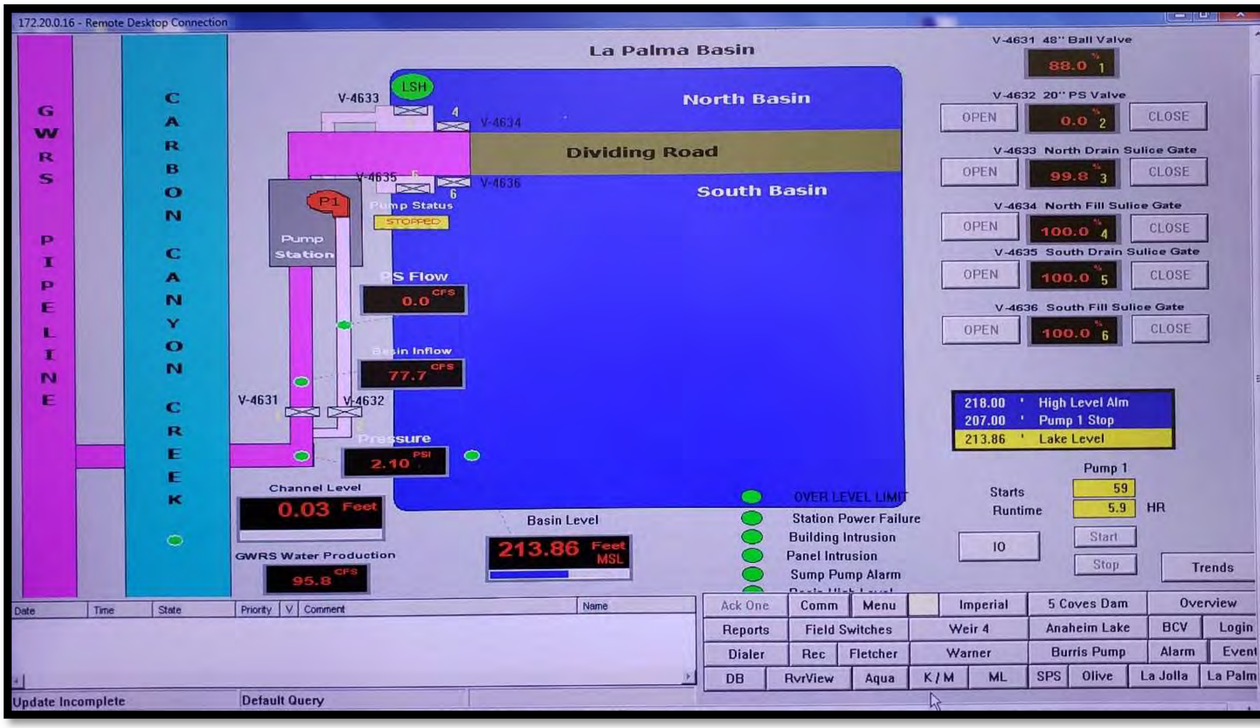
<u>La Palma Basin Dewatering Pump Operations: Remote Mode</u>

For remote (Auto, SCADA) operations use the La Palma Basin SCADA control screen. Before starting the pump in remote, verify the pump control is in “Remote” as indicated on the SCADA control screen. Make sure the low level setpoint (in blue) for the pump is below the current basin level (in yellow). The low level can be changed by clicking on the level (in blue) then a pop-up box will appear. Enter the basin level you want the pump to shut off and press “OK”.

To start a pump, press the “Start” button. The pump will start immediately.

To stop the pump, press the “Stop” button or wait till the low level setpoint is reached and the pump will stop running.

La Palma Basin SCADA Control Screen



Appendix A-10

Conrock Basin Pneumatic Drain Valve Operation

How to Operate the Conrock Drain Valves

1) Go to Conrock drain control boxes (Figure 1). They are located on the East side of the entrance road between Conrock and Warner basins.
2) Facing west you will be looking at the front of the boxes. To your right is the 24" valve control box and to your left is the 36" valve control box.
3) Unload the nitrogen cylinder from the back of truck and attach the regulator to the nitrogen cylinder. Back off low pressure side (left) of regulator until it reads zero by turning the gauge handle counterclockwise.
4) Attach blue hose from regulator to the quick connect protruding from the side of the valve control box (Figure 2) you wish to operate.
5) Open the cylinder 100% by turning the cylinder valve handle counterclockwise till it stops.
6) Next, adjust the low-pressure side of regulator by turning the regulator handle clockwise until the gauge reads 90 psi.
7) Open the valve control box and elect the action you want the valve to perform by putting the lever inside the box to either open or close.
    a. For the 24" drain valve (Figure 3), hold the valve body lever up for 30 seconds to open the valve or down for 30 seconds to close the valve.
    b. For the 36" drain valve (Figure 4), hold the valve body lever down for 40 seconds to open the valve or up for 35 seconds to close the valve.
8) After done opening/closing drain, back off low pressure side of the regulator by turning the handle counterclockwise till there is little resistance.
9) Close cylinder 100% by turning cylinder valve handle clockwise until it stops.
10) Disconnect blue regulator hose from quick connect on side of valve control box.
11) Press and hold end of blue hose against the surface of the valve control box to relieve any pressure in the line (do not press against skin to relieve pressure).
12) Remove regulator with blue hose from nitrogen cylinder.

Figure 1 Conrock Basin drain valve control boxes

<u>Figure 2</u> connecting the nitrogen cylinder regulator hose to the valve control box quick connect

Figure 3 24-inch drain control box

Figure 4 36-inch drain valve control box

Appendix A-11

Warner Outflow Channel Rubber Dam Operation

How to Operate the Warner Outflow Channel Rubber Dam

The Warner Outflow Channel Rubber Dam is operated when the Warner Bypass pipeline is sending flow around the Warner System and out the Warner Outflow Channel.

How to Inflate the Dam

1) Go to the Warner control house at the southwest corner of the basin and locate control panel (Figure 1).
2) Verify the control dial is turned to the “Local” position on the dam control unit (Figure 3).
3) Press inflate on the Allen Bradley touch screen HMI.
4) The compressor (Figure 2) will start running and the dam will inflate to 20 psi (setpoint)
5) Once the dam is inflated the compressor will continue to run until the compressor air tank is full.
6) Verify the dam is fully inflated by walking out to the Warner Outflow Channel (Figure 4) and the compressor stops running.

How to Deflate the Dam

1) Go to the Warner control house at the southwest corner of the basin.
2) Verify the control dial is turned to the “Local” position (Figure 1).
3) Press deflate on the Allen Bradley touch screen HMI.
4) The dam deflate valve will open and the dam will start to deflate.

Figure 1 Warner Dam HMI and compressor

Figure 2 Warner Dam compressor

Figure 3 Warner dam control panel

Figure 4 Warner Channel and dam location (deflated and under water)

Appendix A-12

OC-28 (Tubs) Weir Rating Table

04/02/18 13:00

ORANGE COUNTY WATER DISTRICT

#1 OC-28 2019 WY

04.03.2018 DH

Rating Table 1 from 04/02/2018 00:00

Scale Offset = 0.00

29' rating for weir with end contractions

DISCHARGE IN CUBIC FEET PER SECOND

ght	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	1st diff	2nd diff
1.3				0*	.305	.610	.915	1.22	1.53	1.83		
1.4	2.14	2.44	2.75	3.05*	3.39	3.78	4.20	4.66	5.17	5.74	4.22	
1.5	6.36	7.04	7.79	8.62*	9.17	9.76	10.4	11.0	11.7	12.5	6.87	2.65
1.6	13.2	14.0	14.9	15.8*	16.5	17.3	18.0	18.9	19.7	20.6	8.25	1.38
1.7	21.5	22.4	23.4	24.4*	25.2	26.1	27.0	27.9	28.9	29.8	9.36	1.11
1.8	30.8	31.9	32.9	34.0*	35.0	36.0	37.0	38.0	39.1	40.1	10.4	1.04
1.9	41.2	42.4	43.5	44.7*	45.8	46.9	48.0	49.1	50.2	51.4	11.4	.958
2.0	52.6	53.8	55.0	56.3*	57.5	58.6	59.8	61.0	62.3	63.5	12.2	.825
2.1	64.8	66.1	67.4	68.7*	69.9	71.2	72.5	73.8	75.1	76.4	13.0	.793
2.2	77.8	79.1	80.5	81.9*	83.2	84.6	85.9	87.3	88.7	90.1	13.8	.796
2.3	91.5	93.0	94.4	95.9*	97.4	99.0	100.5	102.1	103.7	105.3	15.4	1.67
2.4	107.0	108.6	110.3	112.0*	113.4	114.7	116.1	117.5	118.9	120.3	14.7	-.738
2.5	121.7	123.1	124.6	126.0*	127.5	129.1	130.7	132.2	133.8	135.4	15.4	.670
2.6	137.1	138.7	140.3	142.0*	143.6	145.3	147.0	148.6	150.3	152.0	16.7	1.32
2.7	153.8	155.5	157.2	159.0*	160.7	162.3	164.0	165.7	167.4	169.1	17.0	.318
2.8	170.8	172.5	174.2	176.0*	177.7	179.3	181.0	182.7	184.4	186.1	17.0	-.004
2.9	187.8	189.5	191.3	193.0*	194.8	196.7	198.6	200.5	202.4	204.3	18.4	1.37
3.0	206.2	208.1	210.0	212.0*	213.8	215.5	217.3	219.1	220.9	222.7	18.3	-.054
3.1	224.5	226.3	228.2	230.0*	232.0	233.9	235.9	237.9	239.9	241.9	19.4	1.06
3.2	243.9	245.9	248.0	250.0*	251.9	253.7	255.6	257.5	259.4	261.3	19.3	-.060
3.3	263.2	265.1	267.1	269.0*	271.0	272.9	274.9	276.9	278.9	280.9	19.7	.423
3.4	283.0	285.0	287.0	289.1	291.1	293.2	295.3	297.3	299.4	301.5	20.7	.924
3.5	303.6	305.7	307.9	310.0*	312.1	314.2	316.2	318.3	320.4	322.6	21.1	.384
3.6	324.7	326.8	329.0	331.1	333.3	335.4	337.6	339.8	341.9	344.1	21.7	.606
3.7	346.3	348.6	350.8	353.0*								

* skeletal rating point

Appendix A-13

La Jolla Basin Rubber Dam and Trash Rack Operation

How to Operate the La Jolla Rubber Dam

Local Mode

1. Go inside the La Jolla Basin Control House and open the control cabinet (Figure 1).
2. Place the DAM PLC MODE dial to the “Local” position (Figure 2).
3. To inflate the dam, turn the “Inflatable Dam Blower” silver sleeve to the right (behind the red knob) (Figure 3).
4. When you turn the silver sleeve, the red knob will pop out and the blower will start running. The blower light will turn on.
5. Go outside and watch the dam inflate (Figure 4).
6. The blower will automatically turn off when the dam is fully inflated.
7. To manually stop the inflation before its full inflated, push the red knob in, the blower will stop running and the blower light will turn off.
8. To deflate the dam, turn the “Deflation Valve” silver sleeve to the right (behind the red knob) (Figure 5).
9. The deflate valve will open and the dam will start deflating (Figure 6).
10. Go outside to the south side of the building and you can feel the air being removed from the dam (Figure 7).
11. When completely deflated push red knob to close the deflation valve.
12. You will hear the deflation valve close.

Figure 1 La Jolla control cabinet

Figure 2 Dam control panel

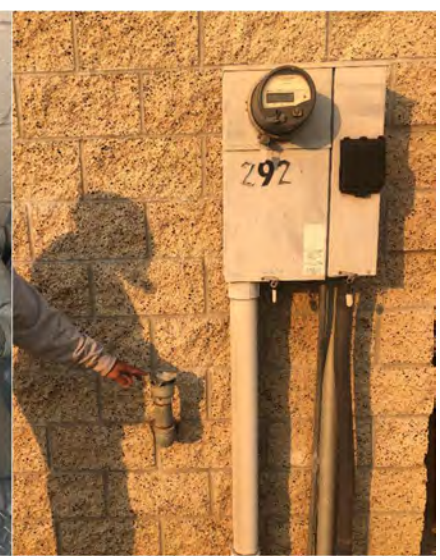
Figure 3 Inflatable Dam Blower control sleeve

Figure 4 La Jolla Rubber Dam inflating

Figure 5 Deflation Valve knob

Figure 6 Deflate Valve

Figure 7 Air discharge pipe



Remote Mode

1. Select La Jolla screen on SCADA (Figure 5).
2. Locate the Dam Control in the middle of the screen.
3. Place the Dam Control dial to either “Auto” or “Def”.
4. In the “Def” dial position the dam will deflate. The deflation valve will remain open until the Dam Control dial is placed in the “Off” position.
5. In the “Auto” position the dam will inflate until the pressure in the dam reaches the Pressure Setpoint (black box with yellow numbers below the Dam Control dial). The Pressure Setpoint is set for 2.51 psi. The pressure setpoint can be changed by pressing on the black box. A new value can be entered in the pop-up box.
6. The dam air pressure is regulated by the plc and will remain inflated until the Dam Control dial is placed in “Def” position.

Figure 8 La Jolla SCADA control screen

Figure 12 Dam Inflated

Figure 13 Dam Deflated

How to Operate the La Jolla Trash Rack

Local Mode

1. Open control panel box located on the West side of the trash rack (Figure 1).
2. Turn the Trash Screen dial to the “Hand” position (Figure 2). The trash rack will start immediately.
3. When all the pool debris is removed turn the trash screen dial to the “Off” position (Figure 3).
4. Rake up and place the debris in the dumpster. (Figure 4).
5. Once all trash is removed, turn the knob from “Off” to the “Auto” position.

Figure 1 Trash Rack Control Box

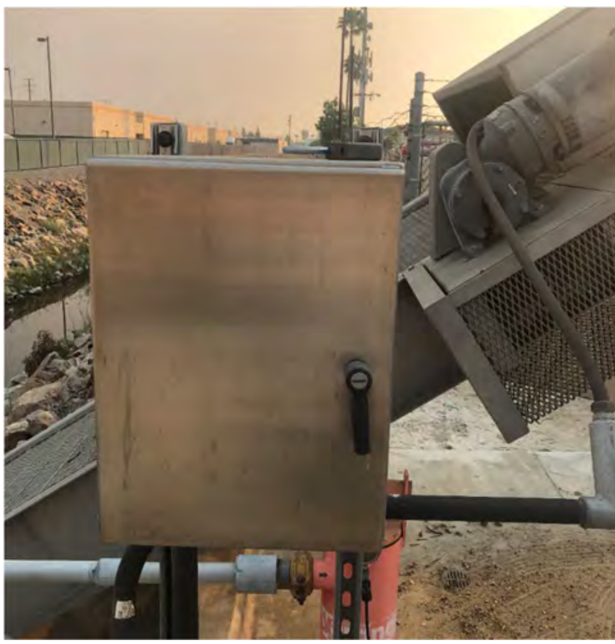
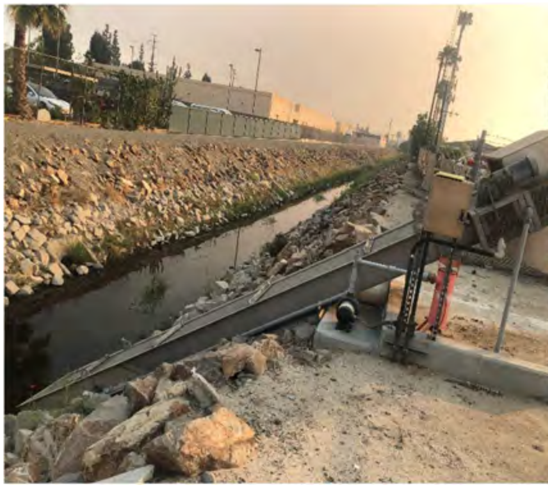


Figure 2 Trash Rack Control Panel

Figure 3 Carbon Creek looking East   Figure 4 Trash Rack debris pile



Remote Mode

7. Select La Jolla screen on SCADA (Figure 5).
8. Locate the Trash Rack Controls on top right of the screen.
9. Turn the Mode dial to either “Auto” or “Man”.
10. In the “Man” mode the trash rack will start immediately and run until the Mode dial is placed in the “Off” position.
11. In the “Auto” mode the trash rack is controlled by the “Interval” and “Duration” values in the “blue” boxes (to the right of the Mode dial). The trash rack will run for 7 minutes every 60 minutes until the Mode dial is turned to the “Off” position.
12. Turn the Mode dial to the “Off” position when the La Jolla Basin is off-line and the dam is deflated.

Appendix A-14

Placentia Basin Influent Valve Operation

How to Operate Placentia Basin Inflow Valve

1. Go to the Placentia Valve Control House located on the East side of the basin accessed from Placentia Avenue (Figure 1). OCFCD owns and maintains the channel, pipe, valve and basin.
2. Remove the nitrogen cylinder from the truck and place in the valve control house. Secure the cylinder with the yellow chain (Figure 2).
3. Connect the regulator to the cylinder.
4. Connect the green regulator hoses to the valve control box.
5. Open the nitrogen cylinder 100% by turning handle counterclockwise until it stops.
6. Make sure the nitrogen low pressure gauge (left side) is reading between 40 and 60 psi.
7. Place the Control Valve Lever to the desired position, "Open" or "Close" (Figure 3). You will hear the pressure stop when the valve has completed traveling to the desired position.
8. Place the valve control lever to the middle position and close the nitrogen cylinder.
9. Disconnect the green hoses from the valve control box.
10. Remove the regulator from the nitrogen cylinder.
11. When water is flowing in the Carbon Creek channel and you open the valve, you should see the flow where the pipe protrudes from the bottom of the channel overflow wing wall. There is also a remediation well that discharges flow from a pipe located at the top of the wall into the basin (Figure 4).
12. If the valve is open and you do not see flow, the inlet grating at the bottom of Carbon Creek channel is clogged with trash. Go down the ladder to the bottom of the channel and remove the trash from the grating.

Figure 1 Placentia Valve Control House

Figure 2 Nitrogen Cylinder and Valve Control Box

Figure 3 Valve Control Box

Figure 4 Carbon Creek overflow wing wall at Placentia Basin

Appendix A-15

Raymond Basin Weir Board Placement Procedures

How to Install Raymond Basin Weir Boards

How to install weir boards

1. Put 20 ft. ladder into the channel on the left side (Figure 1).
2. One person needs to lower the boards one at a time to the person in the channel. (Figure 3).
3. Once all boards are in the channel the second person will come down the ladder.
4. Each person will take a side of the board and place it in the metal groove along the channel wall until the desired weir height is reached (Figure 4).
5. Make sure the holes in the wood are on the left side so you can properly lock it.
6. Lock and chain the boards together (Figure 5).
7. Lay plastic over the boards.
8. Place sandbags over the plastic on the upstream side of the weir.
9. Secure the plastic to the back of the boards with a staple gun.

How to remove weir boards

1. Put 20 ft. ladder down on the left side, make sure 2 people are present (Figure 1).
2. Remove the plastic and sandbags from the channel.
3. Remove the lock and chain.
4. Remove the weir boards one at a time with two people.
5. Lean the boards against the channel wall.
6. One person pushes the boards up to the person at the top removing the boards from the channel one at a time. (Figure 4). When boards are wet and waterlogged call maintenance to use the truck crane to lift out of the channel.
7. Secure the boards together and to the fence with the lock and chain.

