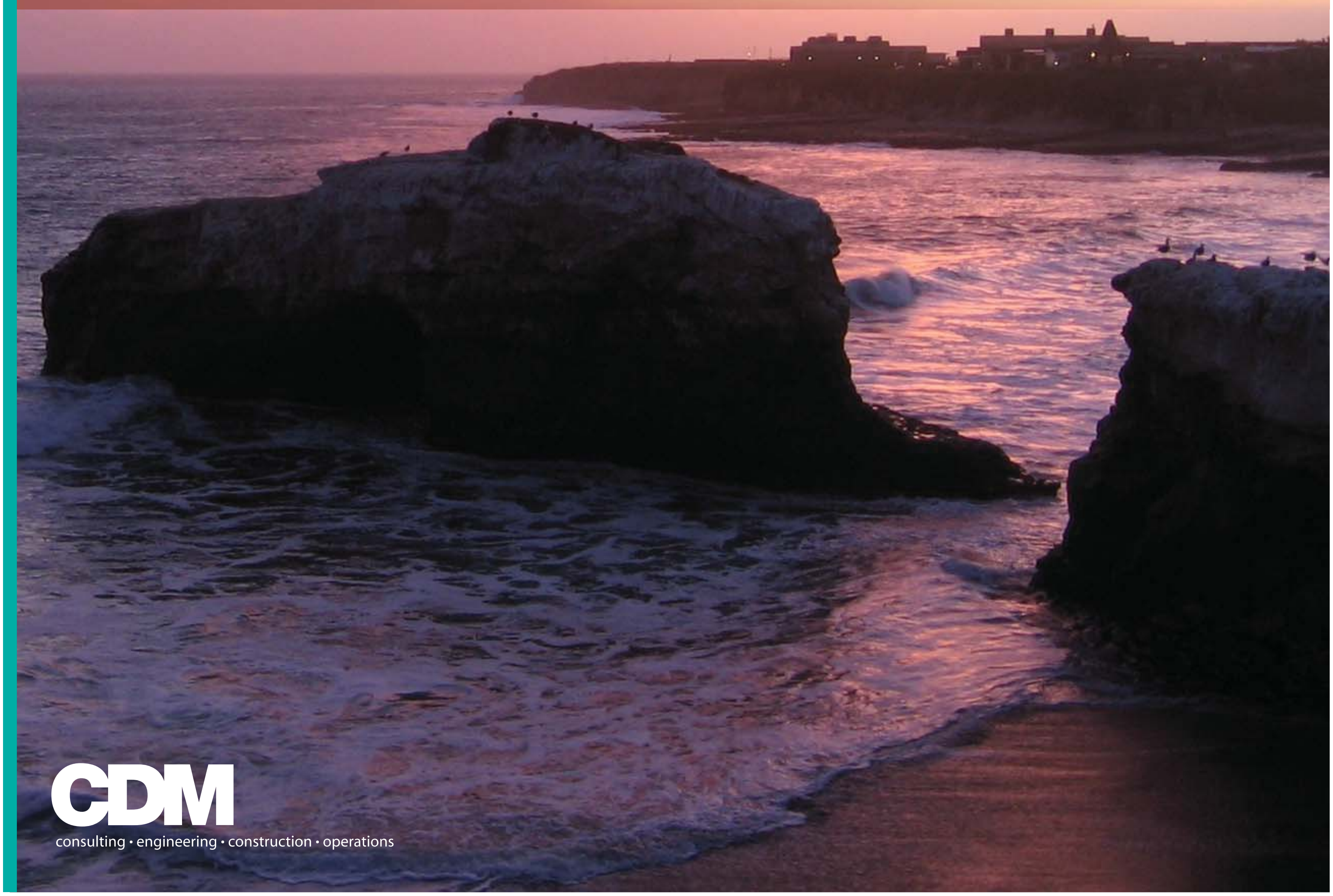
CITY OF SANTA CRUZ

WATER DEPARTMENT

Summary Report

Water Quality and System Improvements Study

October 2007



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consulting • engineering • construction • operations

CDM

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October 15, 2007

Mr. Terry Tompkins
Deputy Director/Operations Manager
City of Santa Cruz Water Department
715 Graham Hill Road
Santa Cruz, California 95060

Subject: Water Quality and System Improvements Study – Summary Report

Dear Mr. Tompkins:

CDM is pleased to submit the following documents heralding the completion of the Water Quality and System Improvements Study:

- Five copies of the summary report, errata sheet for the first page of Appendix A, cover and spine sheet, 3-hole punched, to replace draft versions in the large 3-ring report binder.
- Five copies of the summary report, bound as a stand-alone document.
- Three copies of the entire report plus appendices, on disk.

Among the findings and conclusions summarized in the report is a recommendation that between 2007 and 2016 the Water Department implement approximately $72 million of capital improvements at the Graham Hill Water Treatment Plant and the treated water distribution system. These improvements will enable the Water Department to continue to provide to its customers a drinking water supply that is safe, dependable and aesthetically pleasing.

The study was an outstanding collaboration between the Water Department and CDM. We sincerely appreciated the opportunity to work with the Water Department on this important study.

Very truly yours,

Paul Meyerhofer
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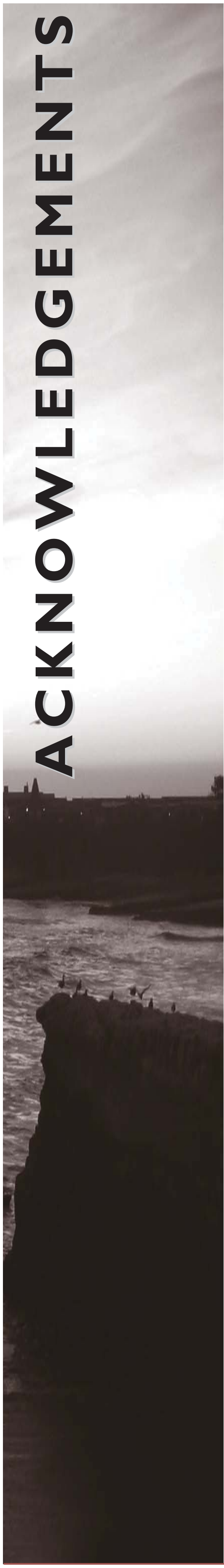
Abbreviations and Acronyms

µg/L	micrograms per liter
BSR	Bay Street Reservoir
CDM	Camp Dresser & McKee Inc.
CIP	Capital Improvements Program
D/DBPR	Stage 2 Disinfectants Disinfection Byproducts Rule
DBPs	disinfection byproducts
DHS	State of California Department of Health Services Office of Drinking Water
GAC	granular activated carbon
gpm/sf	gallons per minute per square foot
HAA_5	haloacids
IDSE	initial distribution system evaluation
LRAA	Locational Running Annual Average
LT2ESWTR	Long-Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
MDD	maximum day demand
MF	microfiltration
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
NTU	nephelometric turbidity units
OSG	onsite sodium hypochlorite generation
PG&E	Pacific Gas & Electric
PRVs	pressure reducing valves
PS	pump station
SCWD	Santa Cruz Water Department
T&O	taste and odors
TDS	Total Dissolved Solids
THMs	trihalomethanes
TOC	Total Organic Carbon
UF	ultrafiltration
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WQ&SIS	Water Quality and System Improvements Study
WTP	water treatment plant

ACKNOWLEDGEMENTS



CDM sincerely appreciates the assistance and support of the City of Santa Cruz Water Department staff in the development of the Water Quality and System Improvements Study Report.

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1.1 Purpose

In April 2002, the Santa Cruz Water Department (SCWD) and Camp Dresser & McKee Inc. (CDM) initiated the Water Quality and System Improvements Study (WQ&SIS). The purpose of the study was to develop a management plan that will enable the SCWD to provide a drinking water supply that is safe, dependable, and aesthetically pleasing, which meets or exceeds current and anticipated drinking water quality standards and regulatory requirements. The project objective is consistent with the SCWD's mission statement:

> ***"To provide a safe, clean, and continuous supply of water for municipal and fire protection purposes that meets or exceeds local, State and Federal standards for public health and environmental quality and to provide courteous, responsive, and efficient service in the most cost-effective manner to our customers".***

Evaluations for the WQ&SIS were limited to the Graham Hill Water Treatment Plant (WTP) and major components of the treated water distribution and storage system; the Beltz Groundwater Treatment Plant and the City's raw water supply facilities and transmission systems were omitted from the study as they are being addressed in other investigations.

The key activities conducted during the study included:

- Develop water quality goals
- Develop system service reliability goals
- Identify, compare and select treatment process improvements for the Graham Hill WTP
- Identify, compare and select treated water distribution and storage improvements
- Prioritize the recommended projects and integrate them into the 10-year Capital Improvements Program (CIP)

This report summarizes the findings from these investigations and presents the recommended projects, estimated costs and an implementation schedule. Additional details on the development of the goals and recommended projects are provided in the interim project deliverables and project workshop materials and minutes, found in the appendices at the end of this report.

It is important to note that this report was written just prior to the SCWD initiating the emergency replacement of the Bay Street Reservoir. The text of this report therefore reflects the presence of the original 35 MG reservoir.

1.2 System Overview

The SCWD provides drinking water to approximately 90,000 persons throughout a 30 square mile service area that includes the City of Santa Cruz, parts of unincorporated Santa Cruz County, and a small portion of the City of Capitola. The service area is shown on Figure 1-1. Treatment facilities include the Graham Hill WTP and the Beltz GWTP. The distribution system consists of almost 250 miles of piping 4 inches in diameter and larger. More detailed descriptions and assessments of the treatment and distribution/storage facilities are provided in Technical Memorandum No. 2 – System Service and Reliability Goals (Appendix B).

Population forecasts for the service area suggest less than 1 percent growth per year through 2020. This growth corresponds to similar increases in anticipated maximum day water demands that will reach 20.5 million gallons per day (mgd) at build-out in 2040 as compared to the current (2006) maximum day demand of approximately 17 mgd.

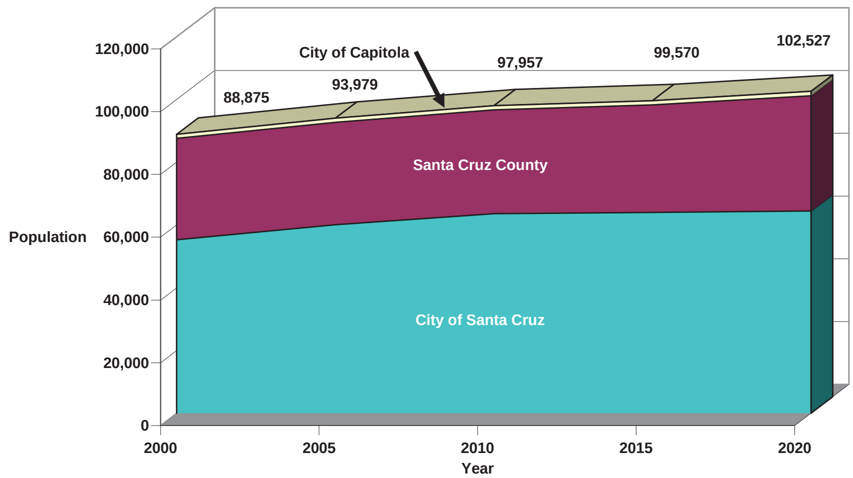

Figure 1-2
Population Forecast for the
Santa Cruz Water Department Service Area

Although growth appears modest, the projected increases in water demands coupled with the limited availability of drinking water supplies, variable source water quality and recently promulgated drinking water regulations, present unique challenges for the SCWD to continue to provide safe, uninterrupted drinking water to its customers. For example, while the Graham Hill WTP was last upgraded in 1986 to a rated capacity of 24 mgd, this capacity is not sustainable for a number of reasons, including lack of redundancy in equipment or treatment systems. Similarly, the Bay Street Reservoir (35 million gallons [MG] storage volume) was constructed in 1924 and has been in service for more than 80 years. A metal and wood roof system was installed at the BSR in the 1970's. In 2003, several trusses that support the

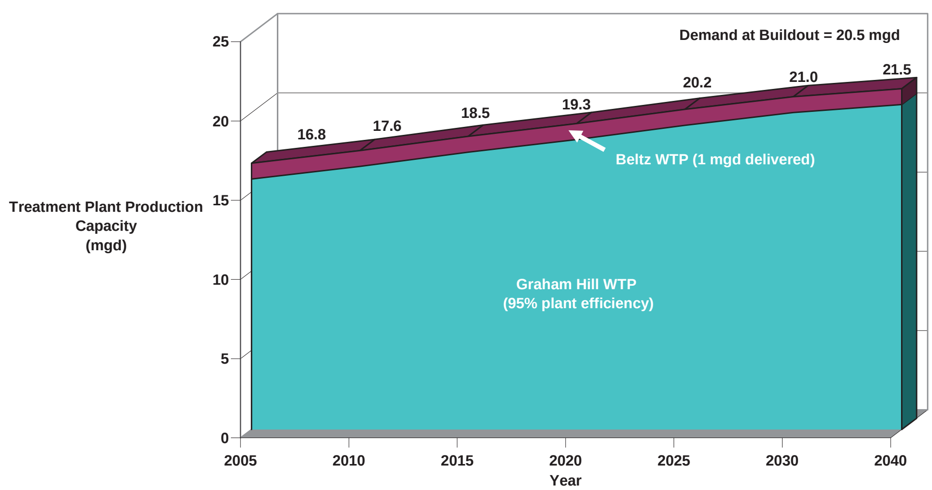

Figure 1-3
Projected Water Demands for the
Santa Cruz Water Department Service Area

Note: On July 11, 2006 the City Council of the City of Santa Cruz adopted a modified version of this map as the official SCWD Water Service Boundary.

