CHAPTER 2
DESCRIPTION OF THE SOURCE WATER SYSTEM

During the last 100 years, the CSD's water system has evolved into a very complex system. It now serves a population of 1.3 million people spread out over 370 square miles (**Table 2.1**). The CSD treats imported raw water and local runoff water in three City WTPs, which have a combined capacity of 294 MGD. The CSD treats water by coagulation, flocculation, sedimentation, filtration and disinfection using conventional technologies. Currently, all CSD water treatment plants are undergoing modification to provide for the addition of fluoride to the potable water supply. To ensure safe and palatable water quality, the CSD collects water samples at its reservoirs, the WTPs, and throughout the treated water storage and distribution system.

The CSD's use of local and imported water to meet water demand is affected by availability, cost, and water resource management policies**.** Imported water availability has decreased the need to carry over local water for dry years in City reservoirs. CSD policy is to use local water first, when available, to reduce imported water purchases. This policy runs the risk of increased dependence on imported water during local droughts.

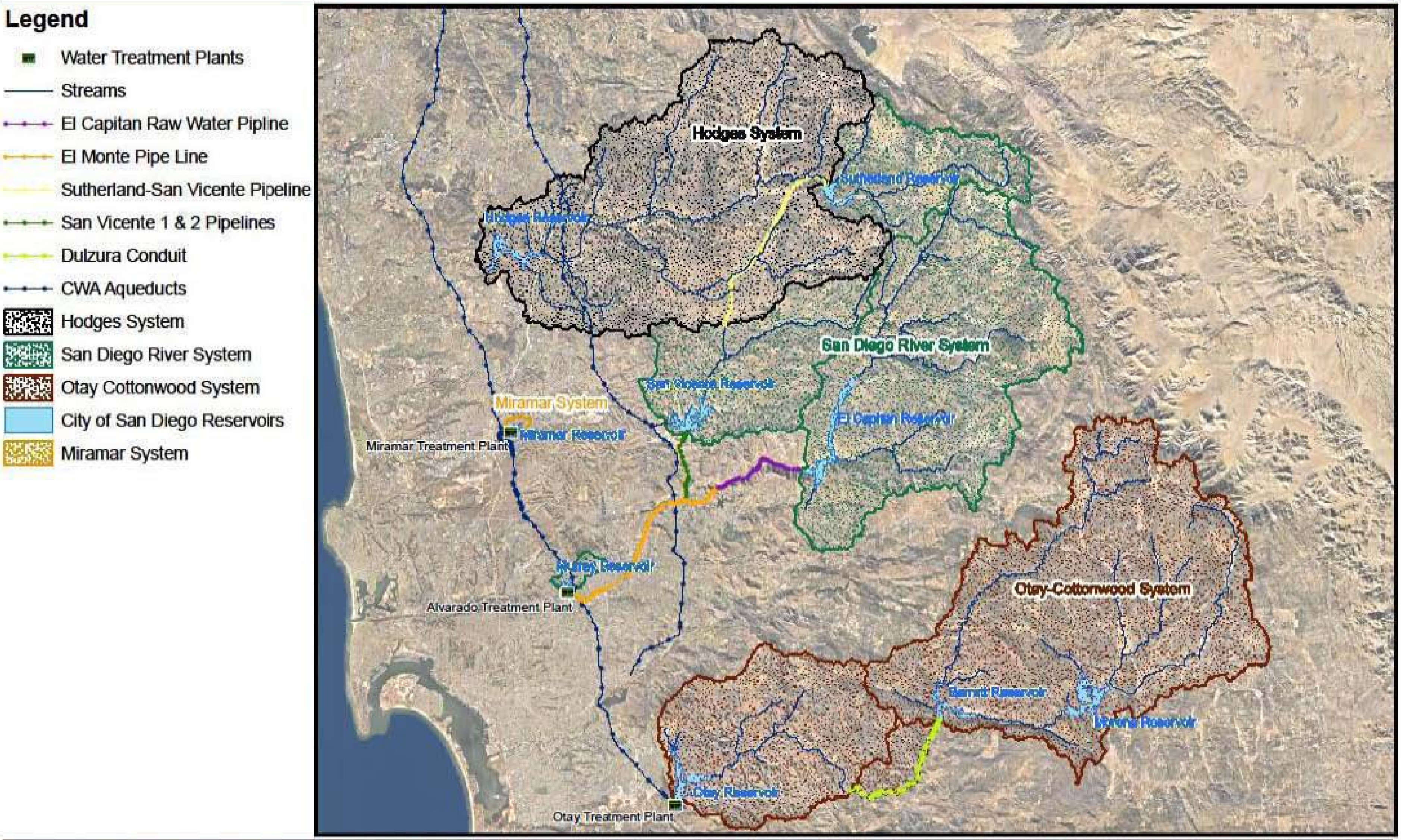
Table 2.1 - City of San Diego General Statistics

Population (2000)	1,223,400
Population (Estimated January 01, 2009)	1,353,993
Population percent change	10.7
Land Area Square Miles	372
Population Density per Square Mile (2009)	3,659
Water Distribution Area Square Miles (2010)	305
Number of Service Connections (2010)	274,832

2.1 Water Sources (**Fig. 2.1**)

Most of California's water development has been dictated by the multi-year wet/dry weather cycles. Records indicate that extremely dry periods frequently last several years both locally and throughout California. During droughts, all imported and local water comes from reservoir or groundwater storage. Runoff in dry years is generally insufficient to meet environmental requirements and riparian water rights in imported water supply watersheds. The CSD has two major sources of water: imported and local runoff (**Table 2.2**).