Figure 1 **20 ft ladder in the Channel**

Figure 2 **Carbon Creek Channel**

Figure 3 lowering boards into channel

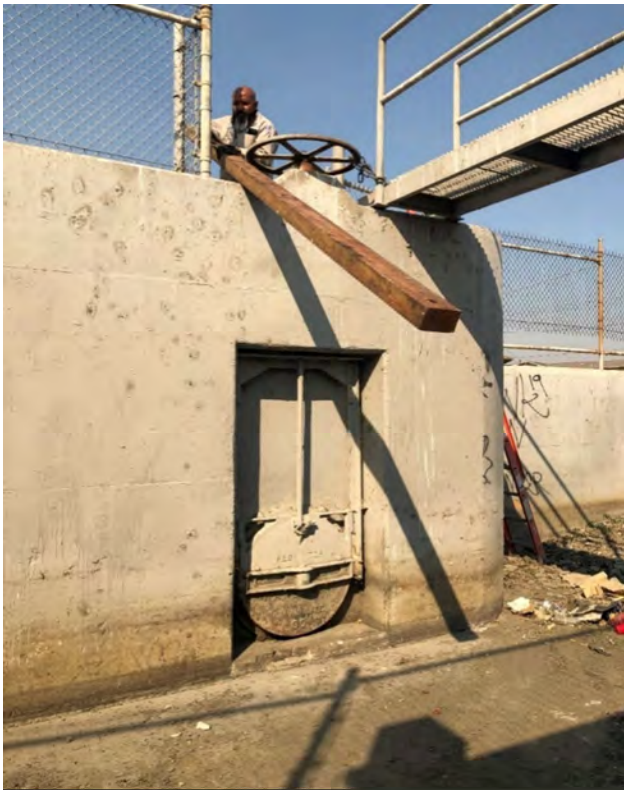


Figure 4 putting the boards in place

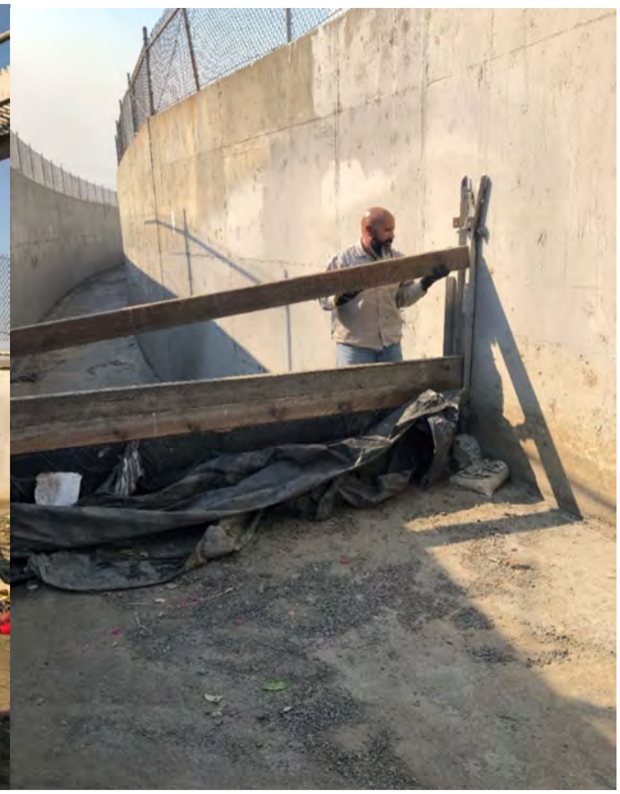


Figure 5 boards secured with chain and lock with the chain

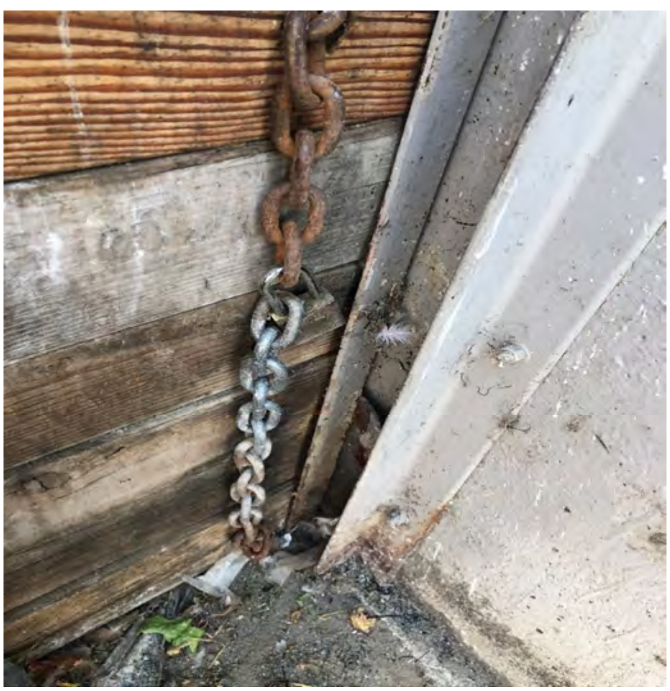


Figure 6 **securing the boards with the chain**

How to Operate Raymond Basins North & South Canal Gates

1. Unlock and remove the chain securing the hand wheel to the catwalk (Figure 1).
2. To open the canal gate, turn the hand wheel clockwise and to close the canal gate, turn the hand wheel counterclockwise.
3. Open or close canal gate to desired height (Figures 2 & 3).
4. Lift the hand wheel off the valve stem (Figure 4).
5. Walk the wheel across the bridge (figure 5).
6. Place the wheel over the valve stem (figure 4)
7. Secure and lock the hand wheel to the catwalk (Figure 1).

Figure 1 hand wheel secured to the catwalk

Figure 2 canal gate closed **Figure 3 canal gate open**

Figure 4 lifting wheel over valve stem

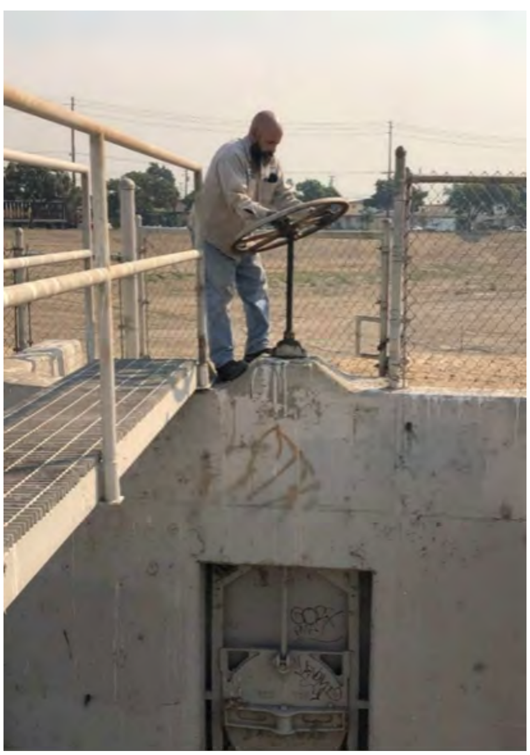


Figure 5 transporting wheel across catwalk

Appendix A-16

How to Read a Staff Gauge

How to read a Staff Gauge

Staff gauges are used for measuring water levels in lakes, rivers, reservoirs, and other bodies of surface water. Water levels for lakes, basins (figures 1 & 2) and ponds are used to find storage in acre feet using content tables. Water levels for rivers, weirs, flumes (figure 3) and flows over dams are used to find flow rates using look up tables. Staff gauges are marked in feet / tenths / hundredths of a foot. The level on a staff gauge is indicated by graduated black bars. Count down from the full graduation mark above the water level. The longer side of the black bars indicates half and full foot.

Figure 1 Staff gauge reading in La Palma Basin 214.02’

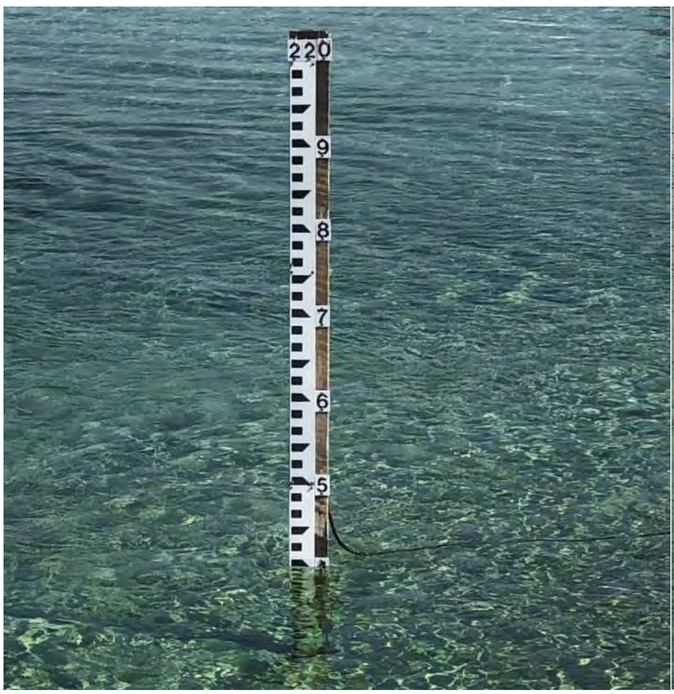


Figure 2 Staff gauge reading 214.69’

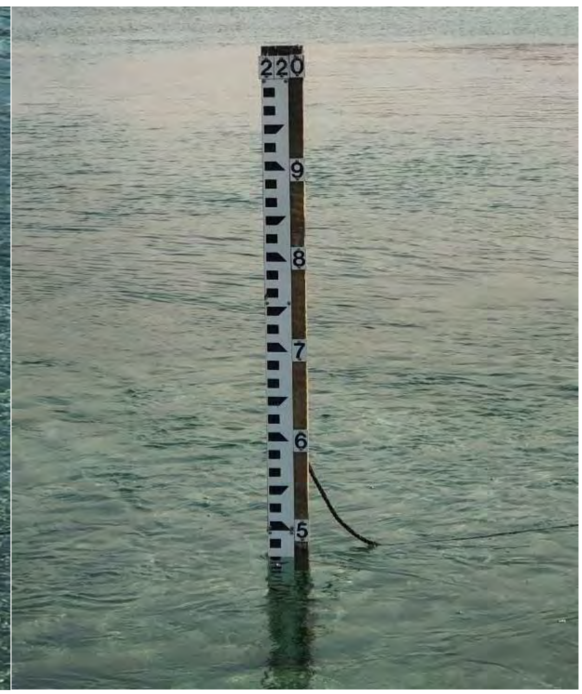


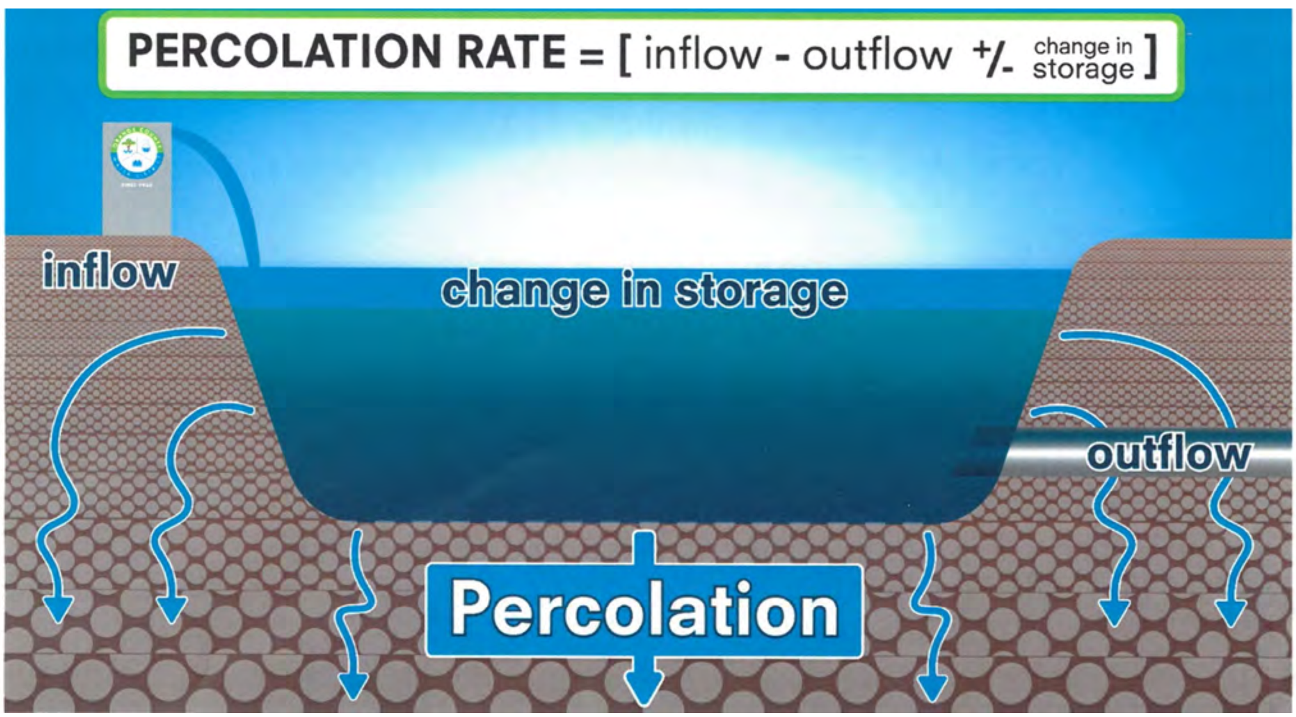
Figure 3 Staff gauge on wall of a flume

Appendix A-17

How to Calculate a Percolation Rate

How to calculate a Percolation Rate

1) Get beginning elevation and ending elevation for a 24 hour period.
2) Find the change in the elevation in that 24 hours.
3) Get the area for the ending elevation from area table.
4) Multiply the change in elevation by the area to get the acre feet.
5) Convert the acre feet into CFS by dividing acre feet by 2.
6) Get the average flow from the same 24 hour period.
7) Multiply the hours by the flows in that 24 hour period.
8) Add all the totals then divide by 24.
9) Take the converted CFS and the average inflow.



Appendix B

Passive Recharge System Background

water

MDPI

Article

Maximizing Infiltration Rates by Removing Suspended Solids: Results of Demonstration Testing of Riverbed Filtration in Orange County, California †

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† This paper was presented at the 9th International Symposium on Managed Aquifer Recharge (ISMAR9) in Mexico City, Mexico, 20–24 June 2016. www.ismar9.org.

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Abstract: Clogging due to the accumulation of suspended solids is a major constraint that limits the capacity of Orange County Water District's (OCWD) surface water recharge system. In order to decrease clogging and increase system capacity, OCWD is testing the ability of riverbed filtration to reduce suspended solids concentrations and improve recharge rates. Riverbed filtration is achieved through a shallow subsurface collector system placed approximately one meter below the surface. Filtered water from the collector system is conveyed by gravity to the receiving recharge basin. Initial results show that riverbed filtration is highly effective in removing suspended solids in the recharge water, which in turn also greatly increases the recharge capacity of the receiving basin. Some other water quality benefits are also achieved. Data collected thus far indicate that it will be cost-effective to use this approach at a larger scale to capture and recharge increased quantities of storm flow obtained from the Santa Ana River.

Keywords: recharge basin; riverbed filtration; clogging; pretreatment

1. Introduction

The Orange County Water District (OCWD) is a special governmental water agency that was created by the state of California in 1933 to manage the surface water and groundwater resources in northern and central Orange County. OCWD programs include aquifer replenishment or recharge, seawater intrusion control, water quality protection and improvement, water recycling, and storm water conservation [1]. OCWD covers an area of approximately 900 km^2 (350 mi^2) and serves a population of 2.4 million (Figure 1). The Mediterranean-type climate in Orange County is generally mild, with annual rainfall of approximately 350 mm (14 in), and average monthly temperatures ranging from 14 to 24 °C (58–75 °F). Most of the rainfall occurs in the months of December through March.

The Orange County groundwater basin formed in a synclinal, northwest-trending trough that deepens as it continues beyond the Orange-Los Angeles county line. The Newport-Inglewood fault zone, San Joaquin Hills, Coyote Hills, and Santa Ana Mountains form the uplifted margins of the syncline. The total thickness of sedimentary rocks in the basin surpasses 6000 m (20,000 ft), of which only the upper 600 to 1200 m (2000–4000 ft) contain fresh water.

Pleistocene or younger aquifers within the basin form a complex series of interconnected sand and gravel deposits. In coastal and central portions of the basin, these deposits are extensively separated by lower-permeability clay and silt deposits or aquitards. In the inland areas, the clay and silt deposits

The primary source of recharge water to the Orange County groundwater basin is the Santa Ana River, the longest river in southern California. Santa Ana River flows are generally comprised of treated wastewater discharged from upstream sewage treatment plants and seasonal storm flows. On average, the total amount of river flow that OCWD is able to capture and recharge in its recharge system is approximately 185 million·m³ (150,000 acre-ft) each year. During periods of heavy rainfall, high volumes of storm flow in the Santa Ana River may greatly exceed OCWD's recharge capacity and discharge to the Pacific Ocean. OCWD also recharges approximately 123 million·m³ (100,000 acre-ft) per year of advanced treated (Reverse-Osmosis and Advanced Oxidation) recycled wastewater from the Groundwater Replenishment System (GWRS) and purchases imported water as an additional source of recharge water. Lastly, the groundwater basin receives an average of 74 million·m³ (60,000 acre-ft) per year of natural recharge from precipitation and infiltration of irrigation water [1].

become thinner and more discontinuous, allowing larger quantities of groundwater to flow more easily between shallow and deeper aquifers [1]. This is particularly true where the Santa Ana River exits the Santa Ana Canyon in east Anaheim. The fluvial deposits in this area are highly permeable with hydraulic conductivities as high as 100 m/day (300 ft/day). As a result, OCWD has concentrated its surface water recharge facilities in this area as shown on Figure 1.

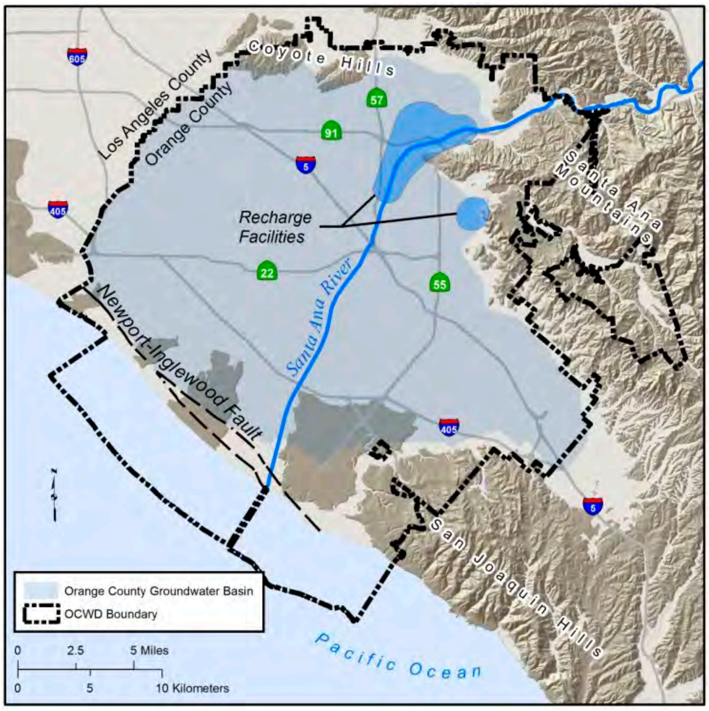

Figure 1. The Orange County Water District recharges the basin with Santa Ana River water, recycled water, and imported water at 400 ha (1000 acre) of infiltration ponds.

Figure 1. The Orange County Water District recharges the basin with Santa Ana River water, recycled water, and imported water at 400 ha (1000 acre) of infiltration ponds.

Land in Orange County is expensive. OCWD's most recent purchase of land in 2014 for a surface recharge facility cost $4M USD per ha ($1.6M USD/acre). Given the high cost of land and lack of available land in what is a highly urbanized area, it is imperative that OCWD maximize the capacity of the existing recharge system. As is the case with most recharge facilities worldwide, one of the primary constraints to maximizing recharge capacity is clogging [2,3].

Clogging of OCWD's recharge facilities is caused primarily by suspended sediments in Santa Ana River water and to a lesser extent, by biological growth resulting from organic carbon and nutrients in the recharge water [3,4]. Recharge rates achieved when using water with little to no suspended sediment,

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sediment, such as imported water from the Metropolitan Water District of Southern California (MWD)

and highly treated recycled water from OCWD's GWRS facility, are many times greater than what is achieved with Santa Ana River water.

In an effort to maximize OCWD's capacity to recharge Santa Ana River water, particularly storm water, which tends to have higher suspended sediment concentrations, OCWD embarked on a multi-phased Recharge Water Sediment Removal Feasibility Study [4]. Phase I of the study identified a number of sediment removal technologies for testing. Phase II of the study included large-scale testing of five different treatment technologies, including:

- Flocculation-Sedimentation
- Dissolved Air Floatation
- Ballasted Sedimentation
- Cloth Filtration (with and without chemical pre-treatment)
- Riverbed Filtration

Phase II results showed that cloth filtration without chemical pretreatment and riverbed filtration were successful in removing sediments and providing increased recharge rates. One of the unexpected outcomes was that any treatment method that used chemical additions, such as flocculants and polymers, while able to produce low turbidity water, resulted in elevated rates of clogging. It is suspected clogging was caused by residual flocculants or polymers remaining in the treated water interacting with the clays and silts present in the sediments.

Phase III of the study is to test cloth filtration and riverbed filtration at the field scale over several years. A key objective of this phase is to assess the performance of these systems to see if it is economical to expand them to treat larger volumes of water. Test results obtained thus far show that cloth filtration, although capable of reducing suspended solids concentrations, can only do so efficiently when total suspended solids (TSS) concentrations range from 5 to 30 mg/L [5–7]. Given this limited range of effectiveness, it is not foreseen that this method can be deployed at a larger scale or at other locations within OCWD's recharge system. The remainder of this paper is focused on presenting the results obtained thus far from the riverbed filtration system (RFS).

The objective of riverbed filtration is to use native river bottom sediments to filter out suspended organic and inorganic solids (e.g., clay and silt particles, algal cells, and microorganisms) and then collect the filtered water in a sub-surface collection gallery. The filtered water is then conveyed to a recharge facility. Success is measured by the increase in the recharge capacity of the receiving basin using filtered water as opposed to unfiltered Santa Ana River water. In addition to examining the overall recharge benefit and water quality improvements, this study also examines design factors that could affect system efficiency with an eye towards expanding this system into the larger Santa Ana River channel.

2. Materials and Methods

The riverbed filtration system (RFS) was installed in a portion of OCWD's recharge system called the Off-River channel. The Off-River channel receives water that flows out of Weir Pond 4 over a sharp-crested weir (see Figure 2). Water depths in the Off-River channel are typically from 15 to 30 cm (0.5–1 ft) and flow velocities range from 0.15 to 0.4 m/s (0.5–1.3 ft/s). Because the upper portion of the Off-River channel sits between the Santa Ana River and Warner Basin (a large recharge basin), groundwater levels tend to be high, causing some reaches the Off-River channel to become a gaining stream. As a result, the upper portion of the Off-River channel is not useful for groundwater recharge. A key consideration for RFS placement was to re-purpose an underperforming portion of the Off-River channel recharge facility and use it to filter sediment laden water and increase recharge rates in a downstream recharge basin.

comprised of material with the following sieve specifications: 100% passing 51 mm (2 in); 90%–100% passing 38 mm (1.5 in); 20%–55% passing 25 mm (1 in); 0%–15% passing 19 mm (0.75 in); and 0%–3% passing 0.074 mm (0.0029 in). The Atlantis Flo-Tank® (Atlantis Corporation, Sydney, Australia) modules were placed end to end and wrapped in geotextile fabric. Once buried, native material was placed around and above the tanks to the ground surface. Each Flo-Tank module is 45 cm (17.7 in) high, 41 cm (16 in) wide, and 69 cm (27 in) long.