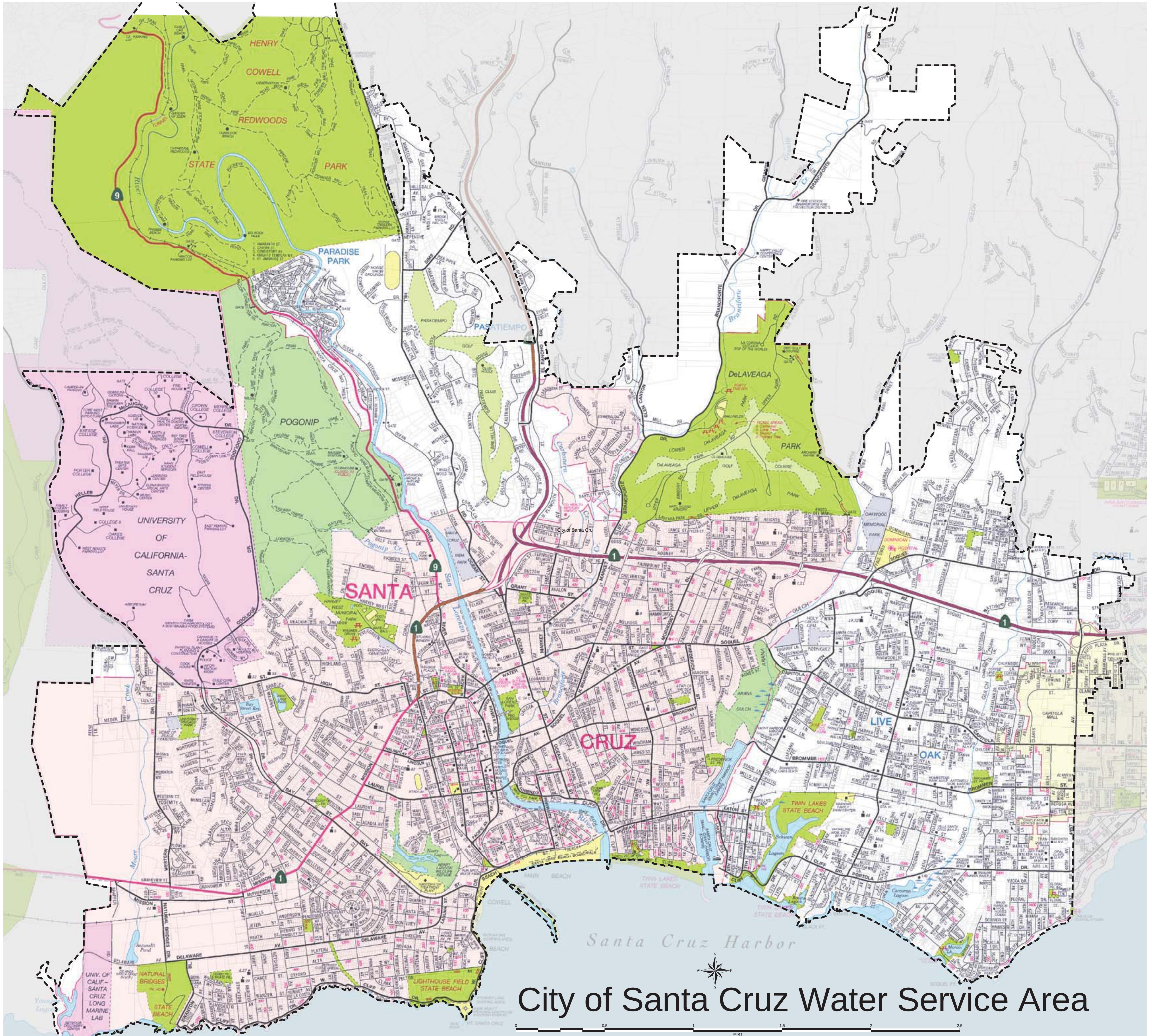

Figure 1-1
SCWD Service Area

metal roof system failed and an emergency repair project was implemented to replace the failing trusses while keeping the reservoir in service. Another challenge is the SCWD's dependency on the Graham Hill WTP and the Bay Street Reservoir, facilities that treat and store more than 95 percent and 80 percent, respectively, of the system's drinking water with limited alternative (redundant) facilities.

1.3 Regulatory Summary

The Graham Hill WTP and Beltz TP currently complies with all drinking water standards set by the United States Environmental Protection Agency (USEPA) and the State of California Department of Health Services Office of Drinking Water (DHS). These regulations require monitoring of source waters, watershed protection, treatment techniques, and extensive monitoring of treated water quality at the Graham Hill WTP and throughout the distribution system; less extensive monitoring and treatment are required for the Beltz TP because it treats groundwater (not influenced by surface water). DHS oversees the operation of all public water systems throughout the State and is responsible for issuing operating permits, certifying operators and enforcing regulations.

The two most recent regulations- the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the Stage 2 Disinfectants Disinfection Byproducts Rule (D/DBPR), were promulgated on January 4, 2006. A schedule of the upcoming regulatory activities and milestones is presented in Figure 1-4.

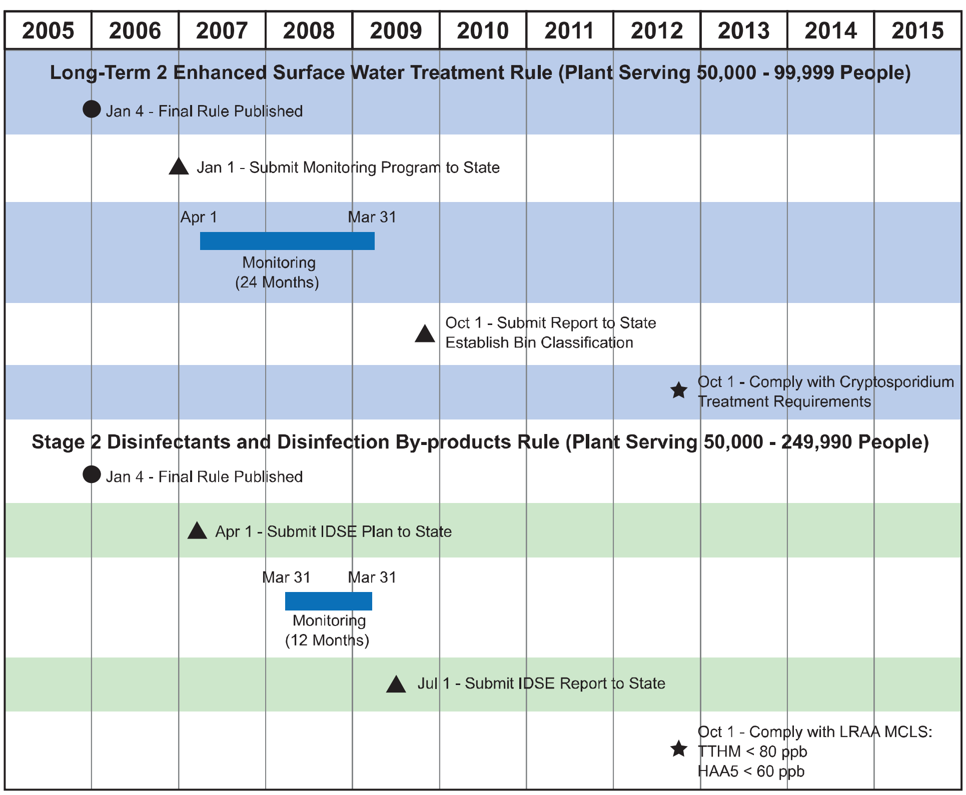

Figure 1-4
Key Water Quality Regulatory Milestones for the Graham Hill WTP

These regulations focus on maintaining greater levels of disinfection to reduce the risk from pathogens (such as *Giardia*, viruses, and *Cryptosporidium*), and at the same time, require water suppliers to reduce the concentrations of disinfectant residuals (such as chlorine, chloramines and chlorine dioxide) and harmful disinfection byproducts (DBPs) (such as trihalomethanes, haloacetic acids, bromate and chlorite). The LT2ESWTR will require the Graham Hill WTP to achieve levels of disinfection beyond the original design expectations and current treatment practices, and Stage 2 D/DBPR will require additional monitoring, treatment process improvements and operational modifications to ensure that DBP levels throughout the system are maintained below the new regulatory limits.

Additional water quality and regulatory information is presented in Technical Memorandum No. 1 – Treatment Plant and Distribution System Water Quality Goals (Appendix A).

2.1 Development of Water Quality Goals

The first activity addressed during the WQ&SIS was to establish water quality goals for the SCWD with respect to water leaving the treatment plants and water throughout the distribution system. The project team defined goals as required criteria by which the alternatives would be evaluated. In other words, for an alternative to be considered feasible, the water quality (and reliability) goals must be met with no exceptions.

Water quality goals were initially developed for both the finished water leaving the treatment plants and water throughout the distribution system. The goals were based primarily on:

- Current and anticipated drinking water regulations
- SCWD aesthetic water quality objectives

Additional factors that influenced the water quality goals were:

- Source water quality variations
- Anticipated changes in source water quality and availability
- Planned use of desalinated seawater as a drinking water supply during droughts
- Historical source water and treated water quality
- Benchmarking water quality goals set by water suppliers in Northern California with similar treatment and distribution issues.

The information described above is presented in *Technical Memorandum No. 1 – Treatment Plant and Distribution System Water Quality Goals* (Appendix A). The (draft) document was submitted to the SCWD in July 2002. The project team re-assessed the water quality goals in a workshop in February 2006 after the LT2ESWTR and Stage 2 D/DBPR were published (in January 2006). The final water quality goals are presented in the following paragraphs.

2.2 Treatment Plant Water Quality Goals

The treatment plant water quality goals, presented in Table 2-1, were developed to apply to all finished water leaving the existing plants (Graham Hill and Beltz) and future treatment facilities (planned Seawater Desalination Plant).