Figure 2.1 City of San Diego Source Water System 2010



File Path: J:\WTRL\ms\GIS_WATERSHED\2010 Sanitary Survey - shape files\System Settings

Created By: Dan Daft

Date: 12/2/2010

Table 2.2 - City of San Diego Local and Imported Water Use

Fiscal Year	Local Volume (AF)	Percent	Imported Volume (AF)	Percent	Total Production (AF)
2010	14,425	7%	187,029	93%	201,454
2009	24,464	11%	202,222	89%	226,686
2008	3,342	2%	219,274	98%	222,616
2007	18,709	8%	229,682	92%	248,391
2006	40,844	17%	197,361	83%	238,205
Total	101,784	NA	1,035,568	NA	1,137,352
Average	20,357	9%	207,114	91%	227,470

Imported Water

Imported water has historically accounted on average for **80%** of the CSD's annual water use, sources include:

- The Colorado River via 300 miles of canals and pipelines.
- The Sacramento River via more than 500 miles of canals and pipelines.
- MWD's Lake Skinner.

Imported water is delivered by federal, state and regional agencies. These are the United States Bureau of Reclamation, the State of California Department of Water Resources (CDWR), MWD, and SDCWA.

Imported raw water originates either from the Colorado River or the Feather River in the Sacramento River watershed. Precipitation on these watersheds has similar seasonal (winter/summer) and cyclical (wet/dry year) patterns to those of local watersheds. In most years, winter snowpack in the High-Sierras stores a significant amount of water until early summer. This "snow pack storage," in combination with reservoir storage, helps to meet seasonal summer demand. To avoid water shortages during cyclical droughts, reservoirs are used to carry over (store) water from wet years to dry years.

Use of imported water peaked at 228,000 AF or 93 percent of total demand in fiscal year 1989 during the last statewide drought of 1987-92. The maximum imported water purchase occurred in fiscal year 1990, when the City purchased 270,000 AF of imported water. This was 11 percent more than the year's water demand of 243,000 AF. The additional imported water was purchased to replace evaporation losses on local reservoirs and to provide some reserve in the event of continued drought.

Local Runoff

Local runoff has historically accounted on average for **20%** of CSD's annual water use; sources include Nine (9) major CSD reservoirs which collect local runoff from watersheds covering more than 900 square miles. The annual average rainfall exceeds fifteen (15) inches in these mostly hilly and mountainous watersheds located outside of the city boundaries.

Local water use varies greatly due to the variation of annual local runoff. The total annual CSD water demand may be served by local water in an average of one out of ten years. In dry years, runoff on local watersheds is generally less than evaporation losses on local reservoirs. The maximum local water use was about 97,000 AF in fiscal year 1984, after a wet winter filled all CSD reservoirs. The minimum local water use was less than 5,000 AF in fiscal years 1964 and 1965, during the local drought between 1959 and 1966.

The rainfall and runoff information in this section was supplied by the CSD Public Utilities Department Production Engineering, National Oceanic and Atmospheric Association, and San Diego Geographical Information System (SanGIS). Rainfall data is collected at each reservoir by a weather station. Runoff data is calculated monthly with measured amount of rainfall, rain on the surface of the reservoir, evaporation, draft, storage, dam leaks, change in reservoir level, and by using other calculated input.

San Diego County's climate is classified as a Mediterranean dry summer type, where, the amount of runoff is highly variable from year to year due to wet and dry cycles. On an average, 90% of the annual rainfall occurs between the months of November and April (**Table 2.3**), and 93% of local runoff occurs during the months of December through May. In their natural conditions, local streams and rivers feeding CSD reservoirs are ephemeral or intermittent.

Table 2.3 - Climate Data for San Diego (Lindbergh Field)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high (°F)	65.8	66.3	66.3	68.7	69.3	72.2	75.8	77.5	77	74	69.9	66.3	70.8
Daily mean (°F)	57.8	58.9	60	62.6	64.6	67.4	70.9	72.5	71.6	67.6	61.8	57.6	64.4
Average low (°F)	49.7	51.5	53.6	56.4	59.8	62.6	65.9	67.4	66.1	61.2	53.6	48.9	58.1
Rainfall (in)	2.28	2.04	2.26	0.75	0.2	0.09	0.03	0.09	0.21	0.44	1.07	1.31	10.77
Avg. rainy days (≥ 0.01 in)	7.2	6.6	7.2	4.1	2	1.1	0.6	0.6	1.5	2.8	4	5.2	42.9

The region needs rainfall levels at about the annual average rainfall level to sufficiently saturate the soils so that significant surface runoff can occur (**Table 2.4**). Therefore, most of the runoff to CSD reservoirs is produced in years with much greater than average rainfall. About one half of the total runoff into CSD reservoirs is produced during the wettest ten percent of the years. To conserve runoff during these wet years requires a large water storage capacity in comparison to the average annual water yield. Reservoir capacity is also less than one half of the annual runoff in the highest (maximum) runoff year resulting in the excess of local water being lost to the ocean and contributing to flooding below CSD reservoirs. Some flooding may occur even during years with average or below average rainfall levels if the annual rainfall volume is concentrated in a few intense storms. During the summer, seepage under dams and irrigation runoff are the sources of water in many streambeds.

Table 2.4 - 30 Year Average Rainfall within Local Source Water System Boundaries; SanGIS update 2008

	San Diego River System		**Otay-Cottonwood System**		**Miramar System**		**Hodges System**	
Range	Acres	% Acres	Acres	% Acres	Acres	% Acres	Acres	% Acres
12 to 15	2,298	1.1	6,573	2.9	121	18.8	2,586	1.6
15 to 18	21,129	10.3	37,011	16.3	524	81.2	41,440	26.2
18 to 21	104,818	51.2	80,018	35.2	0	0.0	86,830	54.9
21 to 24	45,308	22.1	40,629	17.9	0	0.0	24,967	15.8
24 to 27	16,313	8.0	41,085	18.1	0	0.0	2,449	1.5
27 to 30	12,075	5.9	21,700	9.6	0	0.0	0	0.0
30 to 33	2,864	1.4	0	0.0	0	0.0	0	0.0
Total	204,805	100	227,016	100	645	100	158,272	100

Historically on average approximately 13% of local precipitation results in surface runoff to streams and CSD reservoirs (**Table 2.5**). While historical information on rainfall and the resulting runoff is available, accurate and sufficient information on the amount of local groundwater recharge is lacking. In some watersheds, the lower coefficient of runoff may be explained by groundwater recharge. In other watersheds, the difference cannot be accounted for.