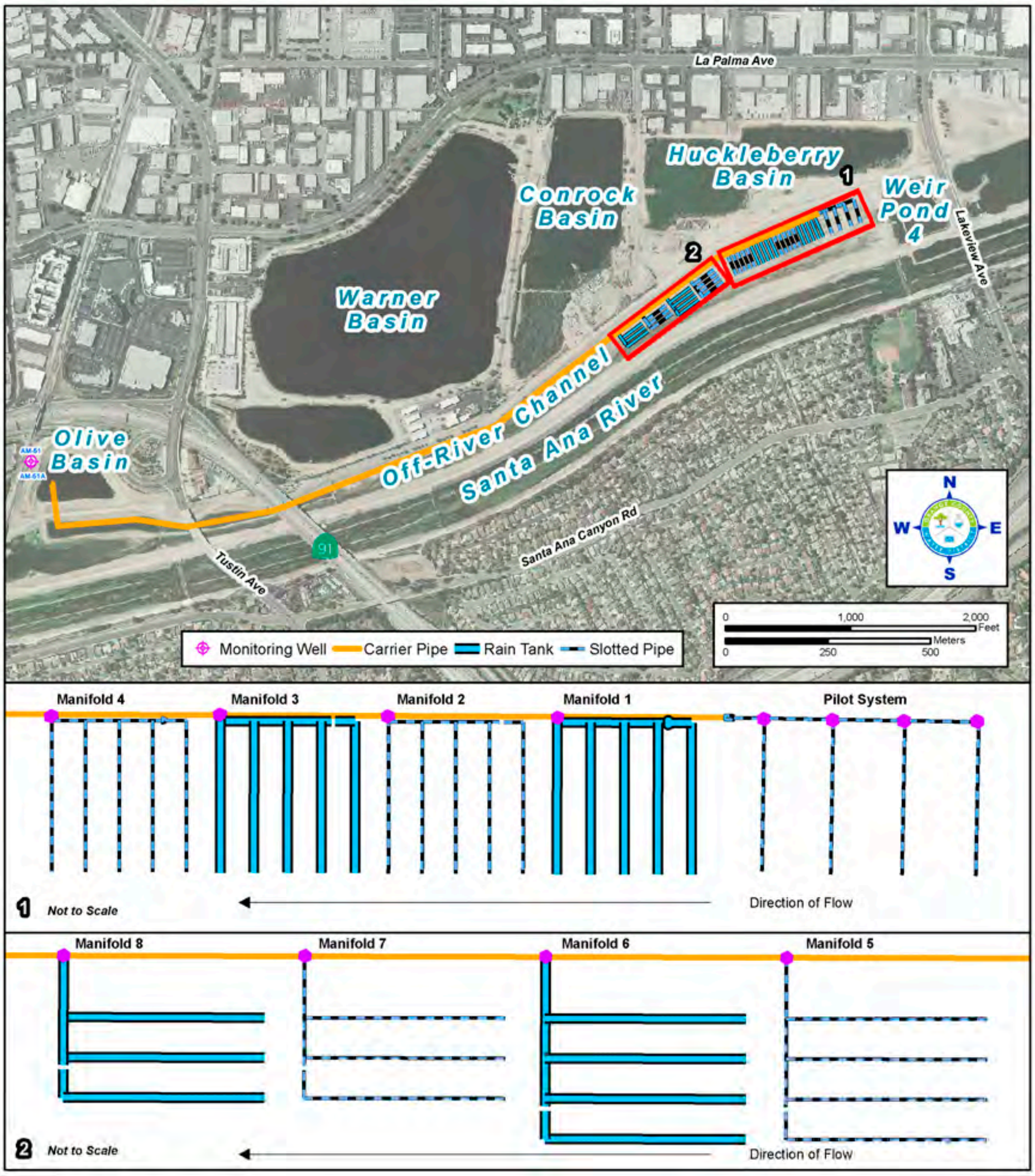


Figure 2. Location and Layout of the Riverbed Filtration System (RFS).

The RFS was constructed with two types of collectors: Slotted PVC Pipe and Flo-Tanks. All the collectors were placed a minimum of 0.9 m (3 ft) below the ground surface and ranged in length from 55 to 61 m (180–200 ft). The total RFS footprint covers 4 ha (10 ac). Table 1 presents key construction details. The PVC pipes are 20 cm (8 in) in diameter and buried in a gravel mixture with a minimum of 2.5 cm (1 in) below and on the sides of the pipe with a minimum of 20 cm (8 in) above the pipe. Native material was then placed on top of the gravel to the ground surface. The pipes were slotted with three rows of 2.54 mm (0.1 in) slots designed to have an overall open area of greater than 10%. The gravel mixture was comprised of material with the following sieve specifications: 100% passing 51 mm (2 in); 90%–100% passing 38 mm (1.5 in); 20%–55% passing 25 mm (1 in); 0%–15% passing 19 mm (0.75 in); and 0%–3% passing 0.074 mm (0.0029 in). The Atlantis Flo-Tank® (Atlantis Corporation, Sydney, Australia) modules were placed end to end and wrapped in geotextile fabric. Once buried, native material was placed around and above the tanks to the ground surface. Each Flo-Tank module is 45 cm (17.7 in) high, 41 cm (16 in) wide, and 69 cm (27 in) long.

Table 1. Riverbed Filtration System (RFS) Construction Details.

Section	Material Type	Length of Collection System	Orientation Relative to Flow in Off-River Channel
Pilot System	Slotted PVC Pipes	220 m (720 ft)	Perpendicular
Manifold 1	Flo-Tanks	220 m (720 ft)	Perpendicular
Manifold 2	Slotted PVC Pipes	220 m (720 ft)	Perpendicular
Manifold 3	Flo-Tanks	220 m (720 ft)	Perpendicular
Manifold 4	Slotted PVC Pipes	220 m (720 ft)	Perpendicular
Manifold 5	Slotted PVC Pipes	244 m (800 ft)	Parallel
Manifold 6	Flo-Tanks	244 m (800 ft)	Parallel
Manifold 7	Slotted PVC Pipes	183 m (600 ft)	Parallel
Manifold 8	Flo-Tanks	183 m (600 ft)	Parallel
Total Slotted PVC Pipes		1087 m (3566 ft)	
Total Flo-Tanks		867 m (2845 ft)	

To quantitatively compare the performance of the two drainage collection types, alternating sets of laterals were constructed as shown on Figure 2. Except for the pilot system laterals, each set of laterals, or sections, are connected to a 36 cm (14 in) diameter trunk line which in-turn feeds a High-density polyethylene (HDPE) carrier pipe that conveys filtered product water to Olive Basin. To accommodate increasing flow from the RFS, the carrier pipe increases in diameter in the downstream direction from 51 cm (20 in) to 91 cm (36 in). Flow from each section is controlled by a gate valve, allowing each set of laterals to be turned on and off to test various section combinations. As shown in Figure 2, the uppermost sections were constructed perpendicular to the direction of surface water flow while the lower sections are oriented parallel to the direction of surface water flow. This was done to assess potential differences in performance obtained by varying the direction of surface water flow. Flow of filtered product water arriving at Olive Basin is measured by a SonTek-IQ Pipe acoustic Doppler flow meter.

The receiving recharge basin, Olive Basin, is a former sand and gravel borrow pit that was purchased by OCWD in 1972. When full, the basin has a wetted area of 2.4 ha (5.8 ac) and a maximum depth of 13 m (40 ft). Historically, surface water from the Santa Ana River was diverted to the basin for recharge. For the study, only filtered product water is supplied to the basin and a comparison of historical performance using unfiltered surface water and RFS product water will provide a measure of the increased recharge obtained using RFS product water. Two groundwater monitoring wells were installed adjacent to Olive Basin, AM-51 and AM-51A. Well AM-51 is screened in the deeper principal aquifer. Well AM-51A is shallow and only receives water when Olive Basin is in operation, thus groundwater in this well is water recently recharged in Olive Basin.

In addition to testing the hydraulic performance of the RFS, a detailed water quality testing program was put into place. As summarized in Table 2, water quality data of interest fall into two categories, (1) Parameters that could impact system performance (i.e., clogging); and (2) Parameters that could impact water quality for potable uses.

Although the reduction of suspended solids and a concomitant increase of recharge rates in the receiving basin are the primary goals of the study, the ability of the RFS to affect parameters related to water quality is also a matter of interest and possibly of regulatory concern. Monitoring parameters related to water quality will show whether the RFS can sufficiently improve the water quality to allow other potential uses, such as direct potable use.

Water quality samples for the RFS influent were obtained from water flowing over the sharp-crested weir in Weir Pond 4 (see Figure 2). RFS product water samples were obtained directly out of the carrier pipe prior to discharge to Olive Basin. Periodically, product water was obtained directly from Olive Basin. Starting in March 2015, auto-samplers were deployed to collect TSS samples to provide a weekly average of TSS concentrations in both the source water at Weir Pond 4 (WP4) and RFS product water.

Table 2. Water Quality Parameters of Interest *.

Impact	Mechanism	Monitored Parameters
System Performance	Clogging due to Solids Accumulation	• Total Suspended Solids • *Particle size distribution*
System Performance	Clogging due to Chemical Precipitation	• *Major cations/anions, TDS, and pH*
System Performance	Clogging due to Biological Activity	• *Principal inorganic nutrients (nitrogen, phosphorus and sulfur)* • Total organic carbon (TOC),dissolved organic carbon (DOC), assimilable organic carbon (AOC)
Potable Use Parameters	N/A	• Indicator bacteria • *Arsenic and other metals* • *Organic halides (TOX)* • Constituents of Emerging Concern (CECs)

Note that italicized monitored parameters are not presented in this paper.

TSS was measured using standard method #2540D [8]. CECs were analyzed at OCWD's Advanced Water Quality Assurance Laboratory following EPA QC protocol using an automated extraction method (Auto-Trace) and isotopic dilution. The analyses were performed using a Liquid chromatography-Mass spectrometry-Mass sprectrometry (LC-MS-MS). All other parameters, other than AOC, were also analyzed at OCWD's Advanced Water Quality Assurance Laboratory using the same methods used for testing potable drinking water supplies.

Assimilable organic carbon (AOC) was monitored as an additional water quality parameter to Total Organic Carbon (TOC). AOC is the fraction of TOC (typically 0.1%–1%) that is most readily utilized by bacteria for regrowth and for metabolic activity. Generally, AOC is the fraction of TOC that heterotrophic bacteria use to increase their biomass. AOC concentrations can serve as an indicator of the nutrient level and a measurement of the potential for microbial regrowth. The AOC concentrations for this study were determined by using a rapid bioluminescence assay that measures the assimilation of organic compounds by a specific organism, *Vibro harveyi* harboring a luminescence gene that responds to organic compounds. The gene is induced, even at low concentrations and produces light in the presence of variety of organic compounds (AOC). The intensity of luminescence increases with the concentration of the organic compounds in water and is measured with a luminometer (Turner Biosystem, Sunnyvale, CA, USA) [9].

3. Results

Construction of the RFS was completed in late 2013 at a cost of $1.9M USD. Of this total, approximately $950,000 USD was for the carrier pipeline. Once put into service, it was discovered that the flowmeter was not operational. As a result, hydraulic performance for 2014 cannot be evaluated. A flowmeter manufactured by SonTek (San Diego, CA, USA) was installed in February 2015 and a hydraulic testing program was developed to measure the performance of various sections of the RFS. Due to drought conditions in Orange County since 2011, it has not been possible to sustain steady flow to the RFS for extended periods of time. As a result, it may take several more years of testing to measure the capacity of all the various RFS configurations.

Testing conducted to date shows the RFS is capable of producing a maximum flow of 44,000 m^3/day (18 cfs), which is greater than the design rate of 37,000 m^3/day (15 cfs). This maximum flow was generated with all slotted PVC pipe and Flo-Tank sections open and was sustained for weeks at a time. Due to supply variability, the duration of the test cycles is highly variable, ranging from a few days to several months. As shown in Table 3, the total flow generally increases with the number of sections open; however, the efficiency, based on the average flow per section, is not consistent with the number of sections open. One key finding is that the efficiency declines when all of the sections are open. Based on the area of recharge created by the number of sections open, the unit infiltration rate ranges from 0.6 to 1.5 m/day (2–5 ft/day). By comparison, the unit infiltration rate of the Santa Ana River, which is adjacent to the Off-River channel, ranges from 0.03 to 0.2 m/day (0.1–0.7 ft/day). The higher unit infiltration rates achieved over the RFS indicate that it is inducing a higher infiltration rate than would occur naturally.

Table 3. Summary of Hydraulic Testing to Date.

Section [1]	Open (Shaded)										
Pilot System (Pipe)											
Manifold 1 (FT)											
Manifold 2 (Pipe)											
Manifold 3 (FT)											
Manifold 4 (Pipe)											
Manifold 5 (Pipe)											
Manifold 6 (FT)											
Manifold 7 (Pipe)											
Manifold 8 (FT)											
No. of Test Cycles	1	1	1	2	1	1	1	1	1	1	3
Flow (1000 m^3/day)	7.3	17.1	21.5	24.1	25.2	29.4	22.0	26.4	39.1	39.1	41.9
No. Open Sections	1	3	3	4	4	5	5	5	6	6	9
Avg Flow/Section (1000 m^3/day)	7.3	5.7	7.2	6.0	6.3	5.9	4.4	5.3	6.5	6.5	4.7

Notes: [1] Pipe = Slotted PVC Pipe; FT = Flo-Tanks.

Note that the testing conducted thus far is relatively limited given the large number of potential section combinations. In addition, potential temperature impacts on performance have not been accounted for. Further testing is needed to help to understand system performance and implications for the design of an expanded system in the Santa Ana River.

Flows shown in Table 3 do not include any significant contribution of shallow groundwater, based on the fact that flow from the RFS with all sections open but no surface flow in the Off-River channel ranged from zero to 1700 m^3/day (0–0.7 cfs).

Figure 3 shows how the water levels in Olive Basin and flows from the RFS into Olive Basin varied in 2015 and 2016. Water flow and water depth were highly variable due to variabilities in the supply of water and RFS system testing (i.e., laterals being turned on and off).

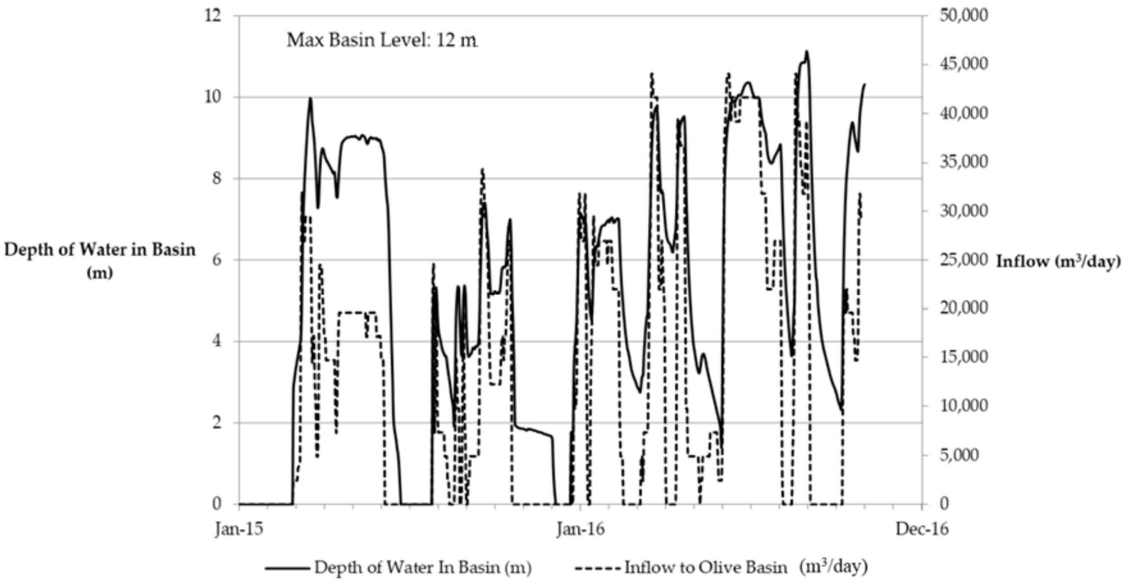
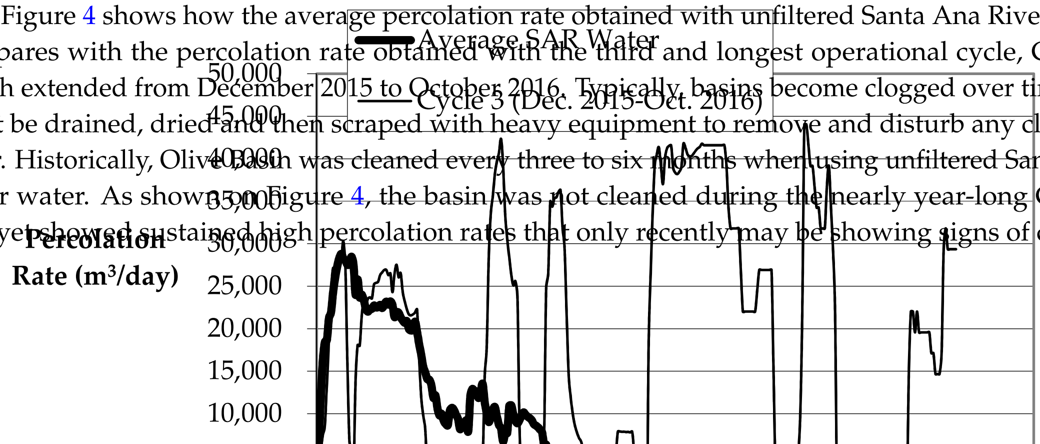
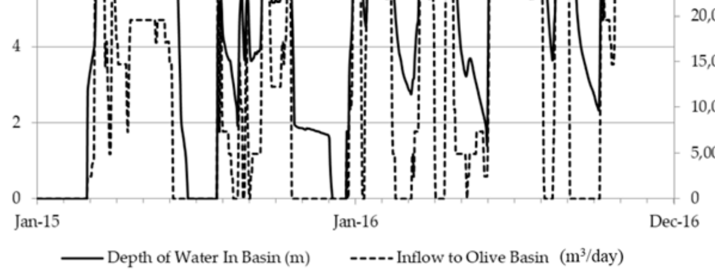


Figure 3. Depth of Water and Flow into Olive Basin.

Figure 4 shows how the average percolation rate obtained with unfiltered Santa Ana River water compares with the percolation rate obtained with the third and longest operational cycle, Cycle 3, which extended from December 2015 to October 2016. Typically, basins become clogged over time and must be drained, dried and then scraped with heavy equipment to remove and disturb any clogging layer. Historically, Olive Basin was cleaned every three to six months when using unfiltered Santa Ana River water. As shown on Figure 4, the basin was not cleaned during the nearly year-long Cycle 3 and yet showed sustained high percolation rates that only recently may be showing signs of decline.





This ... recharge capacity of Olive Basin and reduced operating costs by avoiding the need to clean the basin two to four times per year.

Figure 3. Depth of Water and Flow into Olive Basin.

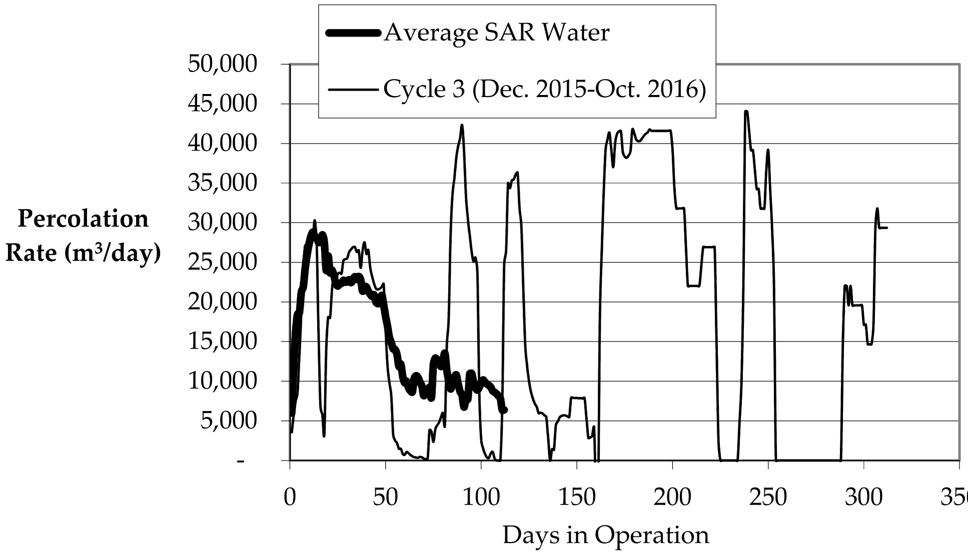


Figure 4. Olive Basin Percolation Rate with Water from Unfiltered Santa Ana River (SAR) and Riverbed Filtration System.

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Water quality testing shows that the RFS is very effective in removing suspended solids. Samples collected to date indicate the RFS removes from 70% to 99% of the suspended solids in the source water with an average removal of 97%. Figure 5 shows the range of source water and RFS product water TSS concentrations from December 2014 to October 2016. Table 4 summarizes changes in selected water quality ...