Table 2-1. Treatment Plant Water Quality Goals(1) (2)

Category	Constituent	Proposed Goal
Microbiological	*Giardia*	≥99.99% removal/inactivation
	Cryptosporidium	≥99.999% removal/inactivation (Bin 3)
	Viruses	≥99.999% removal/inactivation
	Total Coliforms	100% of samples absent of coliforms leaving the plant
	Heterotrophic Plate Count	0 bacterial colonies per mL leaving the plant
	Particles	99.9% reduction for particles > 2 µm (total particles)
	Settled Water Turbidity	< 2 NTU in 95 percent of continuous measurements
	Filtered Water Turbidity	≤ 0.10 NTU combined filter effluent and individual filters ≤ 0.3 NTU individual filters at all times
	Filter Backwash Recycle	< 2 NTU in 90 percent of continuous measurements
	Biodegradable Organic Carbon	<0.5 mg/L
	Assimilable Organic Carbon	<0.2 mg/L
Organics/DBPs	Trihalomethanes (THMs)	<80 µg/L as required to meet distribution system goals
	Haloacids (HAA_5)	<60 µg/L as required to meet distribution system goals
	Formaldehyde	<100 µg/L leaving the plant
	MTBE	< 5 µg/L
	PCE	<0.06 µg/L
	Total Organic Carbon	> 15% removal or as required to meet the Stage 1 D/DBPR
Inorganics	Aluminum	< 0.05 mg/L leaving the plant
	Ammonia	Not-detected
	Arsenic	< 2 µg/L
	Bromate	< 5 µg/L all monthly samples
	Chloramines	1.5-2.0 mg/L total chorine leaving the plant (if chloramines are implemented)
	Chloride	<250 mg/L (leaving the plant)
	Chlorine	GHWTP 0.8-1.5 mg/L free chlorine leaving the plant Beltz 0.5-1.4 mg/L free chlorine leaving the plant
	Chlorine Dioxide	< 0.8 mg/L leaving the plant (if chlorine dioxide is implemented)
	Chlorate	< 0.8 mg/L (if chlorine dioxide is implemented)
	Chlorite	< 1.0 mg/L (if chlorine dioxide is implemented)
	Copper	< 0.17 mg/L leaving the plant
	Hardness	< 150 mg/L as $CaCO_3$
	Iron	< 0.05 mg/L
	Lead	< 0.002 mg/L leaving the plant
	Manganese	< 0.05 mg/L
	Orthophosphate	0.5 to 1.4 mg/L as PO_4^-
	Perchlorate	< 6 µg/L (PHG)
	Sulfate	GHWTP <250 mg/L Beltz TP <500 mg/L
	Total Dissolved Solids (TDS)	GHWTP <500 mg/L Beltz <1,000 mg/L
	Zinc	0 mg/L added to the water
Aesthetics	Threshold Odor Number	TON ≤ 2 100% of the time TON monthly average <1.5
	Flavor Profile Analysis	FPA Rating < 0.5 leaving the plant (if analysis is included)
	Chlorine-to-Ammonia Ratio	Cl_2:NH_3 of 4:1 to 5:1 based on free chlorine residual (if chloramines are implemented)

(1) Final Treatment Plant Water Quality Goals developed from information presented in TM-1 Water Quality Goals (CDM, July 2002); refer to Tables 7-2, 7-3, and 7-4 (TM-1 provided in Appendix A).

(2) VOCs and SOCs are not included in this table because they have not been detected and there is no evidence that suggests that these chemicals present risks to the SCWD water system.

Treatment plant water quality goals that significantly affected the evaluation of treatment process alternatives to upgrade the Graham Hill WTP included:

- *Cryptosporidium* Removal ≥ 99.999% or 5-logs, consistent with Bin 3 Classification as defined in the LT2ESWTR
- Filtered Water Turbidity ≤ 0.10 nephelometric turbidity units (NTU) combined filter effluent and individual filters in 95% of monthly samples; ≤ 0.30 NTU individual filters at all times
- Total Organic Carbon (TOC) > 15% removal or as required to meet the Stage 1 D/DBPR TOC removal requirements and the TTHM and HAA_5 goals
- Trihalomethanes < 80 micrograms per liter (µg/L) as required to meet distribution system goals (provides a buffer to meet the Maximum Contaminant Level (MCL) of 80 µg/L for locational running annual averages [LRAAs])
- Haloacetic Acids < 60 µg/L as required to meet distribution system goals (provides a buffer to meet the MCL of 60 µg/L for LRAAs)
- Threshold Odor Number ≤ 1.5 leaving the plant
- Flavor Profile Analysis ≤ 0.5 leaving the plant

Additionally, adopting a chloride goal of not greater than 250 mg/L leaving the plant will have little or no impact at the Graham Hill and Beltz plants. However, the chloride goal will be an important consideration for designing and operating the planned Seawater Desalination Plant.

2.3 Distribution System Water Quality Goals

Distribution system water quality goals were developed to ensure that the high water quality standards that are achieved at the treatment plants are maintained in water delivered to all customers in the service area. These goals are listed in Table 2-2 and those goals that significantly impacted the development and evaluation of distribution system alternatives included:

- Water Age < 10 days
- Trihalomethanes < 80 µg/L in all distribution system samples (provides a buffer to meet the MCL of 80 µg/L for LRAAs)
- Haloacetic Acids < 60 µg/L in all distribution system samples (provides a buffer to meet the MCL of 60 µg/L for LRAAs)
- Chlorine 0.2 to 1.5 mg/L
- Preliminary recommendations to improve Bay Street Reservoir.

Table 2-2. Distribution System Water Quality Goals

Category	Constituent	Proposed Goal
Microbiological	*Giardia*	0 cysts/100L (assumed with 99.99% removal/inactivation)
	Cryptosporidium	0 oocysts/100L (assumed with 99.999% removal/inactivation)
	Viruses	0 organisms/100L (assumed with 99.999% removal/inactivation)
	Total Coliforms	>95% of samples absent of coliforms in monthly distribution system samples
	Heterotrophic Plate Count	<50 bacterial colonies per mL
	Finished Water Turbidity	$\leq$ 0.20 NTU
	Biodegradable Organic Carbon	<0.5 mg/L
	Assimilable Organic Carbon	<0.2 mg/L
	Water Age	<5 days
Organics/DBPs	Trihalomethanes (THMs)	<80 µg/L for all distribution system samples
	Haloacids (HAA_5)	<60 µg/L for all distribution system samples
	Formaldehyde	<100 µg/L
Inorganics	Aluminum	< 0.05 mg/L
	Ammonia	Not-detected
	Chloramine	0.5-2.0 mg/L total chlorine (if chloramines are implemented)
	Chlorine	0.2 to 1.5 mg/L free chlorine
	Chlorine Dioxide	< 0.8 mg/L (if chlorine dioxide is implemented)
	Chlorate	<0.8 mg/L (if chlorine dioxide is implemented)
	Chlorite	<1.0 mg/L (if chlorine dioxide is implemented)
	Copper	< 1.3 mg/L for 90^{th} percentile
	Iron	< 0.05 mg/L
	Lead	< 0.15 mg/L for 90^{th} percentile
	Manganese	< 0.05 mg/L
	Orthophosphate	>0.05 mg/L for all distribution system samples
	Zinc	0 mg/L added to the water
Aesthetics	Threshold Odor Number	TON <2 100% of the time TON monthly average <1.5
	Flavor Profile Analysis	FPA Rating < 0.5 (if analysis is initiated)
	Chlorine-to-Ammonia Ratio	Cl_2:NH_3 of 4:1 to 5:1 based on free chlorine residual (if chloramines are implemented)

3.1 Description of the Graham Hill WTP

The Graham Hill WTP is a conventional treatment plant that was commissioned in 1960 as a 12 million gallons per day (mgd) plant and has undergone an expansion (to 24 mgd) and a number of plant improvement projects over the last 40 years. The site plan (Figure 3-1) and process schematic (Figure 3-2) describe the current configuration.

3.2 Surface Water Treatment Reliability Goals

Before reliability goals were developed, the project team defined operating conditions for the Graham Hill WTP:

- Normal Operations – The system is unencumbered in meeting the water needs of its customers. Based on discussions with SCWD staff, normal operations for the SCWD system were described as:
  - All water sources are available for service.
  - GHWTP is in service.
  - Beltz WTP is either in service or available for service.
  - Bay Street Reservoir and all other distribution system facilities are in service or available for service.
  - All required power supplies are available.
  - All control systems are operating.
  - All communication systems are in service.
  - No critical staffing shortages exist.
- Planned and Unplanned Outages – The system is slightly constrained in meeting customer demands. This is usually caused by some type of equipment outage.
- Emergency Outage – The system is significantly constrained in meeting customer demands. This is usually due to some major equipment or facility failure. For the SCWD system these could include:
  - Natural disaster (e.g., earthquake, landslide, flood, fire).
  - Extended power outage (>12 hours).
  - Terrorist damage.
  - Source water contamination.
  - Treated water contamination.

The service reliability goals for surface water treatment plant production are presented in Table 3-1. The goals are based on meeting the system's ultimate (build-out) maximum day demand of 20.5 mgd. This demand was selected for planning purposes because of the relatively small incremental increase between the 20-year horizon demand (19.2 mgd) and ultimate demand. It is also assumed that 1.0 mgd would be supplied by the Beltz GWTP and the remaining 19.5 mgd would be provided by the Graham Hill WTP. The project team assumed that restoring the Graham Hill WTP to a treatment (design) capacity of 22 mgd would comfortably deliver 19.5 mgd of treated

Figure 3-1 removed for security purposes

Figure 3-2 removed for security purposes

water to the system during normal and all but the most extreme adverse water quality conditions. After a brief assessment of earthquake, flood, landslide and fire hazards, the project team determined that the threats posed to the SCWD water system by natural disasters justified the emergency condition reliability goals described in Table 3-1. Further details related to the development of the reliability goals are provided in *Technical Memorandum No. 2- System Service Reliability Goals* (Appendix B).

Table 3-1. Summary of Proposed Service Reliability Goals for Surface Water Treatment Production

Condition	Level of Service
Normal Operations – All anticipated water quality conditions.	100% maximum production (22-mgd) continuous for 30 days.
Planned Outages – Routine maintenance.	Never less than 75% (16.5-mgd). 100% (22-mgd) within 72-hours.
Unplanned Outages – Power outages <12 hours. Equipment failure(s)	Never less than 75% (16.5-mgd). 100% (22-mgd) within 72-hours.
Emergency Outages – Earthquake Landslide Flood Fire Damage by third party	25% (5.5-mgd) within 7-days(1). 50% (11-mgd) within 30-days. 100% (22-mgd) within 6-months.

(1) Under emergency conditions the Graham Hill WTP may not provide production (i.e., zero-mgd) for up to 7-days while critical facilities are repaired.

3.3 Assessment of the Graham Hill WTP

The project team conducted a reliability evaluation of the Graham Hill WTP that included the following information for the major unit processes and facilities:

- Recommended and actual design criteria
- Operation
- Performance
- Maintenance requirements
- Failure history
- Status of technology

Details of the plant assessment are also provided in *Technical Memorandum No. 2- System Service Reliability Goals* (Appendix B).

The most obvious reliability problems identified at the plant were:

- Inadequate Treatment Capacity. The Graham Hill WTP does not have a sustainable capacity of 24 mgd. Factors that limit the plant's sustainable capacity include lack of redundancy in equipment or treatment systems, periodic maintenance procedures that require taking a process train or system out of service and potentially high volumes of plant residuals and waste streams at the higher flows.

- Electrical System Capacity. The main service is limited by the capacity of the system main breaker (in MCC-A) and the present service size is inadequate for serving electrical loads associated with potential plant improvements such as air scour, membrane filtration, ozone, hypochlorite generation, or ultraviolet disinfection.

Additional concerns are listed in Table 3-2 and detailed results of this evaluation are found in Appendix B.