Historically on average approximately 13% of local precipitation results in surface runoff to streams and CSD reservoirs (**Table 2.5**). While historical information on rainfall and the resulting runoff is available, accurate and sufficient information on the amount of local groundwater recharge is lacking. In some watersheds, the lower coefficient of runoff may be explained by groundwater recharge. In other watersheds, the difference cannot be accounted for.

Table 2.5 - City of San Diego Reservoirs Historical Average Annual Precipitation & Runoff

Reservoir	Watershed (Acres)	Precipitation (Inches)*	Precipitation (AF)	Runoff (AF)	Precipitation as Runoff
Morena	72,960	19.64	119,404	10,218	9%
Barrett	85,760	17	121,486	12,038	10%
Lower Otay	62,720	11.36	59,371	6,427	11%
El Capitan **	121,600	15.79	159,995	31,666	20%
San Vicente	47,360	15.6	61,564	7,381	12%
Murray	3,200	11.79	3,144	75	2%
Miramar	640	12.45	664	16	2%
Sutherland	34,560	22.96	66,121	11,238	17%
Hodges ***	159,360	14.22	188,830	25,147	13%
Total	588,160	140.81	780,579	104,206	NA
Average	65,351	15.65	86,731	11,578	13%

Table 2.6 - City of San Diego Reservoir 2006-2010 Average Annual Precipitation & Runoff

Reservoir	Watershed (Acres)	Precipitation (In)*	Precipitation (AF)	Runoff (AF)	Precipitation as Runoff
Morena	72,960	17.3	105,184	1,384	1%
Barrett	85,760	12.96	92,621	3,048	3%
Lower Otay	62,720	8.2	42,859	2,440	6%
El Capitan **	121,600	9.2	93,227	3,358	4%
San Vicente	47,360	12.3	48,544	2,845	6%
Murray	3,200	9.11	2,429	0	0
Miramar	640	11.1	592	0	0
Sutherland	34,560	17.8	51,264	2,550	5%
Hodges ***	159,360	11.3	150,064	6,214	4%
Total	588,160	109.27	586,783	21,839	NA
Average	65,351	12.14	65,198	2,427	3%

Minimum Annual Rain Runoff into City Reservoirs: 1,215 AF - 1961

Maximum Annual Rain Runoff into City Reservoirs: 802,546 AF - 1916

* Reservoir precipitation is measured at the lowest point of the watershed.

** El Capitan watershed includes an average runoff of 3,875 AFY from 12 square miles surrounding Cuyamaca Reservoir.

***Hodges average annual runoff is reduced by 8,000 to 10,000 AFY by irrigation pumping in San Pasqual Valley

Since 1971, local water use by the CSD (including California-American Water Company) averaged nearly 40,000 AFY while HWD, SDWD and SFID used an average of 13,000 AFY (**Table 2.7**).

Table 2.7 - Local Runoff Uses/Losses

Description	Historical Average Annual (AFY)	2006-2010 Average Annual (AFY)
Use by City, including Cal American Water Company	40,000	24,300
Use by Helix, San Dieguito, & Santa Fe	13,000	12,900
Evaporation Loss	21,000	14,500
Transit Loss through Open Flumes & Channels	4,000	615
Spill to the Pacific Ocean in Wet Years	27,000	65
Total	105,000	52,380

Historically, about 40% of the local runoff is used for the municipal water supply (**Tables 2.5** & **2.7**). Local water use is much less than the long term average annual runoff into CSD reservoirs due to losses which include:

- Limited reservoir capacity to conserve all local runoff during wet years.
- Limited pipeline capacity between CSD WTPs plants and reservoirs.
- Limited pipeline capacity results in evaporation losses during prolonged storage of water in less efficient reservoirs, and in water losses when water is transferred between reservoirs via streambeds.
- Spills over the dams in very wet years.

2.2 Source Water Reservoirs

Reservoir storage is necessary to balance seasonal and cyclical variations in the water supply (volume and variability of water sources), with losses, system type, intended purposes, and demands. CSD total reservoir capacity is approximately double its average annual water production (**Table 2.2** & **2.8**), and this capacity will be expanded with the expansion of the San Vicente Reservoir.

Table 2.8 - Water Storage Statistics

Combined Capacity of City Reservoirs	408,593 AF
Capacity below Lowest Usable Outlets / Dead Storage	11,492 AF
HWD Owned Storage Capacity in El Capitan Reservoir	10,000 AF
Net Usable City Owned Storage Capacity	387,101 AF
Minimum Usable Hodges Storage Required for SFID/SDWD	8,300 AF
Maximum Usable Hodges Storage Required for SFID/SDWD	15,800 AF

The conservation of local runoff with the least amount of loss requires coordinated management of CSD reservoirs. To accomplish this requires a need to consider local weather patterns, watershed characteristics, storage capacity, and the efficiency of the reservoirs. Under ideal conditions, all water storage would occur in reservoirs with the lowest probability of spillage during the winter; and with the lowest evaporation loss during the summer. Ninety-three percent (93%) of local runoff occurs during the months of December through May, and 94% of the net evaporation occurs from June through December. This seasonal wet/dry cycle requires shifting priorities throughout the year between the need to maximize conservation of runoff and the need to minimize evaporative losses. To accomplish this, the CSD drafts water from its reservoirs as quickly as pipeline capacity, water quality, and CSD water demand allows until only the required emergency storage remains. While this type of operation saves no water in local reservoirs for dry years, it maximizes local water production. This type of operation results in lower water storage levels in CSD reservoirs reducing evaporation losses and reservoir spills. It is not always possible to achieve this goal due to a lack of adequate transfer facilities, the need to distribute emergency storage to designated areas, and the need to access reservoirs for recreation purposes.

Average runoff produced in the watersheds is generally proportional to the size and relative elevation of the watersheds. However, rainfall and resulting runoff in a given year may vary significantly from the average annual patterns. Because of the unpredictable and significant variations in annual rainfall/runoff patterns between watersheds, optimization of the multiple reservoir system depends on whether the reservoirs are on tributary or parallel streams.