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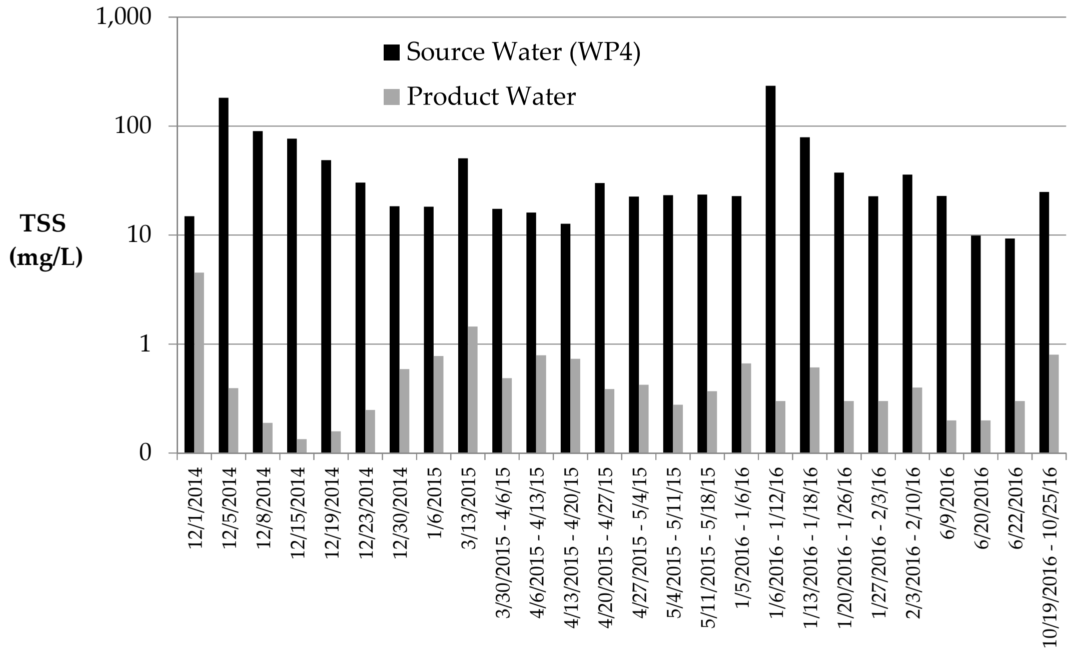

Figure 5. Total Suspended Solids in Source Water (WP4) and Product Water from RFS. (Note Log Scale, samples with a date range are weekly averages).

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Table 4. Changes in Selected Water Quality Constituents.

	Source Water (WP4)	Filtered Product Water	Change
Parameter	Total Suspended Solids (mg/L) (n = 26)		
Maximum	234	4.5	

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	Source Water (WP4)	Filtered Product Water	Change
Parameter	Total Suspended Solids (mg/L) (n = 26)		
Maximum	234	4.5	
Minimum	9	0.13	
Median	23.2	0.39	
Average	45.1	0.62	97% reduction
Parameter	Total Coliform (cfu/100 mL) (n = 8)		
Maximum	24,000	700	
Minimum	400	40	
Median	2800	100	
Average (*)	6290	235	96% reduction
Parameter	Total Organic Carbon (mg/L) (n = 4)		
Maximum	109	6.0	
Minimum	6.2	3.5	
Median	9.8	4.8	
Average	9.3	4.8	49% reduction
Parameter	Dissolved Organic Carbon (mg/L) (n = 4)		
Maximum	9.9	5.6	
Minimum	7.0	3.5	
Median	8.1	4.1	
Average	8.2	4.3	47% reduction
Parameter	Assimilable Organic Carbon (μg/L) (n = 5)		
Maximum	139.9	242.1	
Minimum	15.0	7.15	
Median	114.0	114.3	
Average	92.0	112.8	18% increase

Notes: * Insufficient number of samples to calculate geometric mean.

TOC and dissolved organic carbon (DOC) concentrations were reduced by over 40%, which is consistent with removals seen in monitoring wells adjacent to OCWD recharge basins.

The removal of Constituents of Emerging Concern (CECs) by the riverbed filtration system was monitored during two sampling events in 2016 via collection of grab samples of the source water and filtered product water (Figure 6). Of the 29 compounds that were surveyed in the source water, 18 were detected, typically at similar concentrations between the two sampling events. These compounds are likely derived from upstream treated wastewater effluent discharges to the river. Figure 6 also shows data for monitoring well AM-51A, a shallow well located adjacent to Olive Basin which only has water when Olive Basin is in operation (see Figure 2). Groundwater data indicate that there was additional removal for several compounds through aquifer treatment. Of the 18 CECs detected in the source water, the average removal was significant (greater than 80%) for six compounds, moderate (between 20% and 80%) for six compounds, and low or negligible (less than 20%) for the remaining six compounds (Figure 7), demonstrating that removal is dependent on compound properties, i.e., biodegradable and sorbing compounds will be removed more extensively over short travel times. Sucralose is considered a conservative tracer for wastewater impact because it is not significantly biodegraded nor sorbed in the subsurface [10], and indeed, it showed a relatively high concentration compared to other wastewater-derived organic compounds.

The observed average increase (~20%) in the AOC concentration between the source water and filtered product water in this study could be a result of specific redox conditions whereby complex organics are converted into simpler assimilable organics detected by the rapid AOC assay; of the five sampling events, on three days, the AOC concentration was approximately constant or slightly lower while on the remaining two days it increased. Additional AOC testing over a continuous monitoring period would be needed to establish trends.

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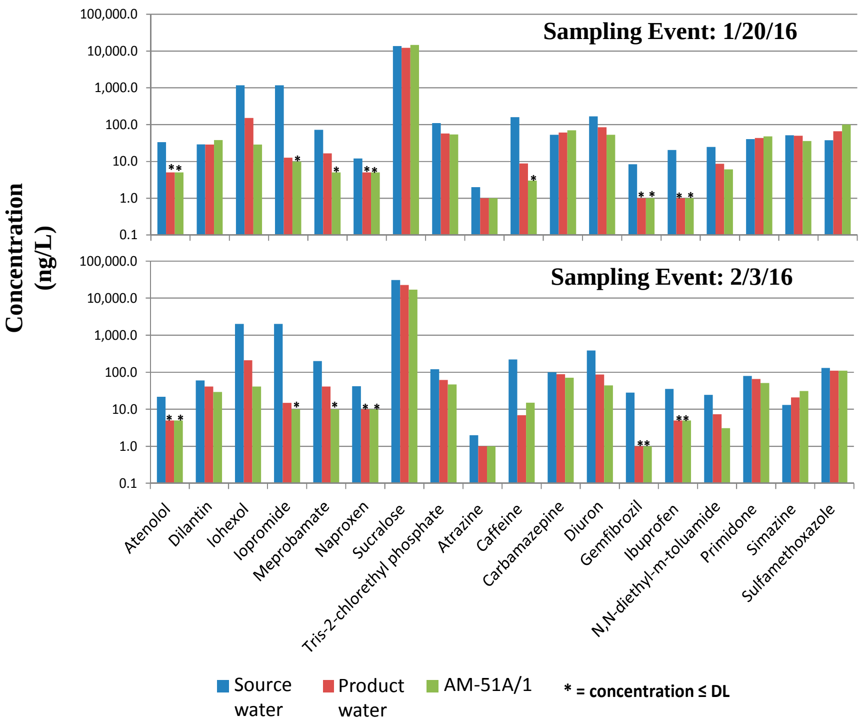

Figure 6. CECs Detected in Source Water, RFS Product Water and in Groundwater (AM-51A) Downgradient of Olive Basin for January and February 2016 Sampling Event. (Note: For compounds detected in source water but not in product water, the detection limit value is shown and denoted with *. Additional compounds were analyzed but were below the detection limit in the source water.)

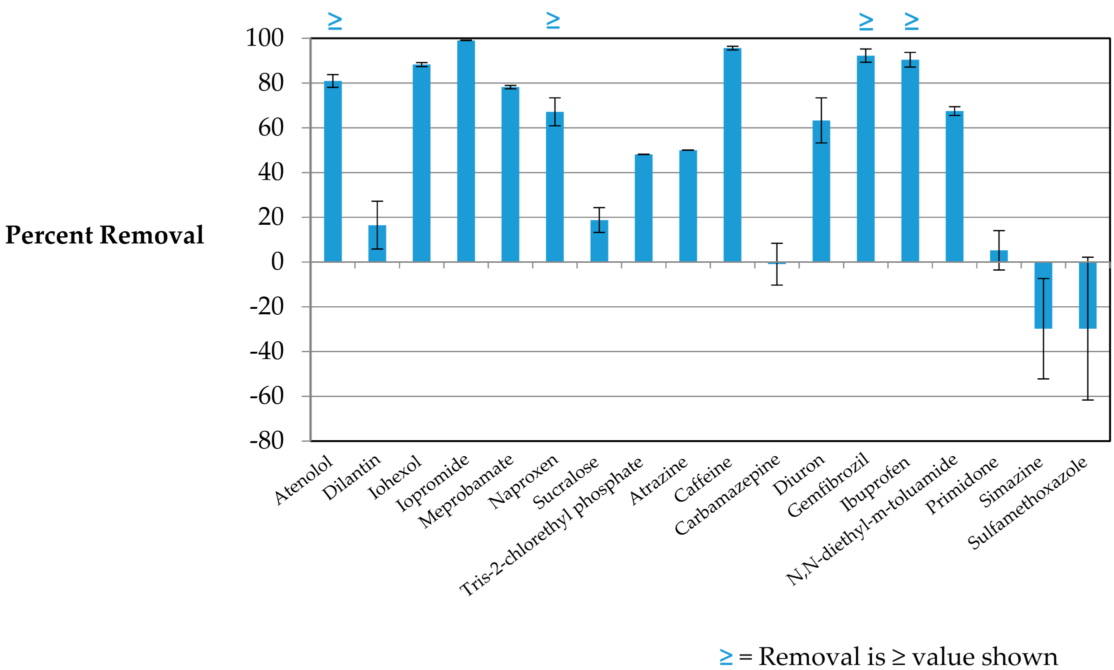

Figure 7. Removal of CECs in RFS (Comparing Source and Product Water). Values are the mean of two sampling events from the previous figure. Error bars represent one standard deviation. In cases where the product water concentration was non-detectable, removal is calculated using the method reporting limit (hence removal is ≥ value shown).

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4. Discussion

Based on data collected thus far, the RFS is effective in reducing TSS concentrations, which is significant given that suspended solids are the primary clogging agent. As a result, the RFS is capable of reducing clogging and significantly increasing the recharge capacity of Olive Basin. The RFS improves overall water quality in a manner consistent with soil aquifer treatment (SAT) despite the short 0.6 to 0.9 m (2–3 ft) distance between the channel surface and the sub-surface collection system. Reductions in organic carbon may be due to filtration and sorption to carbon in the sediments; however, additional data are being collected to assess how much change is caused by biological processes. Removal of CECs, which represent a portion of the organic carbon, is likely due to a combination of sorption and biodegradation, depending on the individual compound.

Flow rate data indicate that the RFS is capable of filtering at least 11,000 m^3/day of water per ha of channel area. The relative efficiency of the RFS is highest with fewer than all nine sections open, which suggests the collection system density is in excess of what is needed and that the limiting factor is the permeability of the near surface sediments. Nevertheless, the unit percolation rate within the RFS footprint is several times greater than what is seen in the adjacent Santa Ana River. The excess RFS capacity could allow for cycling of the sections to reduce clogging rates, or for lower cost future designs with reduced drain system density. Additional testing is required to assess the relative efficiency of the slotted PVC pipes and Flo-tanks, impact of surface flow rates and surface water depths on collection rates, the impact of collection system orientation relative to the direction of surface water flow, and the potential impact of surface clogging in the Off-River channel. Additional testing is also needed to provide information on the increased recharge obtained in Olive Basin using filtered water compared to unfiltered Santa Ana River water. A nearly one-year-long test cycle has shown some promising results, but more testing is needed to both assess the gains in recharge obtained in Olive Basin as well as potential clogging of the RFS. The long-term test results will be central in evaluating the feasibility of using riverbed filtration in other areas, including the main Santa Ana River channel and other parts of the Off-River channel.

5. RFS Expansion Potential

Upstream of the main diversion point off the Santa Ana River is approximately 40 ha (100 acres) of engineered Santa Ana River channel that could potentially be used to install a large RFS. Figure 8 shows the potential location of a large system in the Santa Ana River channel. It is unlikely the system could be further extended upstream due to naturally occurring habitat present in the upper reaches of the river channel. Within the reach shown on Figure 8, the channel is approximately 91 m (300 ft) wide.

Based on RFS testing in the Off-River channel, a range of unit percolation rates were applied to a potential area in the Santa Ana River channel to develop an estimate of the capacity of the system to capture and divert water from the river channel. Table 5 shows how the potential system capacity varies with varying unit percolation rates.

Table 5. Unit Percolation Rates and Estimated System Capacity.

For 40 ha RFS	Low	Medium	High
Unit Percolation Rate (m/day)	0.61	1.1	1.5
Potential System Capacity (1000 m^3/day)	240	440	610

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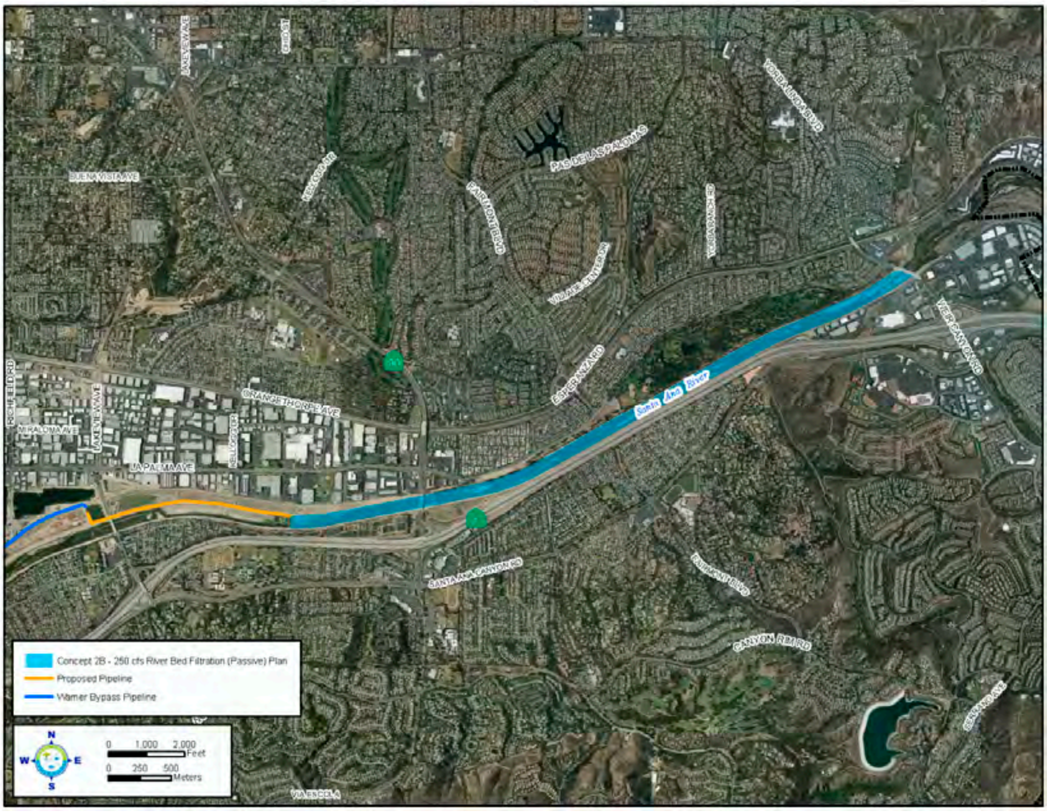

Figure 8. Potential Location of Riverbed Filtration System (RFS) in Santa Ana River Channel.

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Assuming a medium system capacity (0.44M·m^3/day), the collection pipeline to convey water to the recharge basins by gravity would require a telescoping pipeline that expands in the downstream direction from a diameter of 20 cm (8 in) to 229 cm (90 in). The estimated capital cost to construct this gravity system is approximately $90M USD [2]. The annualized capital cost assuming an interest rate of 5% and project life of 50 years, is approximately $4.6M USD. Estimated annual operations and maintenance costs are $500,000 USD, resulting in a total annualized cost of $5.1M USD. The operations and maintenance costs assume that heavy equipment operations will be needed to continuously maintain the river channel, particularly between storm events. It is likely that actual operations and maintenance costs will be lower. The estimated additional recharge of water that would otherwise be lost to the ocean due to producing higher quality water, which results in reduced clogging of the receiving basins, is estimated to be 8.6M·m^3/year (7000 acre-feet/year). As a result, the estimated annualized cost per unit of recharge is $593 USD/1000 m^3 ($730 USD/acre-foot). This cost is comparable to the current cost of untreated imported water. Since the cost of untreated imported water is expected to increase in the future, the cost of the additional recharge produced by the RFS will likely become more cost-effective in the future.

One of the risks associated with placing an RFS in the Santa Ana River is the potential for scour, which could damage the RFS. Additional work needs to be done to assess the potential for scour; however, the presence of Prado Dam upstream controlling flows in the Santa Ana River and several grade stabilizers in the reach considered for the larger system will mitigate potential scour. In addition, the system would be designed so that the laterals could be easily replaced if needed in the event they are damaged by major storm events.

6. Conclusions

Initial data show that riverbed filtration is highly effective, removing suspended solids in the recharge water, which in turn also greatly increases the recharge capacity of the receiving basin.

Some other water quality benefits are also achieved. Data collected thus far indicate that it will be cost-effective to use this approach at a larger scale to capture and recharge increased quantities of storm flow obtained from the Santa Ana River.

The RFS approach has the potential to provide a relatively benign method of diverting filtered surface water from river channels with minimal impacts to aquatic and riparian wildlife once the system is constructed. Finally, the RFS allows the suspended sediment load to remain in the river channel, which not only reduces costs associated with removing sediment from recharge basins, but retains the natural balance of sediment transfer in the river channel, which benefits riparian and marine habitats.

In closing, the RFS approach represents a partnership with nature where natural and engineered processes intersect to produce a result that is beneficial for man and for the environment.

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Author Contributions: Adam S. Hutchinson and Greg Woodside conceived and designed the project. Grisel Rodriguez is the lead on collecting and analyzing water quality data. Mike Milczarek assisted in evaluating hydraulic performance data. Adam S. Hutchinson is the primary author of this paper with contributions from the other co-authors.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ac	acres
AOC	Assimilable Organic Carbon
CEC	Constituents of Emerging Concern
cfs	Cubic feet per second
cm	Centimeters
DOC	Dissolved Organic Carbon
EPA	US Environmental Protection Agency
ft	Feet
ft/s	Feet per second
ha	Hectares
GWRS	Groundwater Replenishment System
in	Inches
km^2	Square kilometers
LC	liquid chromatograph
m	Meters
mm	Millimeters
MS	Mass spectrometry
m/s	Meters per second
m^3/day	Cubic meters per day
mi^2	Square miles
mg/L	Milligrams per liter
MWD	Metropolitan Water District of Southern California
OCWD	Orange County Water District
QC	Quality control
RFS	Riverbed filtration system
SAR	Santa Ana River
SAT	Soil aquifer treatment
Study	Recharge Water Sediment Removal Feasibility Study
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USD	United States Dollar

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Appendix C

Quagga Mussel Background

Orange County Water District

Dreissenid Mussel Monitoring, Response, and Control Plan

Version 4

June 2020

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APPENDICES

1.0 INTRODUCTION

The Quagga Mussel, *Dreissena rostiformis bugensis,* is a small freshwater bivalve mollusk. Mussels of the genus *Dreissena,* including Zebra and Quagga Mussels, are invasive species native to the Ukraine and were probably introduced to the Great Lakes region in the ballasts of transoceanic ships. The mobility and size of their planktonic stages, or veligers, have enabled Dreissenid Mussels to invade numerous waterways. The veligers are free-floating for up to four weeks; moved about by currents, they settle and attach to solid surfaces. Dreissenids are prolific breeders, capable of exponential growth rates within a 10-week reproductive cycle. Each adult Quagga Mussel is capable of producing one million veligers in one breeding cycle.

On January 6, 2007, adult Quagga Mussels were discovered in Lake Mead. By September 7, 2007, the Quagga Mussel infestation had spread via the Colorado River Aqueduct (CRA) throughout the southwestern United States, including San Diego County reservoirs connected to the aqueduct. The Metropolitan Water District of Southern California (MWD) discovered Quagga Mussels in July 2007 at lakes Skinner and Mathews. Lakes Skinner and Mathews supply Orange County Water District (OCWD or District) with untreated water for groundwater recharge. Water from these lakes can contain Quagga Mussel veligers with concentrations varying throughout the year. Note that MWD chlorinates untreated water from these lakes when they enter the conveyance pipelines. This chlorination serves to reduce but not eliminate veliger concentrations in the untreated water. In September 2009, after receiving CRA water from MWD, juvenile and adult Quagga Mussels were discovered around the pump housings and on other hard substrates in Kraemer Basin and Anaheim Lake. Since 2009, adult Quagga Mussels have been detected periodically in Anaheim Lake, Kraemer Basin and Miller Basin following CRA deliveries. Quagga Mussels are not detected every time CRA water deliveries are received. This is likely due to variations in Quagga Mussel veliger concentrations in the source lakes as well as the effectiveness of chlorination. All OCWD facilities that receive CRA water are desiccated prior to resuming operations with other sources of water.

On August 30, 2007, the San Diego County Water Authority (SDCWA) formed a regional Quagga Mussel Control Plan Workgroup consisting of member water agencies. The MWD wholesales water to SDCWA agencies and OCWD, among others, and shares research and control recommendations with agencies potentially affected by invasive mussels. The California Department of Fish and Wildlife (CDFW) staff attends workgroup meetings and as the enforcement agency provides regulatory guidance relating to Quagga Mussel control and monitoring.

The OCWD Dreissenid Mussel Monitoring, Response, and Control Plan (Plan) is designed to provide guidance in the detection of and response to Quagga Mussel veligers and adults in OCWD water spreading facilities. The Plan fulfills OCWD's obligation under Fish and Wildlife Code section 2301 to produce such an instrument. The Plan will be followed to determine population densities, if any. The monitoring results will be used to determine measures for control of mussel populations. The OCWD is the downstream user of water in the Santa Ana River with legal water rights. Any issues with this invasive species affecting OCWD facilities will be dealt with by OCWD in cooperation with CDFW.