Table 3-2. Reliability Concerns at the Graham Hill WTP

Component	Concern(s)
Rapid Mix No. 1	▪ More efficient motors and drives available.
Carbon Contactors	▪ PAC tends to settle in channel between carbon contactors and Rapid Mix No. 2.
Rapid Mix No. 2	▪ More efficient motors and drives available.
Flocculation Basins	▪ Unable to isolate a flocculation basin from corresponding sedimentation basin for maintenance or repairs; entire pretreatment process train must be drained. ▪ Suspected unequal flow splitting and short-circuiting. ▪ Limited flexibility and frequent maintenance requirements of horizontal paddle mixers. ▪ Two-stage flocculation provides only 26 minutes contact time at 24-mgd.
Sedimentation Basins	▪ Suspected unequal flow splitting and short-circuiting. ▪ Limited performance and flexibility and frequent maintenance requirements of tube settlers. ▪ Tube settlers are aging and should be replaced in near future.
Dual-Media Filters	▪ No filter-to-waste facilities. ▪ DHS restriction on filtration rates (3.5 gpm/sf vs. 6 gpm/sf for dual-media filters) results in reduced plant capacity. ▪ Relatively shallow media for treating high turbidity water. ▪ Surface wash is less effective than air scour. ▪ No particle counters for optimization.
Finished Water Tank	▪ Pasatiempo pumps draw water before the Finished Water Tank- plant does not receive credit for use as chlorine contact basin for primary disinfection. ▪ No bypass to allow tank to be taken off-line for service.
Backwash System	▪ Relatively high volume of water (175 gal/sf) needed for washing. ▪ No air-scour facilities to improve backwashing. ▪ No backwash turbidimeter.
Solids Handling System	▪ Overdosing anionic polymer can disrupt coagulation at the plant.
Operations Building	▪ Not designed/constructed to current building, seismic, fire and electrical codes. ▪ Infrastructure is aging. ▪ Vulnerable to damage by earthquake.
Plant Site	▪ Chemical facilities not designed/constructed to current fire/hazmat code. ▪ Vulnerable to damage by earthquake.
Existing Chemical Systems	
PAC Storage/Feed System	▪ PAC may not adequately control moderate to severe algae based taste and odor (T&O) events. ▪ PAC hinders coagulation, filter performance and disinfection with free chlorine. ▪ PAC increases residuals production.
Potassium Permanganate Storage/Feed System	▪ Potassium permanganate may not control moderate to severe algae based T&O events. ▪ Dose is limited to less than 1 mg/L at existing plant flow rates (15 mgd or less). ▪ Plant switches to PAC when 1 mg/L of $KMnO_4$ no longer eliminated taste and odor.
Alum Storage/Feed System	▪ Alum may not meet TOC removal requirements of Stage 1 DBPR if source water TOC rises above 2 mg/L. ▪ Chemical loading, storage and feed facilities do not meet current fire/hazmat code.
Cationic Polymer Storage/Feed System	▪ Chemical loading, storage and feed facilities do not meet current fire/hazmat code.
Gaseous Chlorine	▪ LT-2 ESWTR may require inactivation of *Cryptosporidium* and increased inactivation of *Giardia* and viruses. ▪ Compliance with Stage 2 DBPR and future regulations with free chlorine as the primary and final disinfectant is questionable. ▪ Gaseous chlorine presents safety/neighborhood/environmental concerns; plans to implement onsite generation of sodium hypochlorite are included in the current CIP.
Nonionic Polymer Storage/Feed System	▪ Nonionic polymer application as a filter aid could be optimized by varying the dose to individual filters throughout each filter run.
Corrosion Inhibitor Storage/Feed System	▪ Chemical loading, storage and feed facilities do not meet current fire/hazmat code.
Anionic Polymer Storage/Feed System	▪ Overdosing the anionic polymer to the washwater clarifiers can disrupt coagulation at the plant when the reclaimed water is recycled to the plant influent.

3.4 Summary of Treatment Alternatives

From the evaluation, nine (9) treatment process alternatives were developed as potential upgrades for the Graham Hill WTP to meet the treatment plant water quality and reliability goals. The alternatives, shown schematically in Figure 3-3, were developed based on anticipated water quality benefits, operational enhancements, available technologies, and improved reliability.

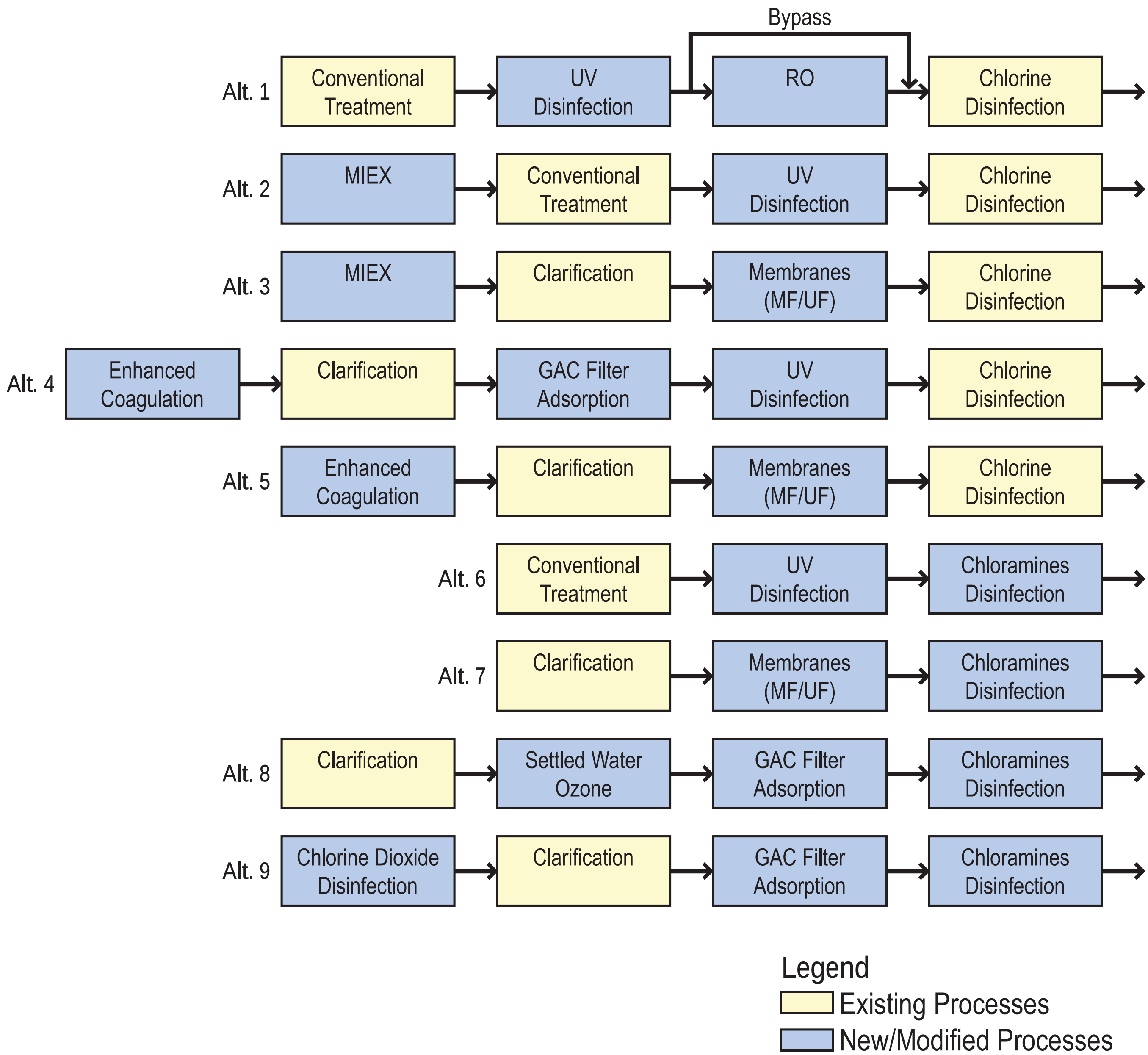

Figure 3-3
Graham Hill WTP Process Upgrade Alternatives

Figure 3-4 presents comparative costs (capital and annual operations and maintenance) that were used to gauge the relative affordability of the alternatives.

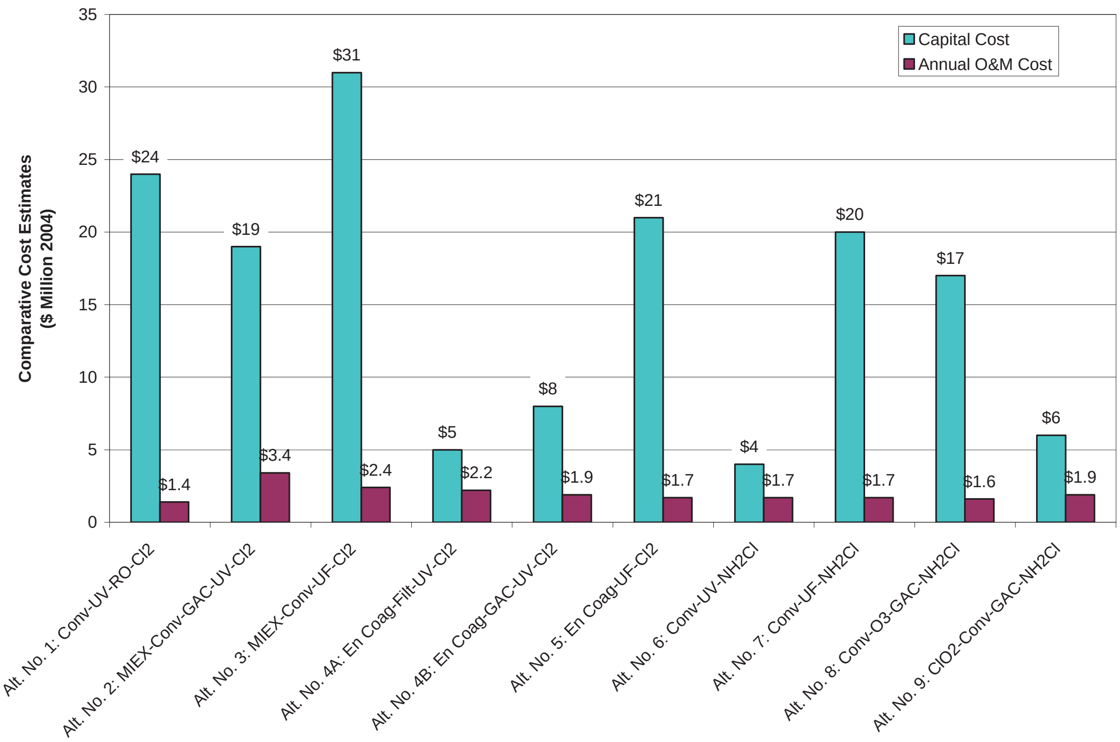

Figure 3-4
Comparative Costs for Process Upgrade Alternatives at the Graham Hill WTP

Technical Memorandum No. 3A – Comparison of Treatment Process Alternatives for the Graham Hill Water Treatment Plant (Appendix C) presents more information on the development and evaluation of the nine alternatives.

3.5 Selected Improvements

The recommended treatment process upgrades for the Graham Hill WTP were selected at a workshop in March 2006. The SCWD considered the preferred alternatives evaluated in previous activities and modified the selection process based on a philosophy of implementing the best available and affordable technologies to meet the water quality and reliability goals. As a result, the selected treatment process combines elements from several of the original nine (9) alternatives to form a unique, preferred alternative. The selected treatment process improvements are shown schematically and at the site in Figures 3-5 and 3-6, respectively.