With the exception of Morena and Barrett, all CSD reservoirs are now considered to be on parallel watersheds. When Hodges reservoir is reconnected to the CSD water supply system, it may be considered as a tributary system to Sutherland.

Reservoirs on parallel systems generally require that the available storage capacity to capture runoff is allocated among the reservoirs. The storage allocation is determined by the historical percent contribution of runoff to each reservoir in the system for a calendar year. This method will optimize local water production by providing the highest overall yield.

On tributary systems, a lower elevation reservoir may capture spills from a higher elevation reservoir while spills from the lower reservoir will be a loss. Therefore, at the beginning of the rainy season it is desirable that most of the available storage capacity to capture runoff is allocated to the lower elevation reservoir. This practice will result in higher water yield as opposed to allocating the water storage between reservoirs in proportion to the average annual runoff patterns of their respective watersheds.

The location of storage is also determined by the intended purpose:

- Emergency storage is located as close to the point of use as possible. The purpose of emergency storage is to provide a minimum reserve of water for use during emergencies such as earthquakes, aqueduct failure, or aqueduct pump station outage. On December 27, 1973, CSD Council Policy 400-4 "Emergency Storage of Water," was updated to require, the storage of 60% of the annual requirement of the CSD and its contractees as active, available storage in Murray, San Vicente, El Capitan, Lower Otay, and Miramar reservoirs. Active, available storage is that portion of the water that is above the lowest usable outlet of each reservoir. To meet this requirement, the CSD reserves up to 175,000 AF (a seven month supply) of storage capacity for emergency storage. Emergency storage requirements are interpreted as fluctuating requirement from month to month as water demand peaks in summer months. This results in a difference of 37,000 acre ft, or more, between the April high and the October low emergency requirements.

- Seasonal storage is located as close to the point of use as possible. Seasonal storage occurs by storing surplus imported water in the wet winter season for use during the dry summer season. Or, it may also be accomplished by increasing the use of imported water for treatment in the winter while saving the local water for summer use. This type of operation increases imported water yield and reduces summer peaking on the imported water delivery system.

- Dry-year storage, sometimes called carry-over storage, may use any location along the water delivery system. The needed capacity is dependent on the volume and variability of water sources, and on the water demand. Dry-year storage is necessary to supply water during droughts. This process stores excess water in wet and normal years for use in dry years to produce a more dependable water supply. The water is stored for many years to provide water during the longest anticipated drought.

- The remainder of the 405,000 AF of storage capacity is used as impounding storage capacity to maximize local water yield by conservation of local runoff in excess of demand, and minimize losses.

Reservoir	Year Built	Construction Type	Total Height(ft)	Crest Length (ft)	Spillway Capacity (MGD)	Transfer Capacity(MGD)- Receiving Facility
San Diego River System						
Murray	1918	Multiple Arch	117	870	1,309	126-Alvarado WTP
San Vicente	1943	Concrete Gravity	219	960	32,651	76-Murray Reservoir/ Alvarado WTP
El Capitan	1934	Hydraulic Fill	242	1,170	110,303	61-Murray Reservoir/ Alvarado WTP
Sutherland	1954	Multiple Arch	174	1,188	26,651	65-San Vicente Reservoir
Otay-Cottonwood System						
Lower Otay	1919	Concrete Gravity	182	741	31,940	48-Otay WTP
Barrett	1922	Concrete Gravity	205	746	56,897	31-Otay Reservoir
Morena	1897	Rock Filled	284	550	16,164	194-Barrett Reservoir
Miramar System						
Miramar	1960	Earth Embankment	155	1189	279	100-Miramar WTP
Hodges System						
Hodges	1919	Multiple Arch	157	729	43,604	387-Hodges Reservoir-Olivenhain Reservoir

Table 2 .9 – City of San Diego Dam & Outlet Structure Statistics

Table 2.10 – City of San Diego Reservoir Statistics

Reservoir	Watershed Area (Mi^2)	Historical Average Annual Rainfall (in)	Historical Average Annual Evaporation (in)	Primary Storage Function*	Storage Capacity (MG)	Usable Storage (MG)
San Diego River System						
Murray	5	11.79	45.98	E,O	1,570	1,303
San Vicente	74	15.6	54.12	E,I,S	29,402	29,001
El Capitan	190	15.79	53.34	E,I,S	36,758	35,518
Sutherland	54	22.96	52.77	I	9,673	9,450
Total	323	66.14	206.21	NA	77,403	75,272

Otay-Cottonwood System						
Lower Otay	98	11.36	50.63	E,O,I,S	18,417	15,641
Barrett	134	17	48.95	I	14,583	10,753
Morena	114	19.64	65.9	I	16,360	15,967
Total	346	48	165.48	NA	49,360	42,361
Miramar System						
Miramar	1	12.45	51.72	E,O	2,341	1,955
Hodges System						
Hodges	248	14.22	60.57	I	10,932	9,124

*E: Emergency Storage, I: Impounding Storage, O: Operational Storage, S: Seasonal Storage

The City owns and operates all of the reservoirs, water treatment plants, pipelines, pump stations, and associated facilities; unless otherwise noted.

San Diego River System (**Fig.2.1**, **Tables 2.9** & **2.10**)

The System is comprised of:

- Reservoirs: Murray, San Vicente, El Capitan, Sutherland, and Cuyamaca owned by HWD.
- Their respective watersheds.
- Interconnecting pipelines and pump stations: Sutherland-San Vicente Pipeline, San Vicente Pipelines Nos.1 & 2, El Capitan Pipeline, El Monte Pipeline, El Monte Pump Station, and Lakeside Pump Station.
- Water treatment plants: Alvarado WTP, R.M. Levy Water Treatment Plant (Levy WTP) owned by HWD, and John C. Bargar Water Treatment Plant (Barger WTP) owned by the Ramona Municipal Water District (RMWD).

The effective volume of this system comprises more than half of the emergency water storage requirement for the CSD.