2.0 OCWD WATER-SPREADING FACILITIES AND OPERATIONS

The District's surface water spreading system is currently comprised of just over two dozen facilities which cover over 1,000 wetted acres and have a combined storage volume of over 26,000 acre-feet (see Figure 1 for facility locations). Table1 lists the areas and storage capacities of each of the recharge facilities as well as the sources of water that can be conveyed to each facility. As a part of normal operations, all of the recharge facilities are periodically drained and dried to remove the clogging layer that accumulates on the bottoms of the facilities. This desiccation and cleaning process also presents an opportunity to rid them of any potential Quagga Mussels.

Water that flows into the District's recharge system does not flow out of the system. That is, the District's system is a terminal system. As a result, any infestation of the Quagga Mussel within the District's system will only affect the District and no other water supplier. Moreover, there are no avenues for the spread of the Quagga Mussel beyond the District's system. Warner Basin is the only OCWD facility regularly open to the public for fishing through a concessionaire, but no private boats are allowed.

The main source of inflow to the recharge system is the Santa Ana River (SAR). SAR flows are comprised of waste-water discharges in the upper reaches of the SAR and storm flows. SAR water flows through Prado Dam, which is located on land on owned by the US Army Corps of Engineers (USACOE). Prior to reaching Prado Dam, up to 50 percent of the flow in the SAR is diverted to OCWD's treatment wetlands, which is on land owned by OCWD. The treatment wetlands serve to improve water quality by removing nitrates, organic carbon and other pollutants. Imported State Project Water (SWP) is periodically delivered to OCWD's spreading grounds via the SAR; however, no imported Colorado River water enters the SAR upstream of Prado Dam.

When SAR flows reach the Imperial Rubber Dam, located just downstream of Imperial Highway, the flows are divided into two streams of water. The first stream is diverted from the SAR to Weir Ponds 1-4 (Desilting System). The second stream is the remaining flow which is bypassed around the dam and placed back into the SAR channel. The maximum flow that can be diverted to the Desilting System is 500 cubic feet per second (cfs). Up to 500 cfs can also be bypassed around the dam.

Flows that pass through the Desilting System are split at Weir Pond 4 with up to 400 cfs being conveyed to Foster-Huckleberry, Conrock, Warner, and Little Warner Basins. At Little Warner Basin, water is conveyed via the 66-inch diameter Warner to Anaheim Transmission Pipeline to Anaheim Lake. Water reaching Anaheim Lake can also be conveyed via a pipeline around the north side of Anaheim Lake to downstream basins, including Kraemer, Miller, La Jolla, Placentia and Raymond Basins (terminal basin). Water conveyed to La Jolla, Placentia and Raymond Basins, is water discharged from a pipeline adjacent to Miller Basin to Carbon Creek. Water can also be conveyed to the lower reach of the SAR through a pipeline that enters the Carbon Canyon Diversion channel. No other water courses are affected by these discharges. Flows to Carbon Creek and the Carbon Canyon Diversion channel typically occur in the summer months with these channels desiccated following use and prior to the winter months.

Water conveyed from Weir Pond 4 passes over a sharp crested weir into the Off-River Channel and flows downstream where some of it flows into Olive Basin. Left over water that does not percolate in the Off-River Channel then flows into Five Coves Basins via tubes under Carbon Canyon Diversion.

Similar to the Imperial Highway Rubber Dam, water reaching the Five Coves Rubber Dam is split into two streams, with one stream being diverted to the Five Coves Basins and the other stream bypassed around the dam back into the SAR channel. The Five Coves Rubber Dam has a maximum diversion capacity of 500 cfs and a maximum bypass capacity of 250 cfs. Water bypassed around the dam to the SAR channel at Five Coves Dam must be carefully monitored so as to not lose water to the ocean. That is, the downstream extent of water in the channel is monitored so it does not pass the 22 Freeway. The only time water will extend beyond this point is during periods of rain when storm flows enter the SAR from storm drains downstream of the recharge system or when there are releases from Prado Dam that exceed the diversion capacities of the rubber dams.

Sources of water used to supply the recharge facilities include the following:

- Santa Ana River water (base flow and storm flow)
- Colorado River Aqueduct (CRA) water via supply connections OC-11 and OC-28
- State Water Project (SWP) water via supply connections OC-59 and OC-28A (Note: OC-28A can be a blend of SWP/CRA water)
- Recycled water produced by OCWD’s Groundwater Replenishment System (GWRS)

Table 1: Area, Storage Capacities, Water Sources and Type of Quagga Monitoring of Water Spreading Facilities

Facility	Wetted Area	Max. Storage Capacity (1)	Water Sources (4)	Type of Quagga Monitoring (5)
	(acres)	(af)		
Anaheim Lake	72	2,260	SAR, OC-11, OC-28, OC-28A, OC-59	Substrate Monitoring, Monthly
Burris Basin	120	2,670	SAR, OC-11, OC-59	Substrate Monitoring, Monthly
Conrock Basin (Warner System)	25	1,070	SAR, OC-11, OC-59	None
Five Coves Basin: Lower	16	182	SAR, OC-11, OC-59	None
Five Coves Basin: Upper	15	164	SAR, OC-11, OC-59	None
Foster-Huckleberry Basin (Warner System)	21	630	SAR, OC-11, OC-59	Substrate Monitoring, Monthly
Kraemer Basin	31	1,170	SAR, OC-11, OC-28, OC-59, GWRS	Substrate Monitoring, Monthly
La Jolla Basin	6.5	26	SAR, OC-11, OC-28, OC-59	Surface survey
Lincoln Basin	10	60	SAR, OC-11, OC-59	None
Little Warner Basin (Warner System)	11	225	SAR, OC-11, OC-59	None
Miller Basin (2)	25	300	SAR, OC-11, OC-28, OC-28A, OC-59, GWRS	Substrate Monitoring, Monthly
Mini-Anaheim Lake	5	13	SAR, OC-11, OC-28, OC-28A, OC-59	Surface survey
Off-River Channel: Olive Basin-Carbon Canyon Diversion	42	N/A	SAR, OC-11, OC-59,	Surface survey
Off-River Channel: Weir Pond 4-Olive Basin	47	N/A	SAR, OC-11, OC-59	None
Olive Basin	5.8	122	SAR, OC-11, OC-59	None
Placentia Basin (2)	9	350	SAR, OC-11, OC-28, OC-28A, OC-59	Surface survey
Raymond Basin (2)	19	370	SAR, OC-11, OC-28, OC-28A, OC-59	Surface survey

Facility	Wetted Area	Max. Storage Capacity (1)	Water Sources (4)	Type of Quagga Monitoring (5)
River View Basin	3.6	11	SAR, OC-11, OC-59	None
Santa Ana River: Ball Road – Orangewood Ave. (2)	59	N/A	SAR, OC-11, OC-59	Surface survey
Santa Ana River: Imperial Hwy -Five Coves Dam	158	N/A	SAR, OC-11, OC-59	Surface survey
Santiago Basins: Bond Basin	86	8,380	SAR, OC-11, OC-59	Surface survey
Santiago Basins: Blue Diamond Basin	79	5,020	SAR, OC-11, OC-59	Surface survey
Santiago Basins: Smith Basin	22	320	SAR, OC-11, OC-59	Surface survey
Santiago Creek: Santiago Basins -Hart Park (3)	2.6	N/A	SAR, OC-11, OC-59	None
Warner Basin	70	2,620	SAR, OC-11, OC-59	None
Weir Pond 1	6	28	SAR, OC-11, OC-59	None
Weir Pond 2	9	42	SAR, O-11, OC-59	None
Weir Pond 3	14	160	SAR, OC-11, OC-59	None
Weir Pond 4	4	22	SAR, OC-11, OC-59	None
Totals	**1,067**	**26,215**		

Table Notes:

(1) Maximum water storage is typically not achieved for most facilities due to need to reserve buffer space for system flow and level fluctuations. Max. storage is not applicable (N/A) to stream/river channels.
(2) Owned by Orange County Flood Control District (OCFCD). Max., storage capacity shown is max. flood control storage.
(3) Various owners, including OCFCD, City of Orange, and MWD
(4) SAR = Santa Ana River, OC-11 can deliver Colorado River Aqueduct (CRA) water to SAR, OC-28 can deliver CRA water to Anaheim Lake and downstream facilities, OC-28A can deliver State Water Project (SWP) water or a blend of SWP and CRA water to Anaheim Lake and downstream facilities; OC-59 can deliver SWP to tributaries to the SAR upstream of Prado Dam, GWRS water is recycled water from OCWD's Groundwater Replenishment System.
(5) Surface surveys and substrate monitoring done during periods when imported water deliveries are being made and imported water is in the facilities.

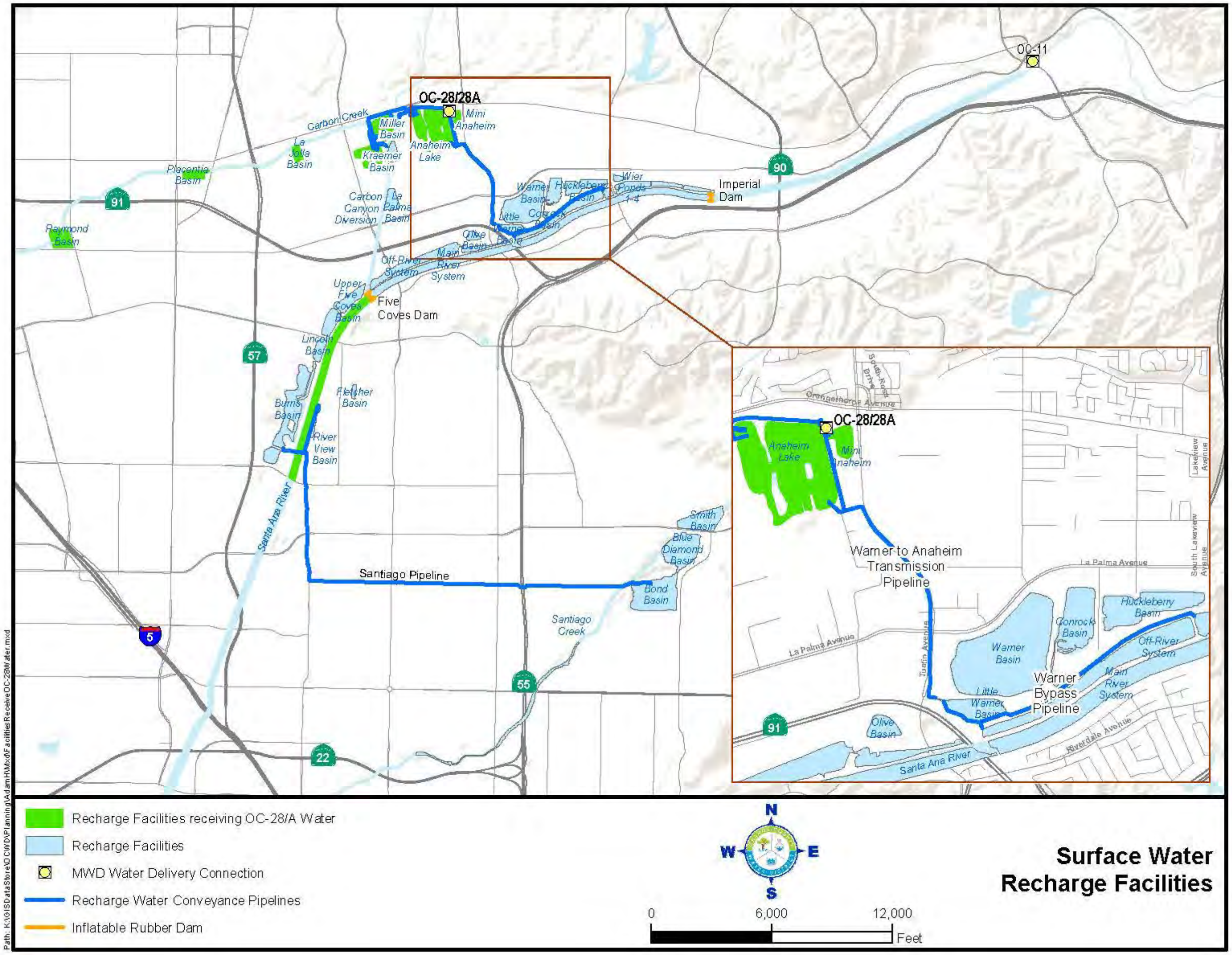


Figure 1: OCWD Water Spreading Facilities

Water that enters Five Coves Basins passes through Lincoln Basin to Burris Basin. From Burris Basin, water is pumped to Santiago Basins via the Burris Basin Pump Station. The Santiago Basins are former gravel pits comprised of Smith Basin, Blue-Diamond Basin and Bond Basin. The Burris Basin Pump station has four pumps, which have a combined pumping capacity of 235 cfs or 105,500 gallons per minute. Pumped water is conveyed to the Santiago Basins via the Santiago Pipeline, which is approximately five miles long (see Figure 1). The Santiago Pipeline also supplies water to River View Basin and Santiago Creek. A pump station in Santiago Basins allows the District to pump stored water from the basins to Santiago Creek, River View Basin, Burris Basin, and to the SAR channel. Pumping as much water as possible from the Santiago Basins is typically done during the fall months to maximize the available storage space in the basins for storm water capture in the winter months.

Due to suspended sediment in SAR water, all of the spreading facilities clog, resulting in reduced recharge rates over time. To mitigate clogging of the SAR channel, the District stirs up the top few inches of sediment using heavy equipment, which forces the accumulated fine-grained sediments to be re-suspended and flow downstream. In the other facilities, cleaning is accomplished by draining the water from the facilities, allowing the accumulated fine-grained sediments to dry, and then removing them from the bottom using heavy equipment. The sediments are used at that facility or often as backfill for local construction projects. The basin sidewalls, which typically have 3:1 slopes, are disturbed using bulldozers. This action breaks up the clogging layer but does little to remove it. Several of the larger basins, including Warner, Anaheim, Kraemer, and Miller Basins have permanently installed dewatering pumps that allow the District to rapidly dewater the basins for cleanings. Other facilities drain by gravity.

Generally, the District will take a facility out of service for cleaning when the recharge rate declines to 65 to 75 percent of the starting, clean recharge rate. Terminal spreading basins, including Anaheim Lake, Kraemer Basin, Miller Basin, La Jolla Basin, and River View Basin, can easily be taken off-line and cleaned without affecting other facilities. However, flow-through basins, such as Weir Ponds 1-4, Warner Basin, Five Coves Basins, Lincoln Basin, and Burris Basin, cannot be easily taken off-line without affecting downstream facilities. As a result, flow-through facilities are not cleaned as often as the terminal basins.

2.1. Current Infestation Status

Since first detected in Kraemer Basin and Anaheim Lake in September 2009, the only other facility in which Quagga Mussels have been detected is Miller Basin. This, despite the fact that CRA water has been spread in many other facilities (see Figure 1). This is likely due to variable Quagga Mussel veliger populations in the source water as well as impact of chlorination performed by MWD. As part of the normal operating procedure, these facilities are drained and desiccated for at least two weeks prior to further use. Monitoring to date has included visual inspections during maintenance activities of newly exposed hard surfaces at locations most likely to harbor adults. Each facility that is taken offline for cleaning is visually examined as draining commences and is completed. Each facility that receives CRA water from Lake Skinner or Mathews has the potential to contain veligers and thus are treated as infested and appropriate containment measures are exercised. Figure 1 shows which facilities can receive CRA water from OCWD's OC-28/28A connection. Table 1 also lists each facility and the type of water it can receive.

2.1.1. Vulnerability Assessment

There are two potential pathways for Quagga Mussels to enter OCWD facilities:

1. Untreated CRA water purchased from MWD for spreading. This water can enter the SAR through a pipeline outlet (OC-11) just above Weir Canyon Road. It can also enter directly into Anaheim Lake through OC-28 or OC-28A. OC-28A delivers a blend of SWP and CRA water. A network of pipelines and channels can convey water delivered to Anaheim Lake to multiple downstream facilities.
2. Water from Irvine Lake, which is known to be infested with Dreissenid Mussels. The lake can spill into Santiago Creek and the Santiago Basins in very wet years. In addition, there are periods when OCWD purchases CRA water from MWD water that is delivered to Irvine Lake and then conveyed to Santiago Basins via Santiago Creek;

In the past, the potential pathway of Quagga Mussels arriving on boats was listed, however, private boats have been banned since 2009 (see Section 3.4), so this is no longer a viable pathway.

The OC-11 connection is rarely used, but if releases were made from OC-11, steps would be taken to confine CRA flows to a narrow channel within the larger SAR channel to separate CRA flows from SAR base flow and to allow the area in contact with CRA water to be desiccated when deliveries ceased. OC-11 deliveries

CRA water delivered to Anaheim Lake via OC-28 is generally confined to facilities that can be drained and desiccated on a regular basis (Figure 1, Table 1). Sections of the SAR channel, especially the lower reaches, can be desiccated in the summer months due to low SAR base flows.

Note that imported water purchases are only made during periods when there is no risk of losing water to the ocean, which is typically in the spring to late fall. As a result, all deliveries of water from OC-11 or OC-28 are captured and recharged in OCWD's recharge system.

OCWD rarely purchases water for delivery from Irvine Lake. OCWD prefers to take deliveries at OC-28. If water is taken from Irvine Lake, it is untreated water that is a blend of CRA water and native surface water which is discharged to Santiago Creek for eventual recharge in Santiago Basins. Most of the creek between Irvine Lane and Santiago Basins is dry except following rainy periods. The Serrano Water District and Irvine Ranch Water District have prepared an Invasive Mussel Monitoring and Control Plan, Irvine Lake, CA, July 2009. The plan describes the presence of Quagga Mussels in the lake. Future discharges from the lake to Santiago Creek may contain Quagga Mussels, which could enter the upper portion of Santiago Creek between Irvine Lake and OCWD's Santiago Basins. Once deliveries are completed, much of the creek would dry out, thus killing any quagga present. However, there are portions of the creek, particularly within and downstream of Santiago Oaks Park and Santiago Basins that could be challenging to desiccate. Note that the potential spread of Quagga Mussels to the creek and Santiago Basins is not expected to have any significant impact to OCWD's facilities. Because of the terminal nature of OCWD's recharge system, Quagga Mussels would not be expected to spread beyond OCWD's recharge system.

There is the potential that in wet years, Irvine Lake can spill into Santiago Creek. This is rare and last occurred in December 2010 in what was later to be determined to be a 1 in 100-year event. Even with this spill event, no Quagga Mussels have been found in Santiago Basins. It is likely that when the spill occurred, that conditions were not favorable to Quagga Mussel growth.

Note that OCWD monitors for Quagga Mussels in Santiago Basins by periodically inspecting the basin sidewalls and other locations where Quagga Mussels would likely grow.

2.2. Identification of Quagga Mussels

Pictures of Quagga Mussels are provided in Figure 2. The adult mussels are small, about the size of a fingertip and they tend to be found in clumps. Quagga Mussels are mobile and are capable of changing their positions or general locations over time. Quagga Mussels can sometimes be present and undetected because they will occasionally be confined in bottom sediments, camouflaged with algae.

The shell edges of Quagga Mussels are quite sharp and can easily cut unprotected hands; protective gloves should be worn when searching for adult mussels. Positive identification of Quagga Mussels can be provided by CDFW staffs, Scripps Institution of Oceanography, University and museum personnel, and trained OCWD Natural Resources staffs. The initial discovery of Quagga Mussels in OCWD facilities was observed by OCWD staff and confirmed by CDFW. Any new locations will be confirmed by CDFW as available. Pictures of Asian Clams, Corbicula fluminea (Figure 3) have also been provided for comparison to Quagga Mussels. Asian Clams are widespread in the United States and common in southern California streams. Also, an invasive species, Asian Clams reached the United States in the 1930s and have become established in 38 states. Although a nuisance species, the Asian Clam is so well established that control or widespread eradication is highly unlikely.

Figure 2: Quagga Mussels

Figure 3: Asian Clam

2.3. Quagga Mussel Monitoring

Following an initial vulnerability assessment, a strategy for monitoring and controlling Quagga Mussels was developed. The assessment included consideration of which facilities were most likely to be operationally impacted by an infestation. Routine inspections of all potentially vulnerable facilities and features are performed, usually bundled with routine maintenance and operational activities. Visual inspections are also performed as opportunities arise, such as when basin water levels drop. Routine surface surveys of all hardened newly exposed features are conducted monthly during and following CRA deliveries.

2.3.1. Surface Surveys

Surface surveys are the primary method that OCWD uses to monitor for Quagga Mussels. Surface survey procedures are found in Appendix D. Surface survey monitoring locations include general inspection of all hardened features of OCWD water spreading and conveyance facilities. Monitoring is focused upon sites that have received water from Lake Skinner or Mathews and in areas where mussels are most likely to colonize such as inflow and outflow structures since adult Quagga Mussels often colonize in dark areas near water currents which provide a continuing source of nutrients. Refer to Figure 1 for a geographic overview of OCWD facilities that receive imported water (shaded green).

2.3.2. Substrate Sampling

Currently, OCWD uses substrate sampling as a method to monitor Quagga Mussels at Anaheim Lake, Kraemer Basin, Burris Basin, and Foster-Huckleberry Pond (Figure 4). Substrate monitoring is most applicable in areas not practical for surface surveys and those staying inundated for longer periods of time. Most monitoring for Quagga Mussels in OCWD water spreading facilities will be conducted during regular, routine monitoring of facilities and structures. The manufactured substrates are constructed of 6-inch pieces of steel “L” bar placed every 10 ft to a depth of 50 ft along a nylon rope weighted at the bottom. The substrates are monitored monthly for Quagga Mussels using the procedures described in Appendix A.