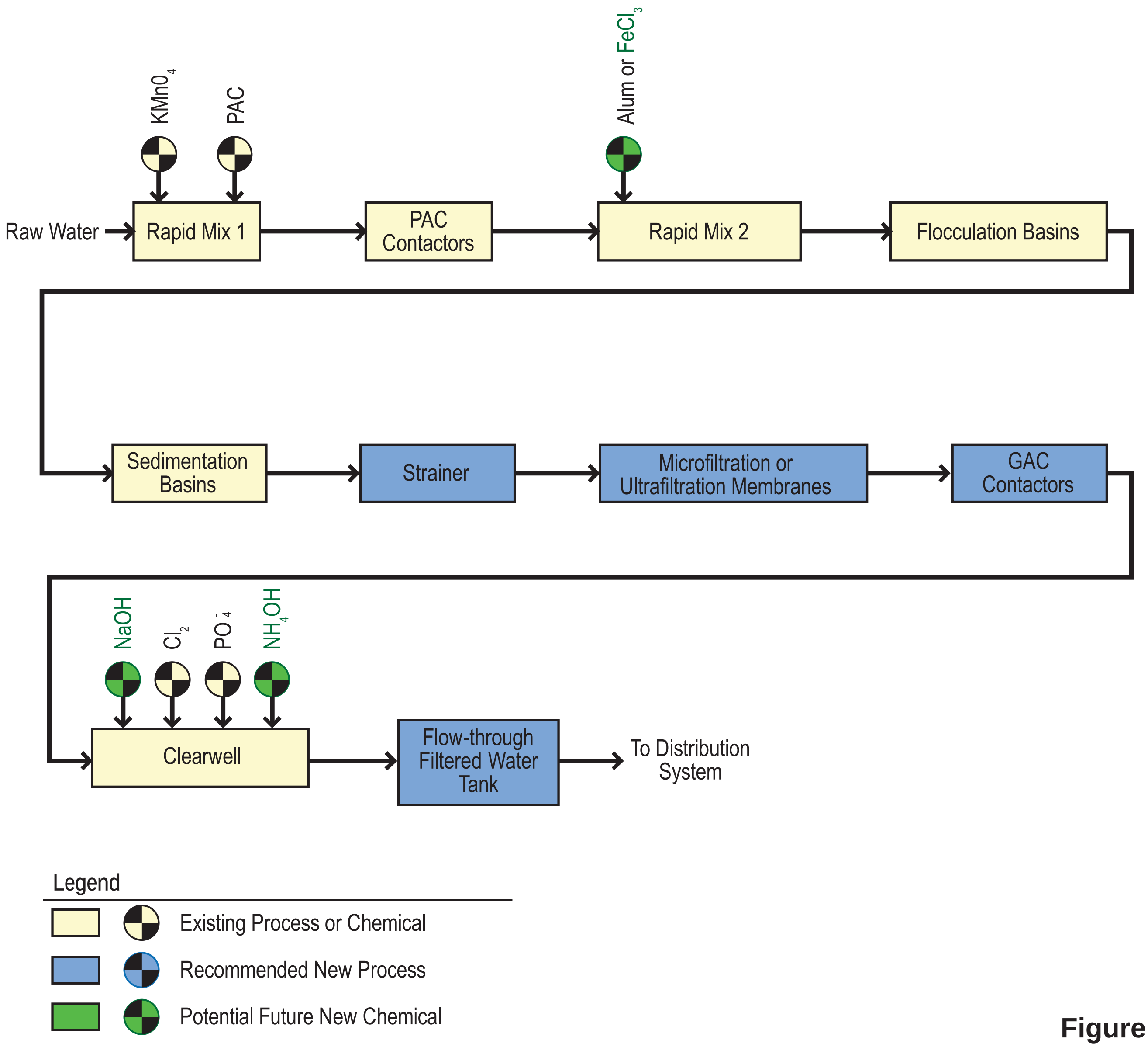

Figure 3-5
Schematic Diagram of Recommended Treatment Process Improvements for the Graham Hill WTP

Featured improvements include:

- Membrane Filtration. The existing sedimentation basins will be modified for submerged microfiltration or ultrafiltration membranes. The membranes will provide an absolute barrier to *Giardia* and *Cryptosporidium* to meet the disinfection goals (Bin 3), and allow the plant to treat high turbidity waters from the San Lorenzo River and possibly other sources.
- Post-Filter GAC Contactors. The sand and anthracite in the existing dual-media gravity filters will be removed and replaced with approximately 36-inches of granular activated carbon. The GAC will adsorb algal-based tastes and odors and remove organic DBP precursors, therefore, allowing the plant to meet the THM and HAA goals with free chlorine as the residual disinfectant.

- Flow-through Filtered Water Tank. The piping to/from the filtered water tank will be changed to allow flow-through operation. This modification will increase chlorine contact time, although adequate contact time is achieved with the additional improvements. Other benefits include the ability to buffer water quality spikes such as turbidity, and provide an alternative monitoring point for combined filter effluent.
- On-Site Hypochlorite Generation. Onsite sodium hypochlorite generation (OSG) equipment will replace one-ton chlorine cylinders and gaseous chlorine feed equipment. The conversion will greatly eliminate the risks of chlorine gas leaks and is expected to reduce chemical costs over the life of the equipment. The SCWD's current CIP includes projects to convert to OSG at the Graham Hill WTP and the Beltz TP.
- Electrical System Upgrade. The Pacific Gas & Electric (PG&E) electrical service to the plant will be upgraded from the current 361 amperes (based on the existing transformer) to 3,600 amperes to accommodate the anticipated electrical loads from the membranes and future potential improvements such as ozone and/or UV disinfection if future regulations require advanced treatment. The upgrade will include a new electrical building as shown on the site plan. The analysis of the existing electrical system and development of alternatives and a recommendation are provided in *Technical Memorandum No. 3B – Graham Hill WTP Power Analysis and Electrical Improvement Recommendations* (Appendix D).

Other projects recommended for the Graham Hill WTP included:

- Solids Handling Study. Conduct a study to project future solids production, identify alternative solids handling techniques and develop cost estimates and a plan to implement the optimal approach to process residuals and handle solids at the Graham Hill WTP.
- Pasatiempo Interim Ultraviolet (UV) Disinfection. Install UV disinfection contactors on the 12-inch diameter Pasatiempo treated water distribution piping. Currently, water is pumped directly from the clearwell by the Pasatiempo pumps; this practice requires the plant to meet all primary disinfection requirements at the filter outlets. UV will satisfy the disinfection goals for the interim period before membranes are operating. If membranes are installed on a fast-track schedule, the UV disinfection project for the Pasatiempo line can be omitted.
- Chloramine Conversion. Install an aqua ammonia system and convert from free chlorine to chloramines. The conversion to chloramines will provide a 60 to 90 percent reduction in chlorinated DBPs (i.e., THMs and HAAs) at the Graham Hill WTP based on studies conducted by CDM during the Water Treatment Alternatives Study in the early 1990s. Converting to chloramines will also provide a more persistent residual in the distribution system and may mitigate some of the problems associated with excessive water ages at treated water storage reservoirs throughout the system such as the loss of chlorine residuals and increased DBP formation. The SCWD has not yet decided to implement chloramines and will continue to assess the benefits of choramines against the costs for conversion and the potential implications of ammonia (i.e., nitrification) as operation of the system is optimized.
- Enhanced Coagulation Improvements. Replace the aluminum sulfate (alum) storage and feed system with a system compatible with ferric chloride; and install a caustic soda system for pH adjustment in the finished water. Bench- and pilot-scale testing conducted during the Water Treatment Alternatives Study (1990s) indicated that ferric chloride provided better removal of turbidity, particles, TOC and DBP precursors when compared to alum. The SCWD has not committed to implementing enhanced coagulation at the same time as the membranes and other process improvements. The decision will be delayed until the results from the initial distribution system evaluation (IDSE) testing are available and the

SCWD can determine if enhanced coagulation (ferric chloride) is necessary to meet the DBP goals with free chlorine as the residual disinfectant.

Technical Memorandum No. 5 – Recommended Improvements (Appendix H) provides more detailed discussions of the selected improvements for the Graham Hill WTP.

The SCWD water system provides drinking water to approximately 90,000 persons within the Santa Cruz City limits and portions of unincorporated Santa Cruz County. The system includes approximately 250 miles of piping, three principal systems and nine pressure zones. Figure 4-1 shows the pressure zones, major piping, and principal facilities in the distribution system. Table 4-1 summarizes the pressure zones and key facilities.

Table 4-1. Pressure Zones and Key Facilities in Santa Cruz Distribution System

Pressure Zone		*Zone Demand*	*Zone Supply Source*		*Zone Storage*		
Name	*Approx. Elev. (ft)*	*2000 Maximum Day (mgd)*	*Name*	*Cap. (MGD)(1)*	*Name*	*Cap (MG)*	*Overflow Elevation (ft)*
Gravity System							
Gravity	0-200	17 - 20	Graham Hill WTP	22.0	Filtered Water Res	1.0	295
			Beltz wells	1.0	Bay Street Res	35	282
					Delavega Res	2.0	254
Santa Cruz Gardens	200-350	0.30	Thurber Pump Station (PS)	0.6	Santa Cruz Gardens 1 Res	0.25	524
					Santa Cruz Gardens 2 Res	0.25	524
Carbonera	200-300	0.60	Carbonera PS	1.3	Carbonera Res	1.0	497
Pasatiempo System							
Pasatiempo	300-500	0.60	Pasatiempo PS	1.6	Pasatiempo 1 Res	0.75	694
					Pasatiempo 2 Res	0.3	694
Kite Hill	600-680	0.03	Kite Hill PS	0.01	-- (2)	--	--
Rollingwood	550-650	0.05	Rollingwood PS	0.2	Rollingwood Res	0.24	877
University System							
University 2	200-370	1.50	University 2 PS	1.2	University 2 Res	1.0	459
Springtree	300-400	0.4(3)	Springtree PS	0.2	-- (2)	--	--
University 4	450-650	0.20	University 4 PS	1.0	University 4 Res	0.4	772
University 5	780-900	0.70	University 6 PS	1.4	University 5 Res	2.0	1014

(1) For pump stations, capacity is calculated with largest unit reserved as a standby unit.
(2) Hydropneumatic zone.
(3) Estimated value.

4.1 Related Project Activities and Key Findings

During the project, there were several engineering evaluation related to the distribution system. These activities were:

- *Technical Memorandum 1 – Treatment Plant and Distribution System Water Quality Goals*; July 10, 2002; includes evaluation of the Bay Street Reservoir.
- *Technical Memorandum 2 – System Service Reliability Goals*; December 18, 2002.
- *Technical Memorandum No. 4A – Redistributing Storage in the Gravity Zone*; November 1, 2004.
- *Technical Memorandum No. 4B – Evaluation of Alternative Sites for New Treated Water Storage Reservoirs on the East Side of the Santa Cruz Distribution System*; February 9, 2005.
- *Technical Memorandum No. 4C – Comparative Cost Estimates for Distributed Storage Versus Upgrading or Replacing the Bay Street Reservoir*; April 12, 2006.
- *Technical Memorandum 5 – Recommended Improvements*; May 3, 2006.

Figure 4-1 removed for security purposes

These activities and their key findings are summarized in the following paragraphs.

4.1.1 Technical Memorandum 1 – Treatment Plant and Distribution System Water Quality Goals

CDM conducted an evaluation of the distribution system to assess distribution system water quality.

The SCWD has several distribution system projects in its current Capital Improvement Program. These include two projects that would affect water quality: the Bay Street Filling Project, a new pipeline from Ocean Street to Bay Street Reservoir, to improve hydraulic capacity to the reservoir; and pump station capacity improvements at each of the University system pump stations.

The Bay Street Reservoir Filling Project will have a positive impact on water quality, because it will increase the inflow-outflow exchange rate at Bay Street Reservoir. The pumping improvements throughout the U2 system provide more flexibility, and thus have a positive water quality impact because the SCWD can operate reservoirs through a wider range, and still re-fill reservoirs quickly to meet reliability and service goals. These benefits are generally limited to higher demand months, since the SCWD has sufficient pumping capacity to meet operational goals during lower demand periods.

Time-of-use operations most likely have different impacts on water quality, depending on the time of year. In lower demand periods, the SCWD's policy of topping off reservoirs nightly to avoid pumping during the day tends to keep reservoirs fuller, increasing reservoir detention times. In recognition of this, the SCWD has implemented the policy of operating Pasatiempo, Thurber Lane and Rollingwood pump stations less frequently to allow zone reservoirs to cycle more, to improve water quality.

Although a number of factors influence water quality, one of the primary factors is water age. In the distribution system, water age is most significantly influenced by reservoir detention times. A water quality evaluation was performed, using the distribution system model, to assess water age in distribution reservoirs under average winter demand conditions. Average winter demands were selected because reservoir detention times are longest, and the SCWD is more likely to have difficulty maintaining chlorine residual. CDM used the Water Department's distribution system hydraulic model to evaluate overall water age through the system for average winter day demands for the existing system, and after implementation of planned CIP projects for Bay Street and University System Pump Stations. The results of the analysis are shown in Table 4-2.

Table 4-2 . Water Age at Reservoirs for Average Winter Day Demand (8 MGD)

Reservoir	Total Water Age (Days)	
	Existing	With CIP Improvements
Delaveaga	> 50	> 50
Bay Street	48	30
Rollingwood	18	18
Santa Cruz Gardens	9	9
Carbonera	5	5
University No.5	5	5
Pasatiempo	4	4
Filtered Water	2	2
University No.4	2	2
University No.2	1	1

The four reservoir sites with highest water ages were reservoirs identified by SCWD staff as historically having periods of low chlorine residuals and higher than average DBP concentrations. The analysis also indicates that an average water age of less than 5 days for average winter demand conditions should result in reasonable water quality.