The San Diego River System covers a combined area of 205,000 acres, or approximately 320 square miles. The Alvarado WTP, located adjacent to Murray Reservoir, is the City terminus for this source water system and serves the central area of the CSD. The Alvarado WTP is of conventional design using ozone for primary disinfection and chloramines for secondary disinfection in the distribution system. During this five-year survey period, the Alvarado WTP was expanded from 120 MGD to 150 MGD pending approval of the California Department of Public Health, and has completed its conversion from chlorine to ozone for primary disinfection.

- **Murray Reservoir** (usable storage: 4,290 AF)
  The function of the Murray Reservoir is to serve as emergency and operational storage to meet Alvarado WTP and city-wide needs. Operational storage is between reservoir gauges 88 and 92; the spillway is at reservoir gauge 95.

Murray Reservoir is located on Chaparral Canyon Stream, a tributary to Alvarado Creek and the San Diego River. Murray Reservoir impounds water transferred from San Vicente, El Capitan, and Sutherland Reservoirs via the El Monte Pipeline, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir is surrounded by a "first-flush bypass system" with a capacity of 39 MGD which diverts runoff from the surrounding 5 square mile watershed; except during large storm events. The reservoir has a storage capacity of 1,520 MG and a surface area of 0.26 square miles at its spillway crest.

Murray Dam is a multiple arch reinforced concrete structure with a 42-foot-wide uncontrolled over pour spillway at elevation 536 ft Mean Sea Level (ft. MSL). The spillway capacity is 1,309 MGD. The dam crest has a length of 870 ft and stands roughly 112 ft above the streambed.

The Murray Reservoir Outlet structure consists of an independent wet tower with eight 30-inch saucer valves for selective level draft control. Water is released from the tower through a 48-inch outlet pipe located at the base of the tower with a maximum draft rate of 126 MGD to the Alvarado WTP.

- **San Vicente Reservoir** (usable storage: 89,300 AF)
  The function of the San Vicente Reservoir is to serve as the primary emergency storage required to meet Alvarado WTP and city-wide emergency storage needs, and impounding storage with a minimum pool of 55,000 AF (inclusive of SDCWA owned water). Seasonal storage is incidental to emergency and impounding storage, or as economically justified.

San Vicente Reservoir is located on San Vicente Creek, a tributary to the San Diego River, and impounds runoff from the surrounding 74 square mile watershed. It also impounds water transferred from Sutherland Reservoir located in the Hodges Watershed via the Sutherland-San Vicente Pipeline, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 29,102 MG and a surface area of 1.8 square miles at its spillway crest.

San Vicente Dam is a straight concrete gravity structure with a 275-foot-wide uncontrolled over pour spillway at elevation 650 ft.MSL. The spillway capacity is 32,580 MGD. The dam crest has a length of 960 ft and stands roughly 199 ft above the streambed. San Vicente Reservoir is in the process of expansion as part of the San Diego County Water Authority Emergency Storage Project. During the expansion, the dam will be raised an additional 117 ft.

The San Vicente Dam Outlet Structure consists of a semi-circular wet tower integrated on the upstream dam face with six 30-inch saucer valves for selective level draft control. Water is released from the tower through three 36-inch cast iron outlet pipes each controlled by 30-inch plug valves located at the base of the tower. One of the 36-inch outlet pipes enlarges to 42.5 inches and connects to San Vicente Pipeline No. 1. The other two outlet pipes discharge to San Vicente Pipeline No. 2. These two pipelines have a maximum combined draft rate of 76 MGD to the Lakeside Pump Station. Water leaves the Lakeside Pump Station and is carried via the El Monte Pipeline with a maximum draft rate of 95 MGD either to Murray Reservoir for storage or to the Alvarado WTP for immediate use.

- **El Capitan Reservoir** (usable storage: 109,900 AF; 10,000 AF owned and managed by HWD)
  The function of the El Capitan Reservoir is to serve as emergency storage as required to meet Alvarado WTP and city-wide emergency storage needs, and to provide impounding storage with a minimum pool of 15,000 AF (inclusive of HWD owned water). Seasonal storage is incidental to impounding and emergency storage, or as economically justified.

El Capitan Reservoir is located on the San Diego River and impounds runoff from the surrounding 190 square mile watershed. It also impounds water transferred from Cuyamaca Reservoir via Boulder Creek, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 36,758 MG and a surface area of 2.44 square miles at its spillway crest.

El Capitan Dam is a hydraulic fill rock embankment with an impervious clay core and a 510-foot-wide uncontrolled independent side channel spillway at elevation 750 ft.MSL. The spillway capacity is 110,000 MGD. The dam crest has a length of 1,170 ft and stands roughly 217 ft above the streambed.

The El Capitan Reservoir Outlet Structure is an independent wet tower with six 30-inch saucer valves for selective level draft control. Water is released from the tower through two 42-inch and two 36-inch saucer valves located within the base of the tower which discharge to the 48-inch El Monte Pipeline. The El Capitan Pipeline extends from the tower, through an outlet tunnel in the dam to the El Monte Pump Station. The pipeline has a 30-inch and a 48-inch blow-off. The pipeline has a maximum draft rate of 61 MGD to the El Monte Pump Station and a combined 345 MGD maximum draft rate to the pump station and blow-offs. Water from the El Monte Pump Station is carried via the El Monte Pipeline to the Lakeside Pump Station. From the Lakeside Pump Station, the El Monte Pipeline with an increased maximum draft rate of 95 MGD delivers water to either to Murray Reservoir for storage or to the Alvarado WTP for immediate use.

- **Cuyamaca Reservoir** (owned by HWD, and transferred via El Capitan Reservoir)
  Cuyamaca Reservoir is a tributary reservoir to El Capitan Reservoir. Cuyamaca Reservoir is located on Boulder Creek, a tributary to the San Diego River, and impounds runoff from the surrounding watershed. The reservoir has a storage capacity of 3,831 MG at its spillway crest. Cuyamaca Dam is an earth-fill embankment with a 30-foot-wide rectangular spillway at elevation 4,635 ft.MSL. The spillway capacity is approximately 2,935 MGD. The dam crest has a length of 665 ft and stands approximately 33 ft above the streambed.