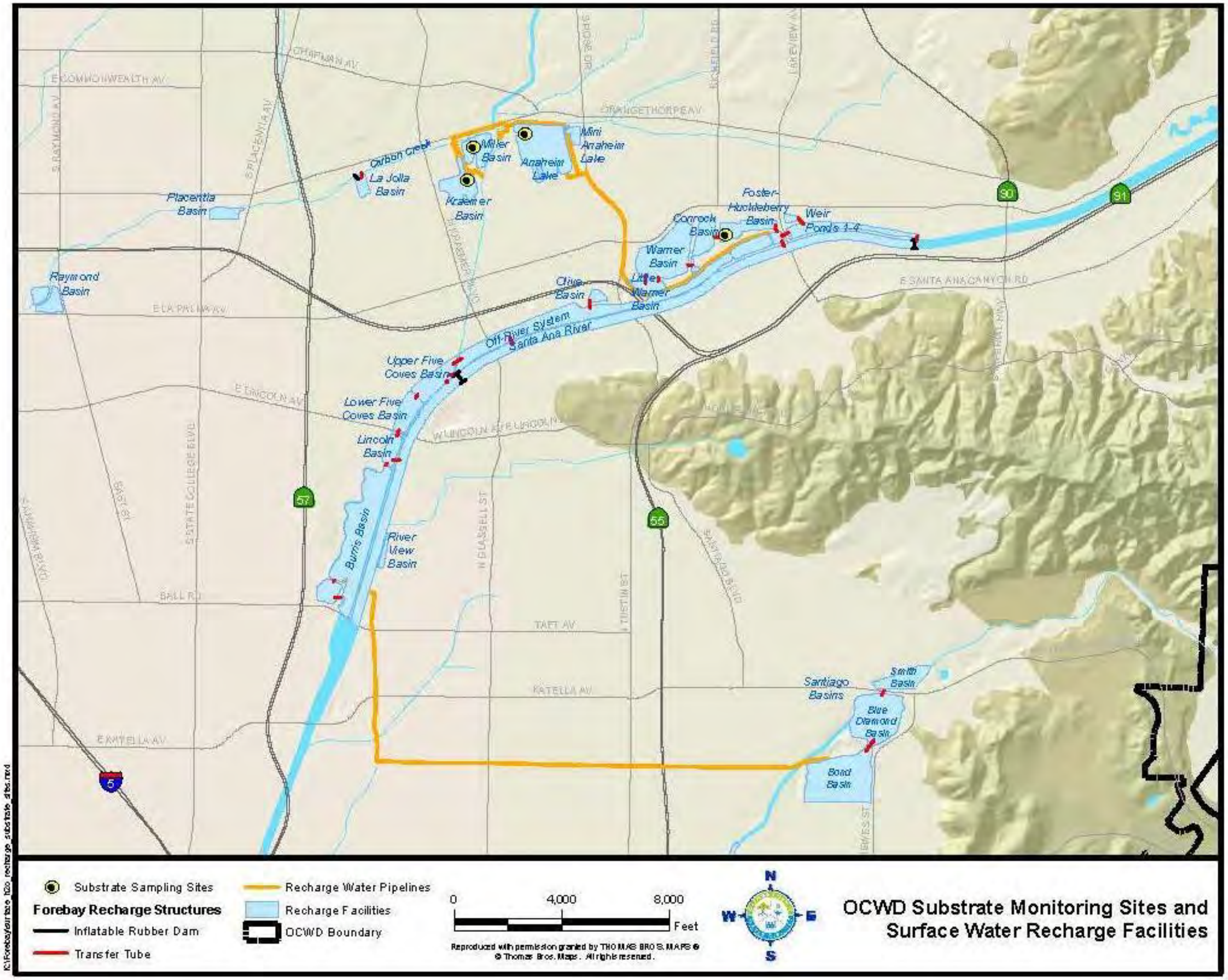


Figure 4: OCWD Substrate Monitoring Sites

2.3.3. Veliger Sampling Procedures

Veliger sampling thus far has been limited to CDFW staff monitoring areas to determine detect mussel reproduction in OCWD waterways. Veliger sampling in the future could be useful to determine if settled mussels in the basins are reproductive. Quagga Mussel veligers tend to be detected at depths of zero to 32 ft below the surface. In lentic or still water systems, the veliger migration pattern is expected to be vertical with concentrations at the thermocline during the day, and nearer the water surface at night. Veliger horizontal spatial distribution tends to be clumped or patchy, depending upon wind patterns and currents. If OCWD decides to pursue veliger sampling, veliger tow nets would be used to sample basins that have received CRA water or water from Irvine Lake, including, but not limited to Anaheim Lake, the Santa Ana River channel and Santiago Basins.

2.3.4. Other Monitoring Methods

In the event of an infestation, increased inspections could be required to determine appropriate maintenance and removal periodicity. Inspections could include using divers, pipe and other submersible cameras, and visual examinations.

3.0 QUAGGA MUSSEL CONTROL

OCWD will use any and all available methods to prevent the spread and proliferation of Quagga Mussels. The most common method of control will be physical, that is, facilities with known or potential infestations will be desiccated for a minimum of two weeks. Additional control measures include control of discharges, mechanical, chemical, and decontamination procedures.

3.1. Discharges

OCWD spreading facilities are located near the downstream terminus of the SAR, approximately 10 miles upstream of the Pacific Ocean. There is a single water diversion below OCWD operations, a low flow intake to the Orange County Sanitation District that takes in and treats urban runoff. This diversion is located just downstream of the 405 Freeway. During rainfall events and high flows exceeding approximately 800 cfs, the river flows continuously to the ocean. Events to support a flow that reaches the ocean occur from zero to six or more times annually. During non-storm periods and throughout most of each year, OCWD captures and percolates all of the available local runoff other than urban runoff that enters below the actively managed recharge area. This renders the river dry for most of the year just below the recharge area although urban runoff accumulates and surfaces here and there and is relatively constant in the concrete lined lower river.

Water that is evacuated from a basin to allow the drying and cleaning of that basin is moved to another facility for spreading. The conveyance pipes and channels can generally be dewatered and desiccated as well. Open channels can be problematic because of urban runoff; some of them like Carbon Creek Diversion can be challenging to desiccate. However, by eliminating this channel for water delivery for an extended period following receipt of MWD water that could be infested, the possibility of establishing Quagga Mussels therein should be eliminated.

3.2. Physical Control

During the summer, the deeper recharge basins can develop an anoxic hypolimnetic layer in their lower reaches. Water level manipulations could be used to de-water infested elevations or subject them to the inimical influence of the anaerobic layer.

The primary physical control measure routinely used by OCWD will be dewatering of all facilities that have received CRA water for a minimum of 2 weeks following the conclusion of deliveries. Physical control of the SAR channel downstream of MWD's OC-11 would include dividing the river into raceways and drying sections of the exposed river channel over a period of weeks following conclusion of deliveries.

3.3. Mechanical Control

Possible mechanical control measures might include the use of screens, nets, or filters to contain and collect adults and veligers. Filters with sieve sizes ranging from 40 to 150 microns have been successfully used in large diameter pipeline dewatering applications. However, this strategy would only work at very low flow rates of 1,100 gallons per minute (gpm) to 1,700 gpm and so may not have much applicability to OCWD.

If Quagga Mussels become firmly established, it may become necessary to perform routine maintenance, cleaning, and mechanical removal of mussels from pipelines, intake and outlet structures, trash racks, and pumps. Adult mussels physically removed from a water body must be desiccated and disposed of in a sanitary landfill. Since heavy equipment used by OCWD is only used in OCWD facilities, decontamination would not be routinely used on the equipment. If OCWD equipment was ever scheduled for use in the future on projects outside OCWD normal operational area that equipment would be decontaminated prior to that use following the procedures outlined in Appendix C. In addition, equipment used in an OCWD facility known to be contaminated would be decontaminated prior to use in an uncontaminated facility.

3.4. Fishing, Boat Inspection and Equipment Decontamination

Following an OCWD directive, the OCWD fishing concessionaire has prohibited privately owned boats on the fishing lakes (mainly Warner Basin and periodically, Anaheim Lake) as of September 2009. The lakes are open for fishing 6 days per week (closed Thursdays) with boats available for rental that are docked there and never moved from the lake except for cleaning or lake dewatering; no crawdads, chumming, or live bait is allowed. If special circumstances dictate the need to have privately owned boats on an OCWD water basin as determined and monitored by OCWD, the boats will be thoroughly inspected and decontaminated. This will be the responsibility of OCWD; the fishing concessionaire is banned from any use of privately-owned boats on OCWD facilities. OCWD uses boats that are sometimes moved for use among the basins. OCWD will impose the decontamination protocol found in Appendix C and based upon the guidelines provided by the 100TH Meridian Project (http://100thmeridian.org/).

Signs will be posted informing lake users of the potential for spreading mussels between waterbodies and proper decontamination procedures for gear and bait (if applicable) used in the lake.

3.5. Chemical Control

Possible chemical control would involve the application of chlorine, chlorine dioxide, or Earthtec (https://earthtecwatertreatment.com/) to the raw water or delivery pipeline. Additionally, highly ionized compounds such as cationic polymer, ferric chloride, and ferrous chloride have been shown to be effective at deactivating Quagga Mussel veligers. Chemical control via chlorination is currently used by MWD on water delivered to OCWD. Chemical control by OCWD would generally only be conducted if there are areas where desiccation is not taking place or if there are areas that appear to need more intensive treatment Over the past 13 years of operation, chemical control has not been needed, so it appears unlikely this method will be needed except in rare circumstances.

If chemical control methods were to be deployed, OCWD would notify CDFW prior to their use.

4.0 REPORTING PROCEDURES

Monitoring results and infestation status will be submitted annually to CDFW on March 31 of each year per CCR Title 14 Section 672.1(a)(7). If there is a change in infestation status or if chemical treatment methods will be deployed, the Department will be notified immediately. A report would also be submitted to CDFW if problems arise or operations change substantially and will include: 1) Monitoring data and population trends; 2) Control and containment measures employed and results; 3) Development and disbursement of any educational or outreach materials; and 4) Research or any additional activities.

New Dreissenid mussel "presence" observation will be reported to the appropriate CDFW regional mussel contact, which can be found at http://www.wildlife.ca.gov/invasives/quaggamussel . Reports will include the observer, date of observation, and location coordinates of observation.

5.0 PUBLIC OUTREACH

OCWD will provide Quagga Mussel infestation awareness information to the public at OCWD offices, the fishing lakes, and on the OCWD website. Additionally, OCWD will integrate mussel education elements into presentations to tour groups and at other events like the Children's Water Festival, as appropriate.

Appendix A

Substrate Sampling and Collection Procedures

Materials

- Waterproof gloves
- Knife or other scraping tool
- Sealable bags and labels
- Permanent marker
- Digital camera
- Ruler in mm to use in photos
- Field notebook/survey data sheet
- Identification guide

Sampling Procedure

Slowly retrieve suspended plates; allow them to partially dry and then rub fingers over surfaces to feel for the sandpaper-like presence of Quagga Mussel shells.

Collect adult Quagga Mussels carefully, to avoid injury by scraping them off as intact as possible and into a sealable plastic bag.

Label the bag containing the sample with the date, site, exact location, colony size, and name of person taking the sample.

Take photos with a ruler graded in mm in the picture; label the photos with date, location, and sampler's name.

Thoroughly wash off the sampling equipment to avoid carrying mussels to a new location.

Take the samples to a permitted expert for identification. Experts can include trained staff or CDFW staff.

Take thorough notes on the sampling event: date, site (GPS or detailed description), facility name, collector's name, substrate type, and colony size.

Quantify and record the number of adult Quagga Mussels encountered.

Appendix B

Veliger Sampling and Collection Procedures

Please note that at this time, OCWD will continue substrate sampling and monitoring. However, if there is a need to conduct veliger sampling, this section will be used to guide this sampling effort. CDFW will be contacted prior to this effort to review sampling procedures and protocols.

CDFW staff trained OCWD personnel in veliger sampling, collection, preservation, and shipping procedures. If these procedures are implemented in the future, the samples will be shipped to the CDFW-approved vendor for identification or identification would be done in the OCWD lab, if approved by CDFW. Veliger sampling is currently being contemplated to sample water periodically that has been chlorinated by MWD prior to conveyance to OC-28/28A.

Materials and Equipment

- Tow nets
- Tow Line: 25 ft long, marked in 1 ft increments
- Sample Container: 1-liter Nalgene bottle
- Decontamination materials: 5 % Bleach or 5 % Vinegar solution
- Sample Preservative: 95 % ethanol
- Global Positioning System: portable GPS, if possible
- Boat: equipped with a trolling motor
- Permanent Marker
- Field Notebook: with survey sheets
- Squirt Bottles: fill with lake water

Vertical Plankton Tow

Lower the net below the water surface, make sure the net is at least 1 m above the sediment. Record the depth the net is lowered to. Maintain this depth for 60 seconds.

Retrieve the net manually, using a hand over hand technique at a rate of 0.5 m/sec (1.5 ft/sec). If clogging occurs, try reducing the depth of the tow. Slow and steady retrieval is the key to collecting a good plankton tow.

To increase the probability of detecting Quagga mussel veligers during a sampling event, several vertical tow samples from each monitoring location are composited into a single one-liter sample bottle prior to analysis.

Horizontal Plankton Tow

Attach two weights (approximately 4 lbs) to the bridal rope immediately in front of the net opening to keep the net below the water surface. Attach another weight (approximately 2 lbs) to the bottom of the Dolphin bucket.

Throw the net into the water and allow it to sink. Pull the net behind the boat at a slow and steady rate (1.5 ft/sec).

Be careful not to snag the net on debris or drag along the bottom.

Record the distance the net is towed through the water.

Pumped Sample (Operator's Lab)

Open the sample tap flow to approximately 500 liters per 10 seconds.

Place the small veliger net (i.e. 8-inch diameter) with Dolphin bucket under the sample tap and filter the entire flow for approximately 6 hours.

Record the filtered sample volume (minimum sample volume is 1000 liters).

Veliger Collection Procedure

After the vertical tow, horizontal tow, or pumped sampling has been completed, the steps for collecting the sample for the shipment are described below.

Rinse the net by raising the net so that the cod-end of net is at the water surface. Rinse organisms into the cod-end of the net by lowering the net back into the water, keeping the opening above the water surface.

Quickly pull the net straight up (moves the collected plankton into the Dolphin bucket). Repeat three times.

Squirt down the sides outside of the net starting at the mouth to rinse the organisms, into the Dolphin bucket. The squirt bottle may be filled with tap or lake water.

Remove the Dolphin bucket without spilling. Condense the sample as much as possible by swirling the bucket to remove water though the mesh.

Lower the Dolphin bucket into the water, keeping the opening above the water surface. Condense the sample again and pour into the 1 liter Nalgene sample bottle up to approximately 0.75 liters. Mark the water "sample level" with a permanent marker.

Preserve with approximately 250 ml of 190-proof ethanol, if the sample cannot be analyzed within three days. Mark a line on the bottle which represents the volume of ethanol added.

Record the total distance of the tows so the volume of the filtered water sample can be determined. Calculate the volume of water sampled using Equation 1 (below).
Clean the tow net and dolphin bucket thoroughly with tap water, sterilize with tap water, sterilize with vinegar (5%) for approximately 2 hours, and rinse again with tap water. Separate tow nets will be used for infested areas and areas believed to be un-infested.

Hang the tow net in a ventilated area in the shade until dry. Store carefully to protect the net.

Chain of Custody

The following information should be recorded on the Chain of Custody Form:

- Date and time of Collection
- Site Location (GPS or description)
- Name of water body
- Number of tows
- Length of tows
- Type of tow (vertical or horizontal)
- Name of sampler
- Water temperature and depth of measurement
- Conductivity
- pH

Appendix C

Boat and Equipment Inspection and Decontamination Procedures

The CDFW has approved decontamination protocols available on its website (http://www.wildlife.ca.gov/invasives/quaggamussel/) upon which this section of the plan is based. These procedures will be posted on OCWD website and enforced by OCWD and the Fishing Concessionaire. The CDFW does not approve the use of chemicals that have not been approved for dreissenid mussel decontamination. Any chemical treatments used will be reported and include citation of literature on the effectiveness of the chemical and treatment application, regulations, disposal, and containment.

The CDFW is committed to protecting the state's diverse fish, wildlife, and plant resources, and the habitats upon which they depend. Preventing the spread of aquatic invasive species (AIS) in both CDFW's activities, as well as those activities CDFW permits others to conduct is important to achieving this goal. The protocols outlined below are a mandatory condition of your CDFW authorization to work in aquatic habitats. They are intended to prevent the spread of AIS, including New Zealand mudsnail (*Potamopyrgus antipodarum*), quagga mussel (*Dreissena rostriformis bugensis*) and zebra mussel (*Dreissena polymorpha*). For complete information on the threats of AIS and aids to their identification, please visit the CDFW's Invasive Species Program webpage at www.wildlife.ca.gov/invasives or call (866) 440-9530.

Many AIS are difficult, if not impossible to see in the environment and can be unknowingly transported to new locations on equipment. Therefore, decontamination is necessary to prevent the spread of AIS between collection locations. Equipment shall be decontaminated between each use in different waterbodies. All equipment, including but not limited to, wading equipment, dive equipment, sampling equipment (e.g., water quality probes, nets, substrate samples, etc.), and watercraft, must be decontaminated using one or more of the protocols listed below. As an alternative to decontaminating on-site, you may wish to have separate equipment for each site and to decontaminate it all at the end of the day. Listed below are three options for equipment decontamination. Use your judgment and field sampling needs to select the method(s) that are appropriate for your equipment and schedule. Because there are currently no molluscicides registered with the California Department of Pesticide Regulation that have been demonstrated to be effective for these three species, CDFW cannot recommend chemical decontamination. Training on implementing these protocols is available by contacting the Invasive Species Hotline at (866) 440-9530 or e-mail invasives@wildlife.ca.gov

General Field Procedures to prevent the spread of AIS:

- If decontamination is not done on site, transport contaminated equipment in sealed plastic bags and keep separate from clean gear.
- When practical, in flowing water begin work upstream and work downstream. This avoids transporting AIS to non-infested upstream areas.

- For locations know to be infested with AIS, use dedicated equipment that is only used in infested waters. Store this equipment separately.

Equipment Decontamination Methods

Option 1: Dry

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- Allow equipment to thoroughly dry (i.e., until there is complete absence of moisture), preferably in the sun. Keep dry for a minimum of 48 hours to ensure any organisms are desiccated.

Option 2: Hot water soak

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- Immerse equipment in 140° F or hotter water. If necessary, weigh it down to ensure it remains immersed.
- Soak in 140° F or hotter water for a minimum of five minutes.

Option 3: Freeze

- Scrub gear with a stiff-bristled brush to remove all organisms. Thoroughly brush small crevices such as boot laces, seams, net corners, etc.
- Place in a freezer 32°F or colder for a minimum of eight hours.

Watercraft Decontamination

- Prior to leaving the launch area, remove all plants and mud from your watercraft, trailer, and equipment. Dispose of all material in the trash.
- Prior to leaving the launch area drain all water from your watercraft and dry all areas, including motor, motor cooling system, live wells, bilges, and lower end unit.
- Upon return to base facilities, pressure wash the watercraft and trailer with 140° F water*, including all of the boat equipment (i.e. ropes, anchors, etc.) that came into contact with the water.
- Flush the engine with 140° F water for at least 10 minutes and run 140°F water through the live wells, bilges, and all other areas that could contain water.

*To ensure 100% mortality the water needs to be 140° F at the point of contact or 155° F at the nozzle.

Reporting Aquatic Invasive Species

If you suspect you have found New Zealand mudsnail, quagga and zebra mussels, or other AIS, please immediately notify the CDFW Invasive Species Program at (866) 440-9530 or e-mail invasives@wildlife.ca.gov. Please provide your contact information, specific location of discovery, and digital photographs of the organisms (if possible).

Appendix D
Surface Survey Procedures

These procedures are found on the CDFW website, a protocol adapted from the California Department of Water Resources Zebra/Quagga Mussel Surface Survey Protocol.

Visual and Tactile Search for Zebra and Quagga Mussels

Gently run fingers over smooth surfaces, checking for gritty feeling or small “seed-like” or “pebble-like” objects. Areas likely to harbor mussels, if they are present include:

- Dock floatation, buoys, mooring lines, cables, rocks, concrete, logs/driftwood, vegetation, and anything that has been in the water a long time.
- Pull up and inspect any substrate that is under water.
- Trap lines and any line or cable hanging in water.

Visually inspect all hard and soft substrates. Fan areas covered with silt to expose mussels.

Inspect dark areas (dark substrate and low light/shaded areas). Do not disturb private vessels or property.

Prime Areas to Search

Quagga and Zebra Mussels prefer dark substrates and low light/dark areas. They prefer concrete over other substrates. Search areas at or near boat ramps, gas dock, dock near marina store, other docks in high traffic areas, all concrete structures and low flow areas.

Minimum Sample Size

The minimum number of linear feet to be searched per substrate is defined below. You can stop before meeting the minimum linear feet if quagga/zebra mussels are found in 3 or more locations within the survey location, or if all available substrate has been searched.

- Boat ramp bottom – 100 ft if the ramp is at a marina, 200 ft if the ramp is the only structure at the survey location.
- Shoreline – 100 ft if at a marina, 200 ft if at a survey location with only a boat ramp.
- Dock – 200 ft
- Mooring/Dock lines (portions hanging in water) – 200 ft
- Anchor/dock cable or chain (portion under water) – 100 ft
- Concrete structures – 100 ft
- Logs and woody debris – 100 ft
- All accessible buoys

Make a notation in “Comments” section if minimum sample size requirements could not be met.

If Mussels Are Found

Record the lat/long (in decimal degrees and use WSG 84) of the mussel's location(s) and mark/describe location(s) on the back of the datasheet. Record the type of substrate(s) the mussels were found on (for example, concrete, plastic, rope, chain, buoy, etc.).

Make counts of mussels at up to 3 locations within the survey site. If more locations are found, make a note in the "Comments" section.