Specific results for the four reservoir locations with the highest water ages are briefly discussed below:

- Delaveaga Reservoirs (Nos. 1 and 2). The analysis found that under low demand conditions, the hydraulic grade in the eastern part of the gravity zone is high enough that the reservoirs experience very little turnover, indicating a need for improvements. The SCWD identified a potential project to provide a dedicated suction line from the reservoir to Thurber Lane Pump Station. Although the project would increase turnover in Deleaveaga Reservoir, improving reservoir water quality (e.g., more stable chlorine residual and lower DBPs), it would serve older water to the Santa Cruz Gardens zone, potentially resulting in lower chlorine residuals and higher DBPs in this zone.

- Bay Street Reservoir. Although the Bay Street Filling Project improves turnover, water age under low demand conditions is still very high, as described below in more detail.

- Rollingwood and Santa Cruz Gardens Reservoirs. The analysis confirmed the SCWD's observation that these reservoirs have low turnover, due to the large amount of zone storage relative to demand. Both of these reservoirs have high water age even when operating with the SCWD's policy of allowing reservoirs to cycle over multiple days, rather than re-filling reservoirs nightly. These reservoirs will be considered for improvements in later tasks of this study.

In summary, the planned capital improvement projects will not significantly reduce water age in key areas of the distribution system. The SCWD has implemented measures (such as re-chlorination at the U2 pump station and other reservoirs; and periodic flushing) to maintain effective residual disinfection for all its customers. However, as the population in the service area grows and greater emphasis is placed on disinfection byproduct control and maintaining effective disinfectant residual levels throughout the system, the SCWD must consider the impacts of these excessive water ages on chlorine residual and potentially on chloramines residual. Many water suppliers that treat sources comparable in water quality to the SCWD sources and who distribute treated water to 50,000 to 100,000 customers over a large service area have converted from free chlorine to chloramines as the residual disinfectant. The primary reasons for the conversion to chloramines were to reduce the formation of disinfection by-products and to provide a more persistent residual disinfectant for bacterial control.

For the Santa Cruz system, the excessive water age raises concerns for modifying chlorination practices or implementing chloramination. If a more robust chlorine residual were maintained in the system, there could be an impact on DBP formation, CDM recommends that the Water Department analyze historical data on DBPs to better understand the possible impacts of a higher chlorine residual. Alternatively, it is recommended that the Water Department evaluate the potential water quality benefits and drawbacks of switching to chloramination for residual disinfection (note: SCWD plans to meet with the East Bay Municipal Utility District to explore this issue).

Reservoirs with higher water ages (Delaveaga, Bay Street, Rollingwood, and Santa Cruz Gardens) should be considered as candidates for structural or hydraulic improvements, especially if chloramination is not implemented by SCWD. The types of structural improvements that reduce water age are those that allow more flexibility to increase turnover in reservoirs, such as:

- The addition of bypass valves at pump stations supplying a pressure (upper) zone to bleed back water to the lower zone (supplying water to the pump station). Allowing water to flow out of the pressure zone during low demand periods provides more flexibility in drawing down the upper zone reservoir;

- Addition of valves at pump stations and/or dedicated pipelines to draw suction directly from a reservoir rather than from the distribution system and reservoir;

- Providing standby power at pump stations supplying a zone, to avoid constructing new zone storage to meet emergencies, or to allow zone storage to be operated at a lower level during lower demand periods.

4.1.2 Bay Street Reservoir Evaluation

Historically, Bay Street Reservoir has had problems with low chlorine residuals due to low turnover. Preliminary water quality modeling, presented in Table 4-2, indicated that under wintertime demand conditions, the reservoir could have a detention time of up to 48 days. The CDM team conducted a focused evaluation of the Bay Street Reservoir to refine reservoir water age estimates, and to evaluate the effects of the Bay Street Filling Project on water quality.

The SCWD re-chlorinates water from the reservoir at the University No. 2 Pump Station, located near the reservoir inlet-outlet. The SCWD considered but rejected re-chlorinating upstream of the reservoir, because long reservoir residence times would promote disinfection by-product formation.

The SCWD has completed the Bay Street Filling Project, a new pipeline from the GHWTP to Bay Street Reservoir. The project was implemented to provide several benefits: 1) increase hydraulic capacity to re-fill the reservoir in summer months; 2) improve GHWTP operations by reduce production fluctuations and improving level control of the filtered water storage reservoir; 3) provide adequate suction to University Pump Station No. 2 with the Bay Street Reservoir off-line; and 5) provide supply to customers in the vicinity of the GHWTP during an emergency shutdown of the plant. Although not an objective of the project, the project also provides some water quality benefits by improving reservoir turnover.

The evaluation used models and methods developed as part of an American Water Works Research Foundation study on distribution system storage mixing. This study found that in order to maintain good water quality, reservoir average detention times must be low, and good mixing must be achieved. Average detention time is a function of how the reservoir operates in the system, while mixing is a function primarily of the inlet-outlet geometry and inflow velocity.

The evaluation (see Technical Memorandum No. 1) consisted of three elements:

- Calculating reservoir average detention times using historical Bay Street Reservoir water level data from April 2001 to April 2002. A data set was also developed for expected reservoir levels after implementing the Bay Street Reservoir Filling Project, to predict detention times after project implementation.

- Evaluating mixing characteristics based on the inlet geometry and inflow rates.
- Reviewing chlorine residual and temperature data and relating data to results of the detention time and mixing evaluations.

The evaluation found the following:

- Based on historical water level data from 2001 and 2002, average detention times range from about 4 to 5 days during the summer to 15 to 20 days during the winter. The Bay Street Reservoir Filling Project will reduce winter detention times by about 30 percent (based on CDM's hydraulic modeling), but will not have a significant impact on average detention time for summer conditions.
- Estimates of mixing during the reservoir fill cycle indicate that reservoir inflow rates are low enough that complete mixing is unlikely, especially during lower demand conditions. In addition, the reservoir dividing wall and possible thermal stratification in the reservoir inhibit mixing. The Bay Street Reservoir Filling project will not have a significant impact on reservoir mixing, because inlet velocities will still be low.
- Chlorine residual data from water quality regulatory compliance sampling indicates that chlorine residuals are not maintained, even in summer months when detention times are low and inlet velocities are higher. Temperature data indicate that water in Bay Street Reservoir is often 1 to 3 degrees C warmer than water coming from the Graham Hill WTP. This temperature difference indicates that temperature stratification may occur, which inhibits mixing.
- Although the Bay Street Reservoir Filling Project will reduce detention times during lower demand months, improvements aren't expected to significantly change water quality conditions in the reservoir.
- CDM recommends considering a combination of inlet-outlet improvements and operational changes at the reservoir to maintain water quality. While re-chlorination at the reservoir outlet currently allows the SCWD to meet its water quality goals, improving water quality in Bay Street Reservoir will minimize the potential for bacterial re-growth in the reservoir, and could eliminate the need for re-chlorination.

4.1.3 Technical Memorandum 2 – System Service Reliability Goals

CDM developed service reliability goals for the distribution system based on system-specific factors and industry accepted norms and guidelines. Goals were established for a wide variety of service parameters – level of service, pressure, fire service, storage, and pumping – based on different operating conditions – normal operations; planned outages; unplanned outages; and emergency outages. The SCWD system was then evaluated against these service reliability goals.

Table 4-3 summarizes the goals and whether the SCWD system met each goal. In summary, the distribution system generally has a significant level of redundancy that allows it to meet many of the reliability goals. However, it is deficient in a few areas, especially related to storage and pumping, along with a limitation in water treatment production at the ultimate (build-out) maximum day demand. Ultimate maximum day demand (MDD) was selected due to the relatively small increase in demand between a 20-year planning horizon and buildout.

Table 4-3. Proposed Distribution System Service Reliability Goals for SCWD

Condition	Service Parameter	Goal	Goal Met with Current System?
Normal Operations – All anticipated water quality conditions.	Level of Service	MDD.	Current production sources (GHWTP and Beltz WTP) can produce 18 mgd. This meets current MDD; however, upgrades at both plants are needed to improve reliability and to meet the ultimate (build-out) MDD of 20.5 mgd.
	Pressure	Meet all service pressure requirements.	No; low pressure reported in east side of Gravity Zone.
	Fire Service	Fire service for existing developments based on standards in place at time of development. Fire service for new developments based on most critical land use. Specific flows established in consultation with fire marshall.	Yes
	Storage (1)	Provide up to 1.0 times maximum day demand for operational and emergency storage, plus fire reserve.	Met in all zones except University No. 2 and Kite Hill.
	Pumping	Provide 1.0 times maximum day demand. Standby power at key facilities.	Pumping capacity met in all zones except Pasatiempo (86% of MDD) and Kite Hill (33% of MDD).
Planned Outages – Routine maintenance.	Level of Service	Maximum day demand (includes meeting demand from storage).	Current production sources (GHWTP and Beltz WTP) can produce 18 mgd. This meets current maximum day demand; however, upgrades at both plants are needed to improve reliability and to meet the ultimate (build-out) MDD of 20.5 mgd.
	Pressure	Pressures within 95% of baseline pressure conditions.	Yes
	Fire Service	Meet fire service during outage	Yes
	Flexibility/ Redundancy	Ability to take single major component out of service.	No. Several tanks cannot be taken out of service due to lack of redundancy.
Unplanned Outages – Power outages <12 hours. Equipment failure(s)	Level of Service	Maximum day demand (includes meeting demand from storage).	Current production sources (GHWTP and Beltz WTP) can produce 18 mgd. This meets current maximum day demand; however, upgrades at both plants are needed to improve reliability and to meet the ultimate (build-out) MDD of 20.5 mgd.
	Pressure	Meet minimum regulatory pressures.	Yes
	Fire Service	Meet fire service during outage.	Yes
	Time to re-establish service	Recover system storage within 48 hours.	Yes
Emergency Outages – Earthquake Landslide Flood Fire Damage by third party	Level of Service	Potable water within 1 to 3 days, via distribution system, truck or central locations for pickup. Average winter demand following event.	Yes
		85% of average day demand within 30 days.	Yes
	Pressure	No specific pressure goals identified. Normal service pressures at reduced level of demand once service re-established.	Yes
	Fire Service	Limited fire service in all areas initially following event.	Yes
		Service to all hydrants within 20 days (probable earthquake) to 100 days (maximum credible earthquake).	Yes

(1) During this study, City staff decided that two storage goals were necessary, one for the gravity system and its zones, and one for pumped or upper-zone storage (i.e., Pasatiempo, Rollingwood, and Kite Hill). The former would be equalization + the greater of fire or emergency. The latter would be equalization + fire + emergency.

4.1.4 Comparing Centralized Storage in Bay Street Reservoir vs. Distributed Storage

Bay Street Reservoir has served as the central element of the Santa Cruz water system since the 1920's. More than 80 years after first being placed into service, Bay Street Reservoir still provides almost 80 percent of the treated water storage for the entire system and 92 percent of the storage for the more than 70,000 residents served by the gravity zone. Finally, Bay Street Reservoir provides almost 2 days of storage at maximum demand conditions – thus, it provides a safety net should the Water Department lose its water supply due to pipeline breaks or other unplanned emergencies.

Unfortunately, there are significant drawbacks to this heavy reliance on Bay Street Reservoir. First and foremost, the reservoir's age contributes to structural worries in the case of seismic events (notwithstanding the fact that the reservoir weathered the Loma Prieta earthquake without any visual or apparent damage). Second, it was not constructed in a way to allow it to be taken out of service for regular repair or maintenance activities. Thus, there are several activities ranging from water quality improvement to roof repair that cannot be either easily or cost effectively accomplished. Third, the location and elevation of the reservoir is not such to provide optimum flows and pressures for the entire gravity zone, especially for those customers living in the eastern half of the zone. Finally, industry-wide guidelines for water system operations and emergency contingency planning recommend against placing most of the system storage in one location.

The Water Department asked CDM to evaluate the benefits and costs of continued reliance on Bay Street reservoir versus the benefits and costs of distributed storage in the gravity zone. The work included hydraulic modeling using the Water Department's network distribution system model, evaluation of potential sites for new reservoirs, and cost estimating. The findings and recommendations of this work are contained in the following memos:

- Redistributing storage in the gravity zone; November 1, 2004 – CDM identified 3 potential areas at ground surface elevation ranges of 250 to 270 ft. (water surface elevation of 270 to 300) for new elevated storage in the east side of the gravity zone.