Cuyamaca Reservoir Outlet consists of a 36-inch steel pipeline extending in a tunnel through the dam and a concrete channel downstream of the dam. All water transferred from Cuyamaca Reservoir to El Capitan Reservoir belongs to HWD. In addition, HWD has a separate and exclusive right to 17 MGD of Upper San Diego River runoff. The water in El Capitan Reservoir owned by HWD is transferred to their Levy WTP via the El Capitan Pipeline and El Monte Pump Station. HWD has a right to a minimum draft rate of 20 MGD.

- **Sutherland Reservoir** (usable storage: 29,400 AF)
  The function of Sutherland Reservoir is to serve as impounding storage. It has a minimum pool of 2,680 AF (reservoir gauge 65), plus any additional water reserved for the RMWD according to a water exchange agreement. Sutherland Reservoir is not a practical operational storage site due to its high elevation and distance from the imported water aqueducts; therefore, water stored in Sutherland Reservoir is transferred to San Vicente Reservoir provided storage capacity is available. Generally, all water above RMWD's contract pool is released.

Sutherland Reservoir is located on Santa Ysabel Creek, a tributary to the San Dieguito River, and impounds runoff from the surrounding 54 square mile watershed. The reservoir has a storage capacity of 9,615 MG and a surface area of 0.87 square miles at its spillway crest.

Sutherland Dam is a multiple-arch, reinforced concrete structure with a 168-foot-long uncontrolled over pour spillway at elevation 2,057 ft.MSL. The spillway is located on the eastern abutment of the dam and has a design capacity of 26,651 MGD. The dam crest has a length of 1,020 ft (1,188 ft including spillway) and stands roughly 162 ft above the streambed.

The Sutherland Dam Outlet Structure consists of a concrete box at 1940 MSL with two 36-inch outlet pipes each controlled by a 30-inch gate valve. In 1983, RMWD modified their 36-inch outlet with a floating flexible line to permit withdrawal from the reservoir at any elevation. The RMWD, through a water use agreement with the CSD, transfers water from Sutherland Reservoir via a service connection off the Sutherland-San Vicente Pipeline to their Barger WTP. Each outlet discharges to the 36-inch Sutherland-San Vicente Pipeline. A 24-inch bypass pipeline with a 20-inch plug valve at the end can be used as a blow off and to control water release into the downstream creek channel below the dam. The maximum draft rate of the Sutherland-San Vicente Pipeline is 65 MGD to San Vicente Reservoir and a combined 225 MGD maximum draft rate to the reservoir and 20 inch blow-off.

The Sutherland-San Vicente Pipeline discharges into San Vicente Creek at Daney Canyon; two miles north of the San Vicente Reservoir. Since the transfer of water from Sutherland Reservoir to San Vicente Reservoir utilizes a natural water course, the water is usually transferred to San Vicente Reservoir in the spring when the streambed is wet to minimize water loss during transport. Controlling the volume and timing of this water transfer is important to minimize streambed erosion; accommodate bass spawning (April 1 through May 15) in Sutherland Reservoir, and the federally endangered arroyo toad (*Bufo californicus*) breeding (March 15 through July 1) in the streambed. In coordination with the USFWS the CSD has agreed to conduct arroyo toad breeding activity surveys prior to, during, and after the water transfer.

The Otay-Cottonwood System

The Otay-Cottonwood System is comprised of:

- Reservoirs: Otay, Upper Otay, Barrett, and Morena.
- Their respective watersheds.
- Interconnecting pipeline: Dulzura Conduit.
- Water Treatment Plants: Otay WTP.

  Runoff from a small area upslope of the Dulzura Conduit can be captured into the conduit via a series of diverting structures. Since it contributes to Lower Otay Reservoir, it is considered part of the Otay-Cottonwood System. Essentially, this system transfers water from the Tijuana River Basin to the Otay River Basin.

The Otay-Cottonwood System covers a combined area of 227,144 acres, or about 350 square miles. The Otay WTP, located adjacent to Lower Otay Reservoir, serves as the terminus for this system and serves the South Bay area of the CSD and the California-American Water Company. The Otay WTP is of conventional design using chlorine dioxide for primary disinfection and chloramines for secondary disinfection in the distribution system. During this five-year survey period the Otay WTP expanded from 32 MGD to 34 MGD, and completed its conversion from chlorine to chlorine dioxide for primary disinfection.

- **Otay Reservoir** (usable storage: 46,020 AF)
  The function of Otay Reservoir is to serve as the primary emergency and operational storage required to meet Otay WTP and city-wide emergency storage needs and impounding storage with a minimum pool of 3,000 AF. Seasonal storage is incidental to emergency and impounding storage, or as economically justified.

Otay Reservoir is located on the Otay River and impounds runoff from the surrounding 100 square mile watershed. It also impounds water transferred from Morena and Barrett Reservoirs located in the Cottonwood Watershed via the Dulzura Conduit, and imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of: 18,417 MG at the top of the central over pour spillway flash gates, 16,243 MG at the crest of the independent spillway, and 15,334 MG at the crest of the central over pour spillway. The surface area of the reservoir is: 1.92 square miles at the top of the central over pour flash gates, 1.78 square miles at the crest of the independent spillway, and 1.61 square miles at the crest of the central over pour spillway.

Lower Otay Reservoir's Savage Dam is a curved concrete gravity structure with a 225-foot-wide gated over pour spillway at elevation 484 ft.MSL, and a 201-foot-wide gated independent spillway at elevation 487 ft.MSL. The combined spillway capacity is 31,870 MGD. The dam crest has a length of 741 ft and stands roughly 145 ft above the streambed. Spillway gates must be fully open during winter from November 1 to April 1.

Otay Reservoir Outlet Structure is an independent wet tower with seven 30-inch saucer valves for selective level draft control. Water is released from the tower through a 48-inch outlet pipe located at the base of the tower with a maximum draft rate of 48 MGD to the Otay WTP, and a combined 248 MGD maximum draft rate to the treatment plant and blow-off.