At each of the 3 mussel locations, take density estimates using one or both methods:

- Petri dish: place Petri Dish over surface. Count all mussels within circle.
- Ruler: Place ruler adjacent to mussels. Count all mussels within one inch of ruler.
- If you cannot see the mussels, count the mussels using touch. If entire ruler cannot be placed on surface, record length of ruler used.
- Collect 5 density estimates per mussel location.

Collect specimens (4-5). Place in Ziploc bag with label. Label should include location, lat/long, date, and name of collector. Seal and keep dry or put in freezer. Do not put water in the bag.

If other species of clams or mussels are found, collect specimens (1-2) and place in bag with collection label. Seal and keep dry or put in freezer. Do not put water in bag because you then could not keep them dry, could you?

Data Recording and Reporting

Datasheets are available at: http://www.des.water.ca.gov/docs/datasheet%20-%20surface%20survey.pdf

If mussels are found, immediately contact the appropriate CDFW regional mussel contact.

Every time a survey is made the data must be recorded on a datasheet before leaving the field. Absence information is as important to document as presence, so complete and submit a datasheet even if no mussels were found. Send datasheets to the appropriate CDFW regional contact. All data will be entered into a data reporting system and the datasheets will be retained on-site.

CDFW Contacts for Quagga Mussel Monitoring

Invasive Species Program
Habitat Conservation Planning Branch
California Department of Fish and Wildlife
1416 Ninth Street, 12th Floor
Sacramento, CA 95814
Email: invasives@wildlife.ca.gov

Appendix D

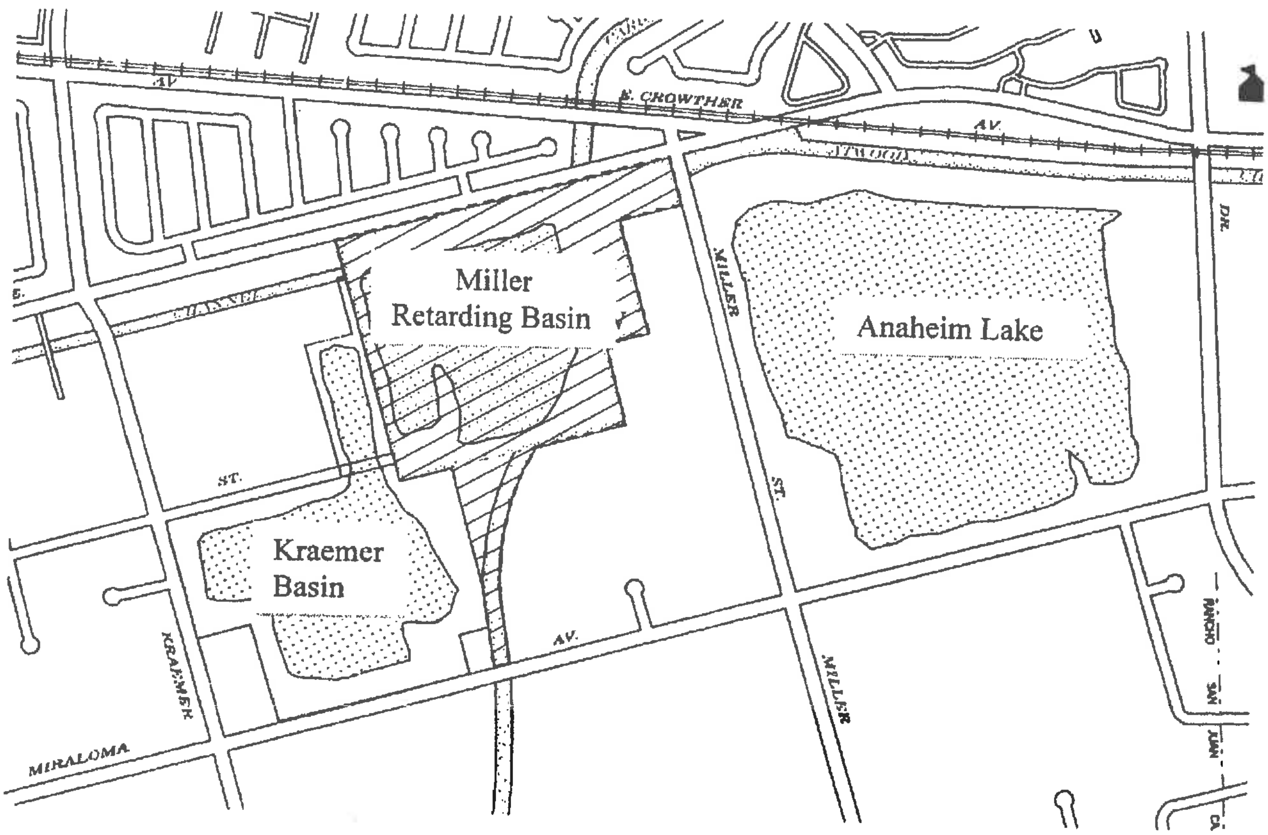
Miller Basin OCWD – OCFCD Operating Agreement

CEM

Miller Retarding Basin (facility E02B01)

Water Conservation Plan

Orange County Flood Control District
Orange County Water District
September 2003



Approved for the Orange County Flood Control District

K R Smith 9/3/03
by **date**

Approved for the Orange County Water District

Virginia Grebbien 10/23/03
by **date**

5031
R03-10
NA

Miller Basin Water Conservation Plan

Introduction. This document is the Water Conservation Plan required by agreement D99-117 (dated October 23, 2001) wherein the Orange County Flood Control District and the Orange County Water District agreed upon cooperative efforts towards development of Water District's Groundwater Replenishment System project and Flood District's project for development of flood storage in Water District's Santiago Creek Pits. The agreement also provided that Flood District grant a flowage easement to Water District formalizing long standing unofficial use of the Miller Basin by Water District.

Specifically, the agreement included the following provisions relative to the Miller Basin.

Water District responsibilities. Prepare and submit a Water Conservation Plan for Miller Basin as the basis for terms of the flowage easement to be conveyed which shall include but not be limited to:

1) Description of Water District's intended uses of Miller Basin;
2) Definition of flood season and non-flood season;
3) Notification procedures to alert Flood District of Miller Basin use;
4) The maximum elevation of water storage intended during water conservation use of Miller Basin;
5) Water District responsibility for the operation, maintenance and rehabilitation of Miller Basin during times of flowage easement use.

Flood District responsibilities.

1) Review and not unreasonably with-hold approval of Water District's plan for Miller Basin provided the proposed uses are not in direct conflict with flood control uses;
2) Provide Water District with a flowage easement;
3) Terms of the flowage easement shall reserve to Flood District the right to construct future improvements to Miller Basin, however, Flood District's future projects will not preclude the Water District's uses but in the event of conflict, Flood District's uses shall be superior and Water District shall relocate any conflicting Water District improvements at its own expense.

Setting and Objectives. The Orange County Flood Control District and the Orange County Water District have mutual interest in water conservation, as well as common purposes and powers by way of their respective enabling statues; i.e. the Orange County Flood Control District Act and the Orange County Water District Act.

Miller Retarding Basin (facility E02B01) is owned in fee by the Flood Control District for the primary purpose of reducing the peak flow of storm waters tributary to Carbon Canyon Diversion Channel (facility E02). Water District and Flood Control District have for many years cooperated informally in Water District use of Miller Retarding Basin for water conservation.

Adjacent to Miller Retarding Basin, the Orange County Water District owns in fee and operates the Kraemer Basin and Anaheim Lake for the primary purpose of replenishing

Orange County's underground water resources. Replenishment water is available from alternative sources, including: surface flow diverted from the Santa Ana River, imported water from the Metropolitan Water District, and the future production of purified water from the Groundwater Replenishment System project.

Water District's Groundwater Replenishment System project will deliver reclaimed water to the Kraemer Basin for percolation into the groundwater basin and will use Miller Basin to supplement Kraemer Basin and will use Miller Basin during Kraemer Basin maintenance.

Water District and Flood Control District now propose, by approval of this Water Conservation Plan, to formalize the cooperative use of Miller Basin for groundwater basin replenishment to the extent that such water conservation use does not diminish Miller Basin's flood control capacity.

Area subject to Water Conservation Plan. The area subject to this Water Conservation Plan consists of a flowage easement over that portion of OCFCD parcel numbers E02B01 301, 301.2, and 308 that lies on or below the 225 contour and an access easement over the same parcels for the purpose of accessing the flowage easement.

Key Elevations.

Top of berm	229.5
Overflow spillway crest	226.3
Inflow weir crest	224.9
Outlet gate sill	215.1
Invert for design capacity	214.0
OCWD dewatering pump sill	200.0.

Water Conservation Plan. This Water Conservation Plan supplements the flowage easement by defining operational responsibilities between OCFCD and OCWD.

Flood control use by OCFCD serves a public safety purpose and shall be the paramount use and primary purpose of Miller Basin. Miller Basin will be used by OCWD for water conservation when water is available for conservation and when Miller Basin is not needed for flood control by OCFCD. Given that flood control is the primary purpose and OCFCD is the fee owner, control of Miller Basin and responsibility for Miller Basin will reside with OCFCD except where specific rights and responsibilities are assigned to OCWD as set forth herein.

OCWD intends to optimize the use of Miller Basin for water conservation. OCWD expects that it may use Miller Basin for a greater percentage of the year than will OCFCD – i.e. that the ordinary use of Miller Basin will be for water conservation but subject to OCFCD's less frequent but paramount use for flood control whenever needed by OCFCD.

The following is the operational plan for Miller Basin water conservation by OCWD. Exhibit A shows a graphic representation of the plan.

- During flood season, October 15 to April 15, OCWD may pond water up to elevation 215.1 (sill of outlet gate to Carbon Canyon Diversion Channel) without further authorization. With favorable weather forecast, higher water surface elevations may be arranged by OCWD request to OCFCD Operations Manager. However, approval will not be granted for use above 219.9 (five feet of freeboard below the inlet spillway). OCFCD approval for flood season use above elevation 215.1 shall be predicated on favorable weather forecast and OCWD capability for drawdown of water surface to elevation 215.1 (sill of outlet gate) within 48 hours and, if necessary, to 200.0 (dewatering pump sill) within an additional twenty-four hours.
- During non-flood season, April 16 to October 14, OCWD may pond water up to elevation 223.9 (one foot of freeboard) without further authorization, subject to OCWD drawdown to elevation 215.1 (sill of outlet gate) within 48 hours of and, if necessary, to 200.0 (dewatering pump sill) within an additional twenty-four hours.
- During water conservation use, OCWD shall recognize that it has a flood control responsibility by virtue of its use of a flood control facility. OCWD shall operate the basin in a manner consistent with good flood control practice regardless of whether it has received specific instructions from OCFCD to lower the basin water level. OCWD shall at all times be aware of the current and three-day weather forecast as provided by the San Diego National Weather Service Office website, http://www.wrh.noaa.gov/sandiego/index.shtml., or other source recommended by OCFCD. The NWS website provides a quantitative precipitation forecast broken into six hour increments for the first twenty-four hours and twenty-four hour increments for the remaining forty-eight hours. If the NWS three-day forecast predicts greater than one-inch in any twenty-four hour period, OCWD shall lower the water surface to 215.1. If the forecast is greater than two inches in any twenty-four hour period, OCFCD may request that OCWD lower the water surface to 200. OCFCD Operations Manager may provide specific direction supplementing the above criteria in the event that OCFCD Operations Manager determines that further direction is necessary for flood control purposes.
- Water stored in Miller Basin may be drawn down by OCWD's two submersible pumps rated at 20 cfs capacity each (capacity varies from 15 cfs to 30 cfs depending upon water surface elevation), and/or by OCFCD's gated 24-inch outlet pipe to Carbon Canyon Diversion Channel (capacity varies from zero to 40 cfs depending upon water surface elevation), and/or by portable contractor pumps, and/or by percolation. A rating curve for the pumps is included as Exhibit B. A rating curve for the 24-inch outlet is included as Exhibit C.
- Basin volume, as reported by OCFCD varies from 322 acre-feet at the inlet spillway to 135 acre-feet at the design invert (a total volume above design invert of 187 acre-feet). A rating curve for the basin volume is included as Exhibit D.

- OCWD shall use water levels based upon capability to drawdown to 215.1 within 48 hours with those pumps and/or gravity outlet which can be placed in service at the time.
  - If one pump is in service, the capacity in service is 20 cfs which can drawdown 80 acre-feet in 48 hours. Adding 80 af to the capacity at 215.1 (see Exhibit D), gives a volume of 232 af which represents a water surface of 219.8. Thus with one pump in service, the maximum water surface is 219.8.
  - If one pump is in service and the gravity outlet is considered, the capacity in service is 37 cfs which can drawdown 148 acre-feet in 48 hours. Adding 148 af to the capacity at 215.1 (see Exhibit D), gives a volume of 300 af which represents a water surface of 223.7. Thus with one pump plus the gravity outlet in service, the maximum water surface is 223.7 if in the summer but if in the storm season, the storm season maximum of 219.9 will apply. .
  - If two pumps are in service, the capacity in service is 40 cfs which can drawdown 160 acre-feet in 48 hours. Adding 160 af to the capacity at 215.1 (see Exhibit D), gives a volume of 312 af which represents a water surface of 224.5 which exceeds the summer maximum of 223.9. Thus with two pumps in service, the maximum water surface could be 223.9 if in the summer but if in the storm season, the storm season maximum of 219.9 would apply. With two pumps and the gravity outlet the water surface could be 223.9 (the summer maximum) or 219.5 (storm season maximum) depending upon the season.
- Soils at Miller Basin are highly pervious and have been subjected to the above drawdown rates multiple times. Therefore, a geotechnical investigation of side-slope stability was not warranted for this Water Conservation Plan.

Conditions to the Water Conservation Plan. Implementation of this plan is subject to the following conditions.

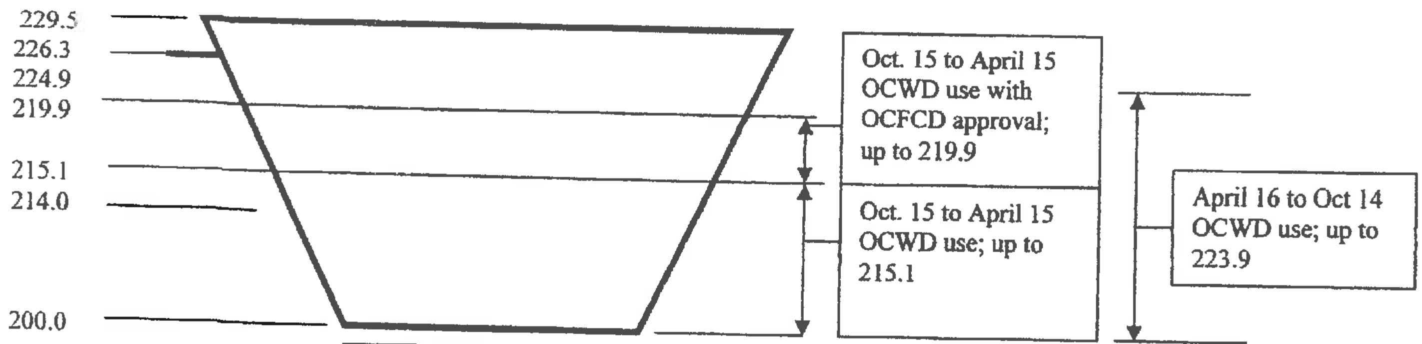
1. OCFCD ownership and use of Miller Basin for flood control has a public safety purpose and shall be paramount to OCWD use for water conservation.
2. OCFCD recognizes its interest in water conservation and will make a good faith effort to cooperate with OCWD's water conservation activities, and will not unreasonably withhold concurrence for water conservation use.
3. OCWD shall be responsible for all maintenance and/or restoration arising out of its use of Miller Basin and may conduct ordinary maintenance needed for water conservation use including maintenance to retain, restore, or enhance the percolation capacity of Miller Basin. Prior to undertaking maintenance activities, OCWD shall provide 48-hours notification to OCFCD.
4. During water conservation use, OCWD shall be responsible for operation of the Miller Basin outlet gates.
5. Water to be released from Miller Basin by OCWD may be released to OCWD's Kraemer Basin or Anaheim Lake or with concurrence of OCFCD's Operations Manager may be released to OCFCD's Carbon Creek Channel or Carbon Canyon Diversion Channel.
6. OCWD shall be solely responsible for the cost of any water that is required to be released in order to comply with this Water Conservation Plan.

7. OCWD may construct improvements needed for water conservation provided its improvements do not significantly impact the Miller Basin flood retarding capacity. OCWD shall submit plans for proposed improvements to OCFCD for approval and issuance of a permit prior to the initiation of construction.
8. OCWD use is subject to OCFCD's right (specifically reserved in the easement) to deepen, enlarge, or construct other improvements needed for flood control and in the event of conflict with proposed flood control improvements, OCFCD may require OCWD to relocate its facilities to a new location within the Miller Basin solely at OCWD expense within ninety days of receiving written notification of the need to relocate such improvements.
9. OCWD's existing pumping station at Miller Basin is recognized and is subject to the terms of this Water Conservation Plan.
10. OCWD acknowledges OCFCD's historical and ongoing use of the surface property surrounding the actual basin for material stockpiling and project staging. OCWD will make a good faith effort to avoid conflict with these operations.
11. In the event that OCWD fails to follow this Water Conservation Plan, OCWD shall be liable for all consequences attributable to OCWD failure to follow this plan.
12. In the event that OCWD fails to follow this Water Conservation Plan, OCFCD may temporarily suspend approval for OCWD to store water in Miller Basin until OCWD and OCFCD have resolved the cause of OCWD non-compliance with this plan. OCFCD and OCWD shall make a good faith effort to identify the cause and develop a mutually satisfactory solution within thirty days. Such mutually agreed solution may add reasonable conditions of approval specific to the issue of timely lowering of water level.
13. This Water Conservation Plan may be amended from time to time by mutual agreement of OCWD and OCFCD.

CEQA Compliance. This Water Conservation Plan merely formalizes existing uses and procedures for Miller Basin and is therefore categorically exempt.

Exhibits.
Exhibit A Graphic Representation of Water Conservation Plan
Exhibit B Pump Rating
Exhibit C 24-inch Gated Outlet Rating
Exhibit D Basin Volume Rating

Prepared by James W. Williams
James W. Williams RCE #13154



Typical Section

Key elevations
229.5 = top of berm
226.3 = crest of overflow spillway
224.9 = crest of inlet spillway
215.1 = outlet gate to E02 channel
214.0 = design (not actual) invert
200.0 = OCWD pump sill

Drawdown requirements
If the NWS 3-day quantitative precipitation forecasts 1-inch or more in any 24-hour period, OCWD shall drawdown to 215.1 within 48 hours. If the NWS 3-day forecasts 2-inches or greater in any 24-hour period, OCFCD may request that OCWD drawdown to 200.0 within an additional 24 hours. In the event of conflict between the drawdown requirement and the above seasonal requirements shown on the typical section, the drawdown requirements shall govern.

Miller Basin

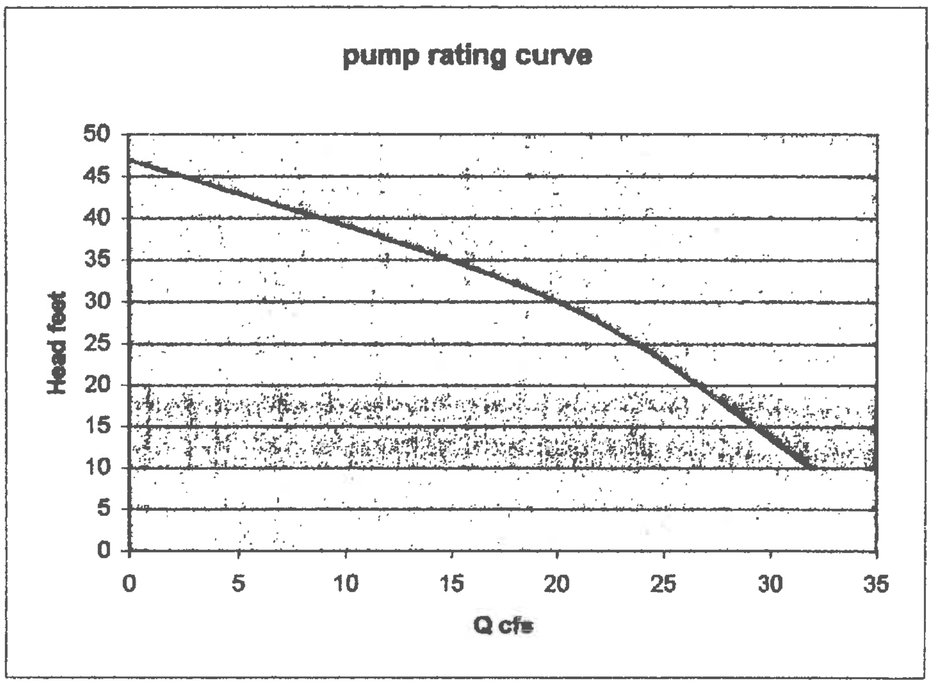
Water Conservation Plan

Exhibit A

Miller Basin Pump Rating

Two submersible pumps.
Each rated at 20 cfs at 30 feet of head and powered by 100 hp electric motor.
Maximum hydraulic grade line: assume 235.
Minimum lift is 235-225 (inlet spillway) = 10 feet.
Maximum lift is 235-200 (pump sill) =35 feet.