- Evaluation of alternative site for new treated water storage reservoirs on the east side of the SC distribution system; Feb 9, 2005 – Hydraulic modeling found that locating elevated storage (i.e., operated by gravity flow) in the east side of the system did not work optimally. Essentially, Bay Street Reservoir and an elevated reservoir on the east side worked against one another – to fill Bay Street Reservoir required draining water from the east side reservoir and vice versa. CDM concluded that providing ground level storage with booster pump stations was preferred to elevated storage. The modeling also found that enlarging the filtered water storage tank at the Graham Hill WTP would improve the operation of the gravity zone. However, there is not sufficient available space at GHWTP to enlarge this tank.

- Comparative cost estimate for distributed storage versus upgrading or replacing the BSR; April 12, 2006 – Based on information in this memo and on discussions in a subsequent workshop with SCWD, it was concluded that major repairs to Bay Street Reservoir would be required either with continued reliance on centralized storage in Bay Street Reservoir or with implementation of distributed storage. Depending upon the amount of storage provided, centralized storage or distributed storage would be similar in cost as shown below in Table 4-4. The least expensive option would be to upgrade the existing Bay Street Reservoir, but such an upgrade does not include seismic strengthening the berms of the reservoir. Thus this option does not provide the same service life expectancy or reliability as the other options listed.

Table 4-4. Summary of Construction Cost Estimates for Treated Water Storage Upgrades in the Gravity Zone

Alt. No.	Description	New (East Side) Storage	Upgraded BSR	New BSR	Total Storage	Construction Cost
		(No. @ MG)	(MG)	(MG)	(MG)	($ millions)
1a	20 MG - Distributed Storage	2 @ 5-MG	-	10	20	29.5
1b	20 MG - Centralized Storage: Upgraded BSR	-	20	-	20	22.6
1c	20 MG -Centralized Storage: New BSR	-	-	20	20	28.4
2a	35 MG - Distributed Storage	2 @ 5-MG	-	25	35	37.1
2b	35 MG - Centralized Storage: Upgraded BSR	-	35	-	35	23.9
2c	35 MG - Centralized Storage: New BSR	-	-	35	35	33.6

4.2 Recommended Distribution System Improvements

The SCWD's current 10 year CIP has delineated a number of projects related to the distribution system. After conducting our reliability review of the distribution system (TM-1 and TM-2 listed above), CDM concluded that the SCWD identified projects were reasonable and should be implemented.

In TM 2 CDM proposed service reliability goals for the SCWD distribution system and compared the current system's capabilities to those goals. Based on this evaluation, CDM developed a list of reliability concerns that are summarized in Table 4-5. CDM conducted a number of modeling runs and other studies to further evaluate how best to address these concerns. Table 4-5 also lists how these reliability concerns are being addressed by either the SCWD's current CIP program or CDM's recommendations.

On May 19, 2006 CDM and SCWD held a workshop to select improvements for the distribution system. Table 4-6 presents a list of distribution system projects that were selected. The list includes those projects currently listed in the SCWD CIP (shown in **bold font**) and additional recommendations. Important considerations about the recommendations listed in Table 4-6 are:

- Many of the improvements require a more complete and fully calibrated hydraulic model to fully detail the size and location of improvements, especially those related to additional transmission/distribution mains. Therefore, the first recommendation is to update and calibrate the Water Department's hydraulic model. Once this task is completed, a concise water facilities planning study should be conducted to evaluate the location of new pipelines depending upon what is done with storage in the gravity zone.

Table 4-5. Summary of Reliability Concerns for the Distribution System

Concern	How It is Being Addressed
1. Gravity zone is served by a single feed from Graham Hill WTP. Damage/failure of pipeline would cause significant service disruption.	The topography around Graham Hill WTP makes installation of a new pipeline on a different alignment very difficult. Construction of second WTP near the Bay St. Reservoir to treat San Lorenzo River water and the Coast sources was evaluated and not advanced. Future upgrade of Beltz WTP (2 mgd) and construction of seawater desalination plant (2.5 mgd) would partially address this concern and provide up to 4.5 mgd during emergencies.
2. Gaps in transmission backbone in Gravity and Pasatiempo zones may limit flexibility in serving water, especially during emergencies.	CDM recommends almost 10 miles of new distribution mains in the CIP.
3. Current interconnections with Soquel Creek WD provide no benefit to Santa Cruz.	Not addressed. Should be explored in discussions with Soquel Creek WD.
4. Low pressures in eastern portion of Gravity zone during peak summer demands.	CDM recommended new distribution mains (item 2 above) should correct this situation.
5. Reinforce and improve connections between upper zones and the gravity zone, through pipeline improvements and the installation of regulators at current zone valve locations, or replacement of existing regulators with larger regulators.	Replacement of some of the existing regulators is addressed in the SCWD current CIP. CDM recommends adding new regulators at pressure zone interfaces.
6. 80% of total system storage is at Bay Street Reservoir. There would be significant service disruption if Bay Street Reservoir is damaged or unavailable.	CDM recommends improvements to Bay Street Reservoir and/or new storage tanks in the gravity zone.
7. Delaveaga Reservoir role and operation should be assessed for potential alternatives to improve operations and customer pressures.	CDM recommended new distribution mains (item 2 above) should correct this situation.
8. Possible capacity deficiencies at Kite Hill PS and Pasatiempo PS need to be investigated.	Pasatiempo PS is not addressed; however the deficiency is minor (firm pumping capacity of 85% of max day demand). Kite Hill hydro-pneumatic system is addressed in SCWD current CIP.
9. Lack of redundant reservoirs or supplemental supply in zones at end of system (University No. 5, Rollingwood, and Carbonera) should be investigated.	Addressed in SCWD's current CIP.
10. Less than 1 max. day storage in Kite Hill, Springtree, and University No. 2 Zones.	These zones are very small and this issue can be addressed by pumping into the zones during emergency.
11. Excessive water age frequently occurs in the Bay Street, Delaveaga, Rollingwood, Santa Cruz Gardens, Carbonera and University No. 5 reservoirs.	Water age would be corrected by piping, valving, and other modifications. This issue should be further evaluated after SCWD decision on use of chloramine.
12. Conduct site specific hazard vulnerability assessments for key distribution system facilities.	Seismic vulnerability and potentially other concerns should be addressed in a separate study.

Table 4-6. Preliminary List of Water Distribution System Improvements(1) (2) (3)

1A. **Phase 1 of new distribution mains** – CDM recommends approximately 10 miles of new distribution mains to improve water flow and pressure in the east side of the gravity zone. Phase 1 would install 5 miles of these new mains.(2)
1B. Phase 2 of new distribution mains – installation of the remaining 5 miles of new mains.(2)
2. **Ongoing main replacement** – location of these mains would be determined by an additional planning study(3)
3A. Phase 1 short-term improvements to Bay Street Reservoir – this project would include an initial engineering analysis followed by replacement of potentially failing roof sections. The goal of this project is to provide assurance that the Bay Street Reservoir will remain in service until SCWD can afford to implement major reservoir improvements in the gravity zone (i.e. after 2015).
3B. Phase 2 final improvements to gravity zone storage - upgrade Bay Street Reservoir and/or add new distributed storage.
4. **Recoating steel tanks** (U2 and U4)
5. **Tank rehab and seismic upgrades** (16 tanks)
6. **Tank redundancy and fire storage** (U2, U4, U5, Rollingwood, Carbonera)
7. **Regulator upgrades** – in addition to the upgrades in the CIP, CDM recommends that several of the gate valves between the upper zones and the gravity zone be replaced with PRVs.
8. **Replace hydropneumatics** (Kite Hill and Springtree)
9. **Highway 9 water main replacement**
10. Improvements to correct water age problems at 5 reservoirs – This project would consist of structural improvements to allow more flexibility in drawing down reservoirs. If chloramination is implemented, some or all of these improvements may not be needed.

(1) Improvements taken from the current SCWD CIP are listed in **bold font**

(2) CDM recommends that the SCWD's hydraulic model be rebuilt using GIS-based demand and calibrated to more accurately model system performance before additional design work is initiated.

(3) CDM recommends a planning study to determine which mains need to be replaced – the SCWD CIP budgets $800,000 per year for replacement of old distribution mains. This study would prioritize main replacement and shift any unnecessary budget for main replacement into installation of new mains.

- There is still some uncertainty of the timing and location of the proposed seawater desalination facility and whether new reservoirs will be located in the gravity zone. This information will impact the size and location of additional transmission/distribution mains. The above described water facilities planning study should evaluate this issue.
- There was no decision made on whether to continue to rely on centralized gravity zone storage in Bay Street Reservoir or to shift to distributed storage. However, there was a preliminary decision to use a staged approach, with an initial focus on constructing new storage on the east side of the zone, and subsequently replacing Bay Street Reservoir. This staged approach would shift the majority of costs until after 2015/16, when there is more money available for additional CIP projects. Potential sites for new ground-level storage tanks in the gravity zone are shown on Figure 4-2.
- The recommendations in Table 4-6 also stage the installation of new distribution system mains to improve the west to east flow of water. After the SCWD hydraulic model is upgraded, modeling is recommended to identify how best to stage these mains. Preliminary routing of new distribution system mains are shown on Figure 4-2.
- The uncertainty of whether chlorine or chloramine will be used as the system disinfectant residual. This could impact the criticality of fixing the water age problem in some of the system reservoirs.

Figure 4-2 removed for security purposes

5.1 Benefits of Implementing the Recommended CIP Projects

Each of the recommended CIP projects is necessary to meet one or more of the water quality or reliability goals developed in the WQ&SIS. The goals are based on State and Federal drinking water regulations, the SCWD's requirements for aesthetic water quality, City and industry standards for water supply and fire flow requirements, and other considerations. The specific benefits that will be realized from the recommended improvements to the Graham Hill WTP are presented in Table 5-1. Similarly, the anticipated benefits from the treated water distribution and storage projects are shown in Table 5-2.

Table 5-1. Summary of Benefits for the Recommended CIP Projects at the Graham Hill WTP

No.	Pro ect Description	Anticipated Benefits
1	Solids Handling Study	• Plan for residuals handling resulting from increases in plant flows and changes to the treatment process. • Work with Public Works to develop a program that is efficient and economical for the City and the rate payers. • Maximize plant efficiency with respect to water use; potential to achieve "zero discharge".
2	Pasatiempo Interim UV Disinfection Improvements	• Provide disinfection consistent with Bin 3 classification on the Pasatiempo water. • Allow modifications to improve disinfection by routing all treated water through the filtered water tank. • Allow the plant to meet primary disinfection (Ct) requirements with lower chlorine residuals. • Optimized disinfection practices may result in lower THM and HAA levels leaving the plant and possibly lower levels in the distribution system.
3	Regulatory, Capacity and Reliability Improvements	• Membranes (MF or UF) will restore the plant's treatment capacity to 24 mgd and will provide the necessary 19.5 mgd of treated water to the system even under adverse water quality conditions. • Membranes provide absolute barrier to *Giardia* and *Cryptosporidium*; meet Bin 3 classification. • Membranes allow the plant to treat high turbidity water from the San Lorenzo River or other sources. • Membranes will require fewer chemicals (i.e., no coagulant aid polymers or filter aid polymers). • GAC contactors reduce algal-based tastes and odors more effectively than PAC. • GAC removes DBP precursors and will allow the plant to meet the Stage 2 D/DBPR standards for THMs and HAA_5 with free chlorine. • GAC may reduce or eliminate the use of potassium permanganate for taste and odor control. • Onsite generation of sodium hypochlorite will eliminate the risk of chlorine gas leaks and make the plant safer for staff, visitors and neighbors. • Electrical system upgrade will accommodate the recommended improvements and allow for future process upgrades such as ozone or UV disinfection. • Electrical system improvements will address power quality, grounding, standby power, and other issues.
4	Chloramine Conversion	• Chloramines will reduce THM and HAA concentrations in the distribution system by 60 to 90 percent. • Chloramine residuals are more persistent than free chlorine and will provide more consistent residuals throughout the system. • Chloramines may reduce or eliminate the need for chlorine booster stations in the distribution system. • Chloramines may reduce or eliminate planned improvements to reduce water age at five treated water storage reservoirs.
5	Enhanced Coagulation Improvements	• Ferric chloride will remove more DBP precursors and produce lower THM and HAA_5 concentrations than alum. • Ferric chloride will remove turbidity and particles more effectively than alum. • Because ferric chloride doses will be lower than alum doses, slightly less solids will be produced. • Caustic soda will produce a more consistent pH in the finished water • Orthophosphate use may be reduced depending on the target pH for the finished water.