- **Upper Otay Reservoir** (no longer used for storage)
  Upper Otay Reservoir is a tributary reservoir to the Otay Reservoir and is no longer used for storage. The reservoir is located on Proctor Valley Creek; a tributary to the Otay River. The reservoir has a storage capacity of 143 MG and a surface area of 0.06 square miles at the 16-inch outlet invert.

The Upper Otay Reservoir Dam is a thin flat concrete arch reinforced with wire rope and steel plates with an independent uncontrolled spillway at elevation 550 ft.MSL. The dam crest has a length of 350 ft and stands approximately 68 ft above the streambed. From a seismic analysis of the dam completed by the California Division of Safety of Dams (DSOD), a mandate was issued requiring the maximum storage level to be lowered. The dam was reduced in size by a trapezoidal notch measuring 30 ft at the base and 160 ft at the top creating an uncontrolled central over pour spillway at elevation 535 ft. MSL with a capacity of 6,789 MGD. This reduced the capacity of the reservoir from 922 MG to 413 MG. In addition, a low-level 16-inch conduit through the Upper Otay Dam Outlet Structure with a maximum draft rate of 22 MGD was made passive. This further reduced the capacity of the reservoir to 143 MG.

- **Barrett Reservoir** (usable storage: 34,206 AF)
  The function of Barrett Reservoir is to serve as impounding storage with minimum pool at 4,372 AF at its lowest available outlet. Barrett Reservoir lacks the ability to provide emergency supply storage for the CSD due to its eastern location, high elevation, and lack of connections to imported water aqueducts; therefore, water stored in Barrett Reservoir is transferred to Otay

Reservoir provided storage capacity is available. Controlling the volume and timing of this water transfer is important to protect the Dulzura Conduit from overflows.

Barrett Reservoir is located on Cottonwood Creek, a tributary to the Tijuana River, and impounds runoff from the surrounding 134 square mile watershed. It also impounds water transferred from Morena Reservoir via Cottonwood Creek. The reservoir has a storage capacity of 14,583 MG at the top of the spillway flash gates, 11,332 MG at the crest of the spillway, a surface area of: 1.4 square miles at the top of the flash gates, and 1.3 square miles at the crest of the spillway.

Barrett Dam is a single curve gravity structure with a 336-foot-wide gated central over pour spillway at elevation 1,607 ft.MSL. The capacity of the spillway is 56,700 MGD. The dam crest has a length of 746 ft and stands approximately 171 ft above the streambed. Spillway gates must be fully open during winter from November 1 to April 1.

The Barrett Reservoir Outlet Structure consists of an independent dry tower with three 30-inch saucer valves on the outside and 30-inch gate valves on the inside for selective level draft control. Each valve is connected to a 30-inch conduit which passes through a tunnel in the right abutment of the dam and discharges to the Dulzura Conduit with a maximum draft rate of 175 MGD. The Dulzura Conduit has the ability to transport 31 MGD and discharges into Upper Dulzura Creek; a tributary to Jamul Creek and the Otay River.

- **Morena Reservoir** (usable storage: 50,020 AF)
  Morena Reservoir is a tributary reservoir to Barrett Reservoir. The function Morena Reservoir is to serve as impounding storage with a minimum pool of 674 AF. Morena Reservoir lacks the ability to provide emergency supply storage for the CSD due to its eastern location, high elevation, lack of connections to imported water aqueducts, and is considered an inefficient reservoir due to its high evaporative losses; therefore, water stored in Morena Reservoir is transferred to Barrett Reservoir provided storage capacity is available.

Morena Reservoir is located on Cottonwood Creek, a tributary to the Tijuana River, and impounds runoff from the surrounding 114 square mile watershed. The reservoir has a storage capacity of 16,519 MG and a surface area of 2.41 square miles at its spillway crest.

Morena Dam is a rock-fill embankment with an impervious upstream face consisting of rubble masonry and concrete with an uncontrolled 312-foot-wide Ogee Crest spillway at elevation 3,039 ft.MSL. The spillway capacity is 16,130 MGD. The dam crest has a length of 550 ft and stands roughly 171 ft above the streambed. The Morena Reservoir Outlet Structure consists of an independent dry tower with three 24-inch sluice gate valves for selective level draft control. Each valve is connected to a 30-inch vertical pipe which discharges through a tunnel the left abutment of the dam into Cottonwood Creek with a maximum draft rate of 194 MGD.

Miramar System

The Miramar Watershed System is comprised of:

- Reservoir: Miramar.
- Its respective watershed.
- Water treatment plant: Miramar WTP.

The Miramar Watershed has an area of 645 acres, or about one square mile. The Miramar WTP, located adjacent to Miramar Reservoir, serves as the terminus for this system and serves the northern section of the CSD. The Miramar WTP is of conventional design using ozone for primary disinfection and chloramines for secondary disinfection in the distribution system. The Miramar WTP is rated at 140 MGD. During this five-year survey period, the Miramar WTP was renovated, and completed its conversion from chlorine to ozone for primary disinfection.

- **Miramar Reservoir** (usable storage: 5,700 AF)
  The function of Miramar Reservoir is to serve as emergency and operational storage for the Miramar WTP and city-wide emergency storage needs. Operational storage is between reservoir gauges 104 and 106; the spillway is at reservoir gauge 114.

Miramar Reservoir is located on Big Surr Creek and impounds runoff from its one (1) square mile watershed. It also impounds imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 2,178 MG, a surface area of 0.42 square miles at the spillway crest.

Miramar Dam is a zoned earth embankment with a 10-foot-wide uncontrolled open channel spillway at elevation 714 ft.MSL. The spillway capacity is 279 MGD. The dam crest has a length of 1,189 ft and stands roughly 150 ft above the streambed.

The Miramar Reservoir Outlet Structure consists of an independent wet tower with seven 36-inch saucer inlet valves for selective level draft control. Water is released from the tower through a 48-inch conduit located at the base of the tower with a maximum draft rate of 100 MGD to the Miramar WTP, and a combined 178 MGD maximum draft rate to the WTP and 24-inch blow-off.