Q cfs	H ft
0	47
20	30
32	10

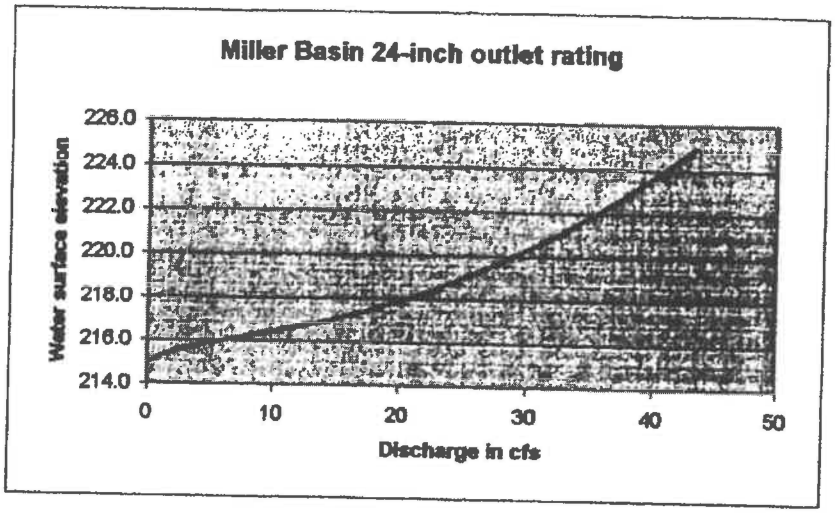


Miller Basin Water Conservation Plan
Exhibit B

Miller Basin Gated Outlet Rating

One 24-inch CMP with invert at 215.1
rating assumes no flow in E02.
ratings 218 and below from Miller Basin Operations Manual
ratings 218 and above from orifice formula

discharge - cfs	water surface
43.3	225.0
40.8	224.0
38.2	223.0
35.4	222.0
32.3	221.0
28.9	220.0
25.0	219.0
20.4	218.0
14.4	217.0
6.0	216.0
2.5	215.6
0.0	215.0



median rate between 215 and 220 is 17.4 cfs
median rate between 215 and 224 is 26.9 cfs

Time required for outlet to drain Miller Basin

discharge - cfs	water surface	Q average cfs	Q average af/day	volume af	delta vol af	time days	cumulative days
43.3	225.0			322			
40.8	224.0	42.1	84.1	304	18	0.21	0.21
38.2	223.0	39.5	79.0	287	17	0.22	0.43
35.4	222.0	36.8	73.6	269	18	0.24	0.67
32.3	221.0	33.9	67.7	252	17	0.25	0.92
28.9	220.0	30.6	61.2	235	17	0.28	1.20
25.0	219.0	27.0	53.9	218	17	0.32	1.52
20.4	218.0	22.7	45.4	201	17	0.37	1.89
14.4	217.0	17.4	34.8	184	17	0.49	2.38
6.0	216.0	10.2	20.4	168	16	0.78	3.17
2.5	215.6	4.3	8.5	160	8	0.94	4.11
0.0	215.0	1.3	2.5	151	9	3.60	7.71

Miller Basin Water Conservation Plan
Exhibit C

Miller Basin Volume Rating

This model is not based on surveyed volumes.
Model calibrates with two data points: 213.0 and 226.3.
Volume of 340 acre-feet at watersurface of 226.3
Volume of 120 acre- feet at watersurface of 213.0
The two data points are from OCFCD Operations Manual
Inlet spillway is 224.9
Design invert is 214.0
Model assumes 2:1 sideslopes
Model is not calibrated below 213.0

water surface	delta h	phantom x	delta AF	AF	
226.3	0	890	0	340	check
224.9	1.4	884.4	18.0	322	inlet spillway
224	0.9	880.8	17.8	304	
223	1	876.8	17.6	287	
222	1	872.8	17.5	269	
221	1	868.8	17.3	252	
220	1	864.8	17.2	235	
219	1	860.8	17.0	218	
218	1	856.8	16.9	201	
217	1	852.8	16.7	184	
216	1	848.8	16.5	168	
215	1	844.8	16.4	151	
214	1	840.8	16.2	135	design invert
213	1	836.8	16.1	119	check
212	1	832.8	15.9	103	
211	1	828.8	15.8	87	
210	1	824.8	15.6	72	
209	1	820.8	15.5	56	
208	1	816.8	15.3	41	
207	1	812.8	15.2	26	
206	1	808.8	15.0	11	
205	1	804.8	14.9	-4	
204	1	800.8	14.7	-19	
203	1	796.8	14.6	-34	
202	1	792.8	14.4	-48	
201	1	788.8	14.3	-62	

Appendix E

Emergency Phone Numbers and Utility Locations

EMERGENCY PHONE NUMBERS
Orange County Water District
Field Operations

4060 E. La Palma Avenue
Anaheim, CA 92807
(714) 378-3320

Primary Contacts

Don Houlihan, Recharge Operations Supervisor...(714) 378-3355
Work Cell ....(714) 553-5202

Paula Bouyounes (Chemical Emergencies) ....(714) 392-2294
Ben Lomeli...(714) 951-6136

24 Hr. Number

GWRS Operations Control Room..(714) 378-3240
GWRS Operations Control Room Emergency...(714) 378-3300

FHQ Security Guard

Anaheim Hills Patrol (Ron Duffin)...(714) 524-5700
Valley Alarm...(800) 228-0580

In Emergency (If no answer above)

John Bonsangue, Director of Recharge Operations ....(714) 329-6184
Ray Abrahamson, Maintenance Supervisor ....(714) 465-7907
Tom Stevens, Heavy Equipment Supervisor ....(714) 887-6454
Octavio Reynoso, Groundskeeping Supervisor...(714) 904-9426

On-Call Operators

Julio Langarica..(714) 757-9781
Jeff Boudreau ....(714) 855-6004

Emergency Numbers

Anaheim Police Department...(714) 765-1900
Anaheim Fire Department ....(714) 765-4000
Orange Police Department...(714) 744-7444
Sherriff's Department ....(714) 647-7000

Army Corps of Engineers ....(213) 452-3532
Storm Operations..(213) 452-3623
Metropolitan Water District/Scheduler (Chuck Schroeder) ....(626) 844-5677
24/7 Line ....(626) 844-5610
Burris Pump Station ....(714) 632-9206

FOREBAY'S ELECTRICAL UTILITY LOCATIONS

ELECTRIC METER ADDRESS	ACCOUNT #	ROTATING OUTAGE GROUP	RATE	METER LOCATION	METER IS USED FOR	JDE CODE	ACTIVITY CODE
ANAHEIM CONCESSION 3451 E. Miraloma Anaheim Meter: 1761W22DKS	City of Anaheim 110196000	1301	Stabilization	The meter is on the back of the concession building facing the street towards the west side of the middle of the wall	This meter powers the concession building and lights	1060.54501	9920
ANAHEIM IRRIGATION WELL 3415 E. Miraloma Anaheim Meter: 170G342NKS	City of Anaheim 110198000	1301	Stabilization	Enter the main gate go west past the concession and house, before the road turns right on your left is the well and meter	Remote fill the water truck to use in the area and to run the Anaheim irrigation pump and pre-lube	1060.54501	9920
ANAHEIM PUMP STATION 1600 N. Miller Anaheim Meter: 904000143	City of Anaheim 110199000	1302	Stabilization	North west corner of Anaheim Lake Open the gate to electric panel access and just left of the gate is the meter inside the cabinet	Power to pump 1,2,3,4 the vertical turbine, MOV's and OC-28 tubs	1060.54501	9920
SCADA/ANAHEIM 3 3435 E. Miraloma (PDSTL) Anaheim Meter: 164200066	City of Anaheim 151869000	N/A	Stabilization		Feeds Anaheim 3 SCADA equipment and the inflow valves in the area	1060.54501	9920
BURRIS GWRS 14895 E. Ball Road Anaheim Meter:58S422NKS	City of Anaheim 134965000	1703	Stabilization	Burris - GWRS meter is west of the driveway into Burris pump station right on Ball Road	Powers GWRS MOV's and the equipment in the vault on the west side of the river north of Ball Road	1060.54501	9920
BURRIS IRRIGATION 2950 E. South Street Anaheim Meter: 59W432DKS	City of Anaheim 127603000	1827	Stabilization	Burris Irrigation needs more information South Street is in a gated community no one on guard when I checked	Natural Resources has a mitigation site near Burris.	1060.54501	9920
BURRIS BASIN 14899 Ball Road Orange	SCE 2-20-236-0772	N/A	Misc. Charges	Burris Pump Station there is no meter for this charge	Extra fee's charged for Burris	1060.54501	9920
BURRIS BASIN PUMP STATION 14899 Ball Road Orange Meter: 315110-007016	SCE 2-19-908-3726	S068	TOU-8-D-RTP	Enter through Ball Rd., open 2 gates on located on left side.In a cage adjacent to substation	Powers Burris Pump Station	1060.54501	9920
CATHODIC SANTIAGO 1 1369 W. Struck Orange Meter: 222013-910556	SCE 2-21-975-6301	N001	TOU-GS-1-D	Pedestal on north east corner of Struck and Main next to the power pole by the street	Cathodic protection for the Burris to Santiago pipeline	1060.54501	9920
CONROCK ACCUSONIC 4060 E. La Palma Ave.(PDSTL) Anaheim Meter: 63856021	City of Anaheim 145552000	N/A	Stabilization	Conrock side of the road between Warner and Conrock just past the middle of the lakes next to the bridge	Powers the Accusonic from Conrock to Warner channel, SCADA, and the gauge house lights	1060.54501	9920

FOREBAY'S ELECTRICAL UTILITY LOCATIONS

ELECTRIC METER ADDRESS	ACCOUNT #	ROTATING OUTAGE GROUP	RATE	METER LOCATION	METER IS USED FOR	JDE CODE	ACTIVITY CODE
DESILTING STUDY (2009) 4068 E. La Palma Avenue Anaheim Meter: 410S420DKS	City of Anaheim 138802000	2014		Desilting Study meter is near FRLAB east of the lab parking lot near a green transformer in grey cabinet	Power is not in use the main breaker is powered down or off	1060.54501	9920
FHQ FIELD LAB 4062 E. La Palma Avenue Anaheim Meter:1628W122DKS	City of Anaheim 132538000	2014	Stabilization	FRL pedestal located between the lab parking and the lab trailer behind the beginning of the stream	Powers both labs, and the stream lights	1060.54501	9920
FHQ MAIN OFFICE 4060 E. La Palma Avenue Anaheim Meter: 399W410DKS	City of Anaheim 128279000	2014	Stabilization	FHQ meter located outside the main office building across staircase, inside double doors	Powers the main office, HE shop, fuel station and shop lunch room	1060.54501	9920
FIVE COVES RUBBER DAM 3056 E. Frontera Street Anaheim Meter: 343S420DKS	City of Anaheim 127704000	1311	Stabilization	Located on the end of the control building in a metal cabinet on the opposite side from the trash racks	Powers lights, SCADA, trash racks, rubber dam, MOV's for the bypass gates and the north inflow gates	1060.54501	9920
FLETCHER BASIN 650 W. Fletcher Orange Meter: 254000-030968	SCE 2-38-482-1559	X999	TOU-GS-1-E	Facing the street on the sw corner of the basin, between gauge house and front wall by sidewalk	Power to gauge house and pump station	1060.54501	9920
IMPERIAL HEADGATES 5300 E. La Palma Avenue Anaheim Meter: 7W422DKS	City of Anaheim 128660002	2006	Stabilization	Located at the east end of the control building outside in a metal cabinet	Powers the trash racks, 2 MOV's for the bypass gates, 3 MOV's on the diversion channel, Obermeyer dam, lights and SCADA	1060.54501	9920
KRAEMER MILLER PUMPS 3151 E. Miraloma Anaheim Meter: 199W420DKS	City of Anaheim 110562000	1306	Stabilization	North side of the two story building between Kraemer and Miller is the pump house. Meter inside the lower level door	Kraemer, Miller pumps, all MOV's for Kraemer basin cathodic protection, lights SCADA	1060.54501	9920
LA JOLLA BASIN 2921 E. La Jolla Street Anaheim Meter: 171S422DKS	City of Anaheim 111128000	1305	Stabilization	Located on the west side of the control building, at the back of the basin away from the street	Powers La Jolla rubber dam, trash rack, MOV. SCADA, lights and control building	1060.54501	9920
LITTLE WARNER CHANNEL 4060 E. La Palma Avenue Anaheim Meter: 55700129	City of Anaheim 128284000	1309	Stabilization	Pedestal is at the west end of Little Warner channel next to the power pole by S/W corner	Powers the tipping bucket, MOV, SCADA, flow meter, lights and transformer	1060.54501	9920
LOWER FIVE COVES 2941 E. Lincoln Avenue Anaheim Meter: 5492P420DRS	City of Anaheim 134145000	2019	Stabilization	The building west of lower 5-Coves pond facing the pond in a metal cabinet at the back of the building	Powers the irrigation well, SCADA, and the night lights	1060.54501	9920

FOREBAY'S ELECTRICAL UTILITY LOCATIONS

ELECTRIC METER ADDRESS	ACCOUNT #	ROTATING OUTAGE GROUP	RATE	METER LOCATION	METER IS USED FOR	JDE CODE	ACTIVITY CODE
MIRALOMA BUILDING PDST 3255 E. Miraloma Anaheim Meter: 233S422DKS	City of Anaheim 140776000	N/A	Stabilization	Pedestal is at the control building in the front. To the rear of the basin on the west side	Powers Miraloma pumps, GWRS MOV's in Kraemer SCADA, Mira Loma MOV's and lights	1060.54501	9920
MIRALOMA IRRIGATION 3261 E. Miraloma (PDSTL) Anaheim Meter: 19362S122NKS	City of Anaheim 118602000	N/A	Stabilization	In front of Miraloma Basin by the east entrance in front of the wall is the pedestal for the irrigation	Power for irrigation landscaping at Mira Loma basin	1060.54501	9920
OLIVE BASIN PEDISTAL 945 N. Tustin Avenue Anaheim Meter: 74319011	City of Anaheim 139824000	N/A	Stabilization	Next to the gauge house is the pedestal near power lines. S/W corner of Olive Basin next to the road by R&R	Powers Passive system testing, SCADA, Olive Basin pumping bubbler	1060.54501	9920
POND FOUR LAKEVIEW 1107 N. Lakeview Avenue Anaheim Meter: 106S422DKS	City of Anaheim 131487000	2019	Stabilization	Gauge house is on the north side of Pond-4 on the west corner next to Huckleberry gates	Powers 3 MOV's at pond-4, Scada. Will soon power hoist at pond-4 (to be added to the trash gates)	1060.54501	9920
RIVERVIEW BASIN 1940 N. Main Street Orange Meter: 256000-069512	SCE 2-25-170-5067	A071	TOU-GS-1-D	Pedestal is inside the main gate to the right in the area of the restroom and Cloth Filter	Powers the cloth filter, bathroom, Fletcher flow meter and valve, sump pump, SCADA and all MOV's	1060.54501	9920
SANTIAGO BUILDING 821 Prospect Orange Meter: V349N-005211	SCE 2-22-308-7081	A040	TOU-PA-3-B	Meter is inside the control building at Santiago	All of Santiago is powered by meter 1, 2, 4 pumps, MOV's, Scada, lights climate control, and barge controls	1060.54501	9920
SANTIAGO CATHODIC 2 159 W. Collins Orange PED Meter: 222013-775789	SCE 2-21-975-5279	A011	TOU-GS-1-D	Pedestal located on shopping center side of Collins just past Glassell to the west by the street	Cathodic protection for the Burris to Santiago pipeline	1060.54501	9920
SANTIAGO CATHODIC 3 1641 E. Collins Orange PED Meter: 222013-776063	SCE 2-22-397-5590	A026	TOU-GS-1-D	Pedestal located on north west corner of Collins west of Tustin before the first driveway into the shopping center	Cathodic protection for the Burris to Santiago pipeline	1060.54501	9920
SANTIAGO CATHODIC 4 2932 E. Collins Orange Meter: 222013-752604	SCE 2-21-992-6482	N001	TOU-GS-1-D	Pedestal is on Collins if you are coming from Santiago, it's just past Wanda on the left next to the fire station	Cathodic protection for the Burris to Santiago pipeline	1060.54501	9920
W/S SAR N/O Ball Anaheim Meter:222-020-026-232	SCE 3-001-3969-92	A056	TOU-GS-1-D	Meter located inside the Burris switchgear at Burris basin, north of the SCE substation (between the driving range parking lot and Anaheim Coves Trail parking lot)	This is a 120v control power meter for the Burris main switchgear near the substation. This is a separate meter from the 4.1kv service that feeds the station but in the same gear it has two meters.	1060.54501	9920

FOREBAY'S ELECTRICAL UTILITY LOCATIONS

ELECTRIC METER ADDRESS	ACCOUNT #	ROTATING OUTAGE GROUP	RATE	METER LOCATION	METER IS USED FOR	JDE CODE	ACTIVITY CODE
WAREHOUSE & MAINT. 4050 E. La Palma Avenue Anaheim Meter: 573W410DKS	City of Anaheim 128277000	2014	Stabilization	Meter is on the back wall of the warehouse next to the restroom N/E end of the building	Powers warehouse, maintenance shop, chemical room, lights, library, Natural Resources shed	1060.54501	9920
WARNER IRRIGATION 4060 E. La Palma Avenue Anaheim Meter: 174S422DKS	City of Anaheim 128276000	1309	Stabilization	Meter is inside the Warner irrigation pump building west end of Warner Lake north of the center by stand pipe	Powers the irrigation pump, pre-lube, lights and irrigation timers	1060.54501	9920
WARNER PUMP HOUSE 3850 E. La Palma Avenue Anaheim Meter: 5225P420DRS	City of Anaheim 128283000	1309	Stabilization	Meter is located at the S/W corner of Warner by the fence next to the shopping center inside the control building	Powers Warner pump 1 & 2, Little Warner dam SCADA and lights	1060.54501	9920
WEIR #3 1150 N. Lakeview Avenue Anaheim Meter: 338W420DKS	City of Anaheim 134144000	2025	Stabilization	Pond 3 House is pm north side of Weir #3 toward Lakeview just past mitigation project	Powers Weir-3 Scada and lights	1060.54501	9920
WQ's MONITORING WELL 1394 N. Miller Anaheim Meter: 9061S122NKS	City of Anaheim 129051000	1302	Stabilization	Facing Miller St., between Miraloma and Orangethorpe, across freight company	Power Water Quality's monitoring well AMD-9 (1-4)	1060.54501	9920
748 N. Hewes, Orange SCE	None	**No Service**	None	Cathodic Protection for SANTPS		1060.54501	9920

FOREBAY'S WATER UTILITY LOCATIONS

WATER METER ADDRESS	ACCOUNT #	METER LOCATION	METER IS USED FOR	JDE CODE	ACTIVITY CODE
Miraloma Basin 3261 E. Miraloma Anaheim Meter: 43543481B022	City of Anaheim 110452300	West end of Miraloma basin by the street next to the back flow preventer	Landscape at Miraloma	1060.54515	9920
La Palma Basin 3203 E. La Palma Ave. Anaheim Meter: 60909200N112	City of Anaheim 45085300	North east corner of Shepard and La Palma. Meter next to sidewalk in planter	La Palma Basin, which is still under construction	1060.54515	9920
La Palma Basin Irrigation 3205 E. La Palma Ave. (LSCAP) Anaheim Meter: 60909199N112	City of Anaheim 145086300	North east corner of Shepard and La Palma. Meter next to sidewalk in planter	La Palma Basin, which is still under construction	1060.54515	9920
La Jolla Landscape 2901 E. La Jolla St. Anaheim Meter: 48010N01122	City of Anaheim 137310300	Just west of businesses in the middle of the basin. Meter is in the sidewalk just west of the driveway and the backflow is behind the block wall	Landscape at La Jolla	1060.54515	9920
Kraemer Basin 3169 E. Miraloma Ave. (LSCAP) Anaheim Meter: 50513N02002	City of Anaheim 110561300	East end of Kraemer basin just off the street by the house. In front of the backflow preventer	Kraemer landscape	1060.54515	9920
Fire Line @ FHQ 4060 E. La Palma Ave. FLINE Anaheim Meter: 9174300H041	City of Anaheim 128280300	Tustin street east entrance on the left side of the driveway close to the gate. Meter mounted on the check valves facing toward driveway	Fire lines for FHQ	1060.54515	9920
FHQ 4060 E. La Palma Ave. Anaheim Meter: 1402T02002	City of Anaheim 128282300	Tustin street east entrance on the left side of the driveway in the sidewalk next to the driveway entrance	FHQ water for Lab, shop, warehouse, office, lunch rooms, outside areas and HE building	1060.54515	9920
Burris Basin (Flushing Water) 1200 S. Auto Center Drive Anaheim Meter: 42705N02002	City of Anaheim 127464300	Confined space vault on Ball Rd. and Phoenix Club Dr. south east corner	Water supply to Burris	1060.54515	9920

FOREBAY'S WATER UTILITY LOCATIONS

WATER METER ADDRESS	ACCOUNT #	METER LOCATION	METER IS USED FOR	JDE CODE	ACTIVITY CODE
Anaheim Coves 2850 E. South St. (APPOX) Anaheim Meter: 1002N04002	City of Anaheim 127602300	This area is under construction and has no access at this time gates locked	Landscaping	1060.54515	9920
Anaheim Concession 3451 E. Miraloma Ave. Anaheim Meter: 26064N01002	City of Anaheim 110196000	East side of the driveway into concession parking lot. By the street	Concession building and hose bibs	1060.54515	9920
Bike Trail Landscape 3837 E. Bond Ave. Orange Meter: 1850245360	City of Orange 38354	On Bond street a hundred yards from Prospect. Inside the bike path	Landscaping	1060.54515	9920
Santiago Pump Station 821 N. Prospect St. Orange Meter: 1831505484	City of Orange 30145	Just right of the driveway entering Santiago basin across from the backflow preventer	Santiago pump station and hose bibs	1060.54515	9920
Riverview Basin 1940 N. Main St. Orange Meter:1852742923	City of Orange	Left side of the driveway entrance off of main street, just off the curb in the grass	Landscaping and Riverview building	1060.54515	9920
18815 E. Villa Park-Agri Ave. Orange	City of Orange	Out of Service	Out of Service	1060.54515	9920
11203 N. Hewes Street Orange	City of Orange	Out of Service	Out of Service	1060.54515	9920