Hodges System

Hodges Watershed System is comprised of:

- Reservoirs: Hodges, San Dieguito jointly owned by SDWD and SFID, Olivenhain owned by the SDCWA.
- Their respective watersheds
- Interconnecting pipelines: San Dieguito/Santa Fe Flume jointly owned by SDWD and SFID, Hodges-Olivenhain Pipline owned by SDCWA.
- Water treatment plants: Badger Water Treatment Plant (Badger WTP) jointly owned by SDWD and SFID.

The Hodges System covers a combined area of 158,278 acres, or about 250 square miles. Currently, the Badger WTP, located adjacent to San Dieguito Reservoir, serves as the terminus for this system. The City has no treatment facilities for water impounded by this system.

Although the Hodges Watershed is a large watershed in the CSD system, it is not considered a major contributor to the CSD water supply system. Since 1969, Hodges Reservoir has not been connected to the CSD's water system; therefore, the CSD currently has no means of delivering the water impounded in Hodges Reservoir to its service area. However, Hodges is currently involved in the San Diego Water Authority’s Emergency Storage Project. This project includes construction of the Hodges-Olivenhain Pipeline and pump station connecting Hodges to Olivenhain Reservoir. Once completed, this connection will provide the ability to transfer water between Hodges Reservoir and the SDCWA Aqueduct System via Olivenhain Reservoir. Therefore, the CSD will have the ability to utilize the storage capacity of Hodges Reservoir to augment overall emergency and impounded storage.

- **Hodges Reservoir** (usable storage: 28,420 acre ft).
  The function of Hodges Reservoir is to serve as impound storage with a minimum emergency pool of 8,300 AF according to agreement with SDWD and SFID. Currently, Hodges Reservoir is not considered a reliable source of emergency water supply due to lack of connections to imported water aqueducts, high evaporative rates, and a high-spill risk over Hodges Dam during storm events. Upon completion of the Hodges-Olivenhain Pipeline, operational storage will be between reservoir gauges 96 and 111; the spillway is at reservoir gauge 115.

Hodges Reservoir is located on the San Dieguito River and impounds runoff from the surrounding 250 square mile watershed. It also impounds water that spills over Sutherland Dam via Santa Ysabel Creek; a tributary to the San Dieguito River, and in the future, imported water from the SDCWA Aqueduct System carrying Colorado River and State Project water to the San Diego area. The reservoir has a storage capacity of 9,857 MG and a surface area of 1.74 square miles at the spillway crest.

The Hodges Dam is a Multiple-arch Buttress Dam with a 342-foot-wide uncontrolled over pour spillway at elevation 315 ft.MSL. The spillway crest consists of 202-foot-wide Ogee weir section and 140-foot-wide broad-crested weir section with a design capacity of 43,509 MGD. The dam crest has a length of 729 ft (342 ft spillway and 387 ft non-overflow length) and stands roughly 130 ft above the streambed.

The Hodges Dam Outlet Structure comprises of four downspouts on the face of the dam for selective level draft control. The downspouts are 20-inch diameter cast iron pipes controlled by 20-inch gate valves that discharge to the San Dieguito/Santa Fe Flume with a maximum draft rate 117 MGD. San Dieguito/Santa Fe Flume has a maximum capacity of 13 MGD.

Currently, all impounded water stored in Hodges Reservoir is sold as raw water to SDWD and SFID. The Badger WTP treats water transferred from Hodges Reservoir via the San Dieguito/Santa Fe Flume to San Dieguito Reservoir.

2.3 Emergency Plans

Typically, the City manages its water supply system to restrict the purchase of imported water and to regulate the reservoir levels to maximize the use of local water. Under all conditions, an emergency supply is maintained in the reservoirs to be available if a failure occurs to the imported water supply system.

The DSOD has jurisdiction over 13 CSD dams. The Dams and Reservoir Team (DRT) in the CSD Public Utilities Department System Operations Division serves as the City's liaison with DSOD and coordinates all dam safety related issues.

One of the City’s most critical responsibilities is to keep CSD dams the safest possible. This requires continuous staff education and training, regular and thorough inspections, and evaluation of the collected data.

The CSD's Dam Instrumentation Program includes piezometer readings of water levels in earth-filled dams, micrometer readings of cracks on concrete dams, leakage readings, survey monument readings and recording of reservoir levels. These readings are taken by trained reservoir keepers on a weekly and monthly basis and by surveyors on annual and semi-annual basis. The data is then compiled, graphed and analyzed monthly by the DRT. On a yearly basis, this information is forwarded in the Annual Dam Instrumentation Report to DSOD for their review. The DRT, with DSOD, conducts annual dam inspections on all CSD Dams. The DRT formally documents and details each inspection through Dam Inspection Reports, which include required maintenance and work items. The reports and their findings are reviewed and discussed with each reservoir keeper. It is also part of the DRT's role to identify, plan check and inspect major capital facility improvements necessary to keep all dams and outlet work facilities in safe and operable condition. This practice ensures that DSOD and CSD comments and concerns are adequately addressed.

Runoff is conveyed through natural water courses in the rural and remote portions of the watershed to their respective storage reservoirs. These systems are not likely to fail due to age and deterioration. Structural conveyance facilities between storage reservoirs are subject to damage by vandalism and major events such as earthquakes, storms, and fires. For these reasons, CSD staff performs inspections of these facilities periodically and after major events. Other problems may be encountered in the pumping process between the reservoirs and the WTPs, and can be minimized through regular maintenance.

There are no written emergency plans addressing accidental or intentional disposal of contaminants to the raw water supply system for the CSD. However, the CSD does have two understood policies to follow if an emergency occurs relating to water quality:

- If a WTP cannot treat the water to an approved health standard level, due to upstream contaminants or treatment plant failure, the WTP shall be shut down. The CSD will then re-direct treated water to the downed service area through the distribution system served by other WTPs [or SDCWA].
- If any emergency exists, the CSD has a chain of communication procedure for notification of CSD staff.