Table 5-2. Summary of Benefits for the Recommended Distribution and Storage CIP Projects

No.	Pro ect Description[1]	Pro ect Benefits
	Bay Street Reservoir Fill Line *(in progress)*	Improve inflow-outflow of water at Bay Street Reservoir and improve water quality in the distribution system.
1	Upgrade hydraulic model and provide water system facilities planning.	Optimize system improvements – location and size of pipelines, new regulators, and water age improvements.
2	Study to determine which mains need to be replaced – the SCWD CIP budgets $800,000 per year for replacement of old distribution mains. This study would prioritize main replacement and shift any unnecessary budget for main replacement into installation of new mains.	Reduce main replacement cost and use savings on more beneficial system improvements.
3A	Phase 1 of new distribution mains – CDM recommends approximately 10 miles of new distribution mains to improve water flow and pressure in the east side of the gravity zone. Phase 1 would install 5 miles of these new mains.	Improve movement of water to east and increase system pressure.
3B	Phase 2 of new distribution mains – installation of the remaining 5 miles of new mains.	Improve movement of water to east and increase system pressure.
4	**Ongoing main replacement – location of these mains would be determined by project 2.**	Enhance system reliability
5A	Phase 1 short-term improvements to Bay Street Reservoir – this project would include an initial engineering analysis followed by replacement of potentially failing roof sections. The goal of this project is to provide assurance that the Bay Street Reservoir will remain in service until SCWD can afford to implement major reservoir improvements in the gravity zone (i.e. after 2015).	Increase reliability of storage in the gravity zone and improve water quality in the distribution system.
5B	Phase 2 final improvements to gravity zone storage - upgrade Bay Street Reservoir and/or add new distributed storage.	Increase reliability of storage in the gravity zone and improve water quality in the distribution system.
6	**Recoating steel tanks (U2 and U4)**	Increase supply reliability for zones
7	**Tank rehab and seismic upgrades (16 tanks)**	Increase supply reliability for these zones
8	**Tank redundancy and fire storage (U2, U4, U5, Rollingwood, Carbonera)**	Increase supply reliability for these zones
9	**Regulator upgrades** – in addition to the upgrades in the CIP, CDM recommends that several of the gate valves between the upper zones and the gravity zone be replaced with PRVs.	Improve supply reliability. Replacing gate valves with PRVs will facilitate quicker flow response and alleviate pressure problems in the case of supply problems in the gravity zone.
10	**Replace hydropneumatics (Kite Hill and Springtree)**	Increase supply reliability for these zones
11	**Highway 9 water main replacement**	Improve fire supply reliability
12	Improvements to correct water age problems at 5 reservoirs – This project would consist of structural improvements to allow more flexibility in drawing down reservoirs. If chloramination is implemented, some or all of these improvements may not be needed.	Improve water quality

1. Existing CIP projects are listed in **bold** font

5.2 Planning Level Cost Estimates

Planning-level capital costs estimates for the projects identified in the WQ&SIS (and the Water Department's current CIP) total $72.2 million dollars (in 2006 dollars) through FY 2015-16. The estimates included construction costs and engineering (preliminary design, design, engineering support during construction, and construction management). Figure 5-1 shows the cost breakdown among project types.

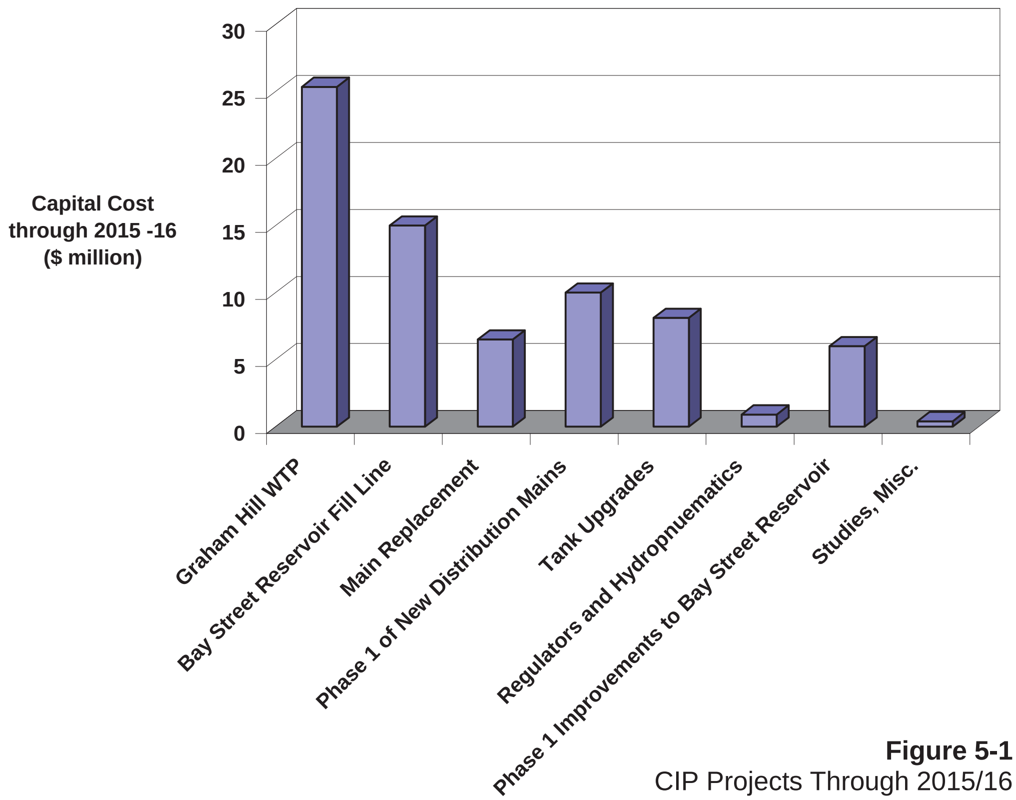

Figure 5-1
CIP Projects Through 2015/16

As shown in Figure 5-2, two-thirds of the costs to meet the water quality and reliability goals established in the WQ&SIS will be spent on distribution system improvements over the next 10 years. These estimates assume that SCWD will not encumber costs for the following projects through 2016:

- Phase 2 final improvements to gravity zone storage ($30-$46 million in $2006)
- Phase 2 of New Distribution System Mains ($8 million in $2006)

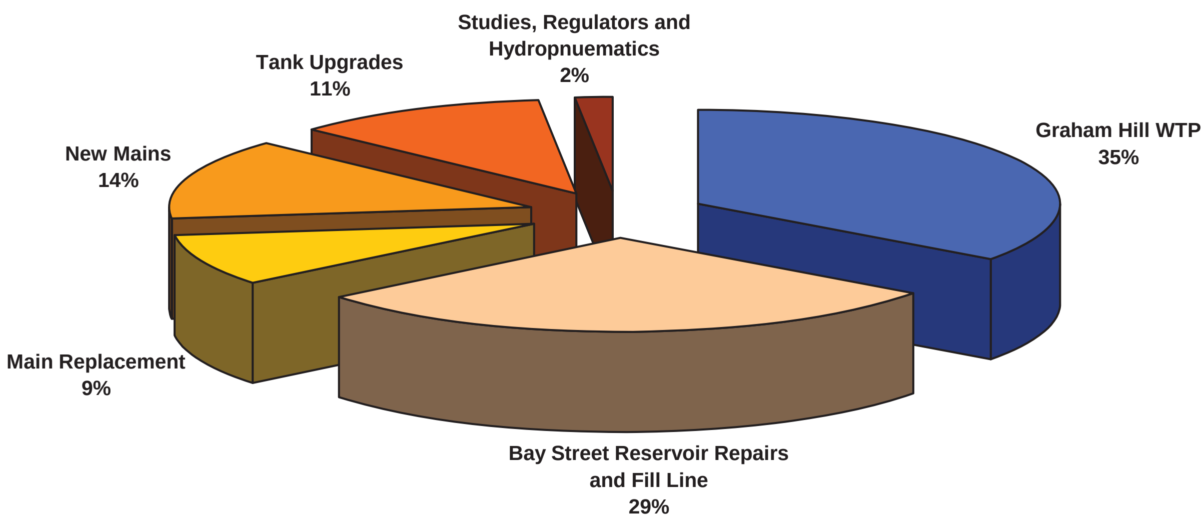

Figure 5-2
Allocation of CIP Funds through 2015/16

5.3 Drinking Water 10-Year CIP

The costs for each of the projects identified in the WQ&SIS were integrated into the SCWD's 10-year CIP as presented in Figure 5-3. Projects previously identified by the SCWD are shown in plain text; and the new or modified projects developed in the WQ&SIS are shown in bold text and orange shading.

5.4 Potential Impacts on Ongoing and Future Water Projects

During the WQ&SIS, the project team identified five (5) projects at the Graham Hill WTP and twelve (12) projects throughout the distribution system to be implemented between 2007 and 2016. Several of these projects may change how the SCWD operates the system including selection and conveyance of raw water supplies, treatment, and distribution and storage of the finished water. The SCWD and designers for the recommended projects must carefully consider how the recommended projects may affect existing facilities and operating procedures as well as the anticipated changes to the system from ongoing and future projects.

Table 5-3 presents a list of the recommended projects from the WQ&SIS and the ongoing and future projects. A brief list of considerations identified by the project team are also presented in the table. However, more thorough evaluation of the issues for each project should be addressed by the SCWD and design teams as the individual projects are implemented.

Table 5-3. Potential Impacts of Recommended Projects on Ongoing and Future Projects

W SIS Pro ects	Ongoing Pro ects	uture Pro ects	Considerations
Graham Hill WTP			
1. GHWTP Regulatory, Capacity and Reliability Improvements	• Beltz GWTP Rehabilitation Project	• Tait Street Diversion Upgrades • Chloramine Conversion • Enhanced Coagulation Improvements	• Ability to treat high turbidity water may diminish benefits from riverbank filtration or other improvements. • Make provisions for chloramines and enhanced coagulation.
2. Solids Handling Study	• Beltz GWTP Rehabilitation Project	• Seawater Desalination Plant • Enhanced Coagulation Improvements	• Develop a program for all anticipated sources of solids production.
3. Pasatiempo UV	• None	• GHWTP Regulatory, Capacity and Reliability Improvements • Chloramine Conversion • Enhanced Coagulation Improvements	• May not be required if GHWTP improvements are implemented soon. • Will require additional ammonia and caustic soda feed points.
4. Chloramine Conversion Improvements	• Beltz GWTP Rehabilitation Project	• Bay Street Reservoir Upgrade/Replacement • Improvements to Correct Water Age at Five (5) Reservoirs • Seawater Desalination Plant	• Provide for future ammonia at Beltz GWTP and Seawater Desalination Plant. • Water age improvements may not be necessary if chloramines are implemented.
5. Enhanced Coagulation Improvements	• None	• Solids Handling Study • Chloramine Conversion	• Enhanced coagulation will change the characteristics and quantities of solids. • Reductions in DBPs could delay or eliminate need for chloramines.

Projects	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-13	2013-14	2014-15	2015-16	Totals FY 2006-07 to FY 2015-16
	10-Year CIP 2006-07 through 2015-16											
DISTRIBUTION SYSTEM											Category Total	36,166,000
BSR Transmission Main		Construct				* Blue text and shading indicates new or modified projects.						
	12,000,000											0
Upgrade Hydraulic Model		Modeling/Planning										
		0										0
Main Replacement Study		Pre-Design										
		0										0
Phase 1 New West to East Transmission Mains				Design		Construct						
	500,000	500,000	500,000	500,000	3,000,000	3,000,000	3,000,000					10,500,000
Ongoing Main Replacement Programs						Ongoing Design/Construction						
	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	800,000	8,000,000
BSR Improvements Phase 1 - Roof Repair		Design (2010/2011)	Construct									
		150,000	8,000,000	0	0	0						8,150,000
Recoating Steel Tanks (U2 and U4)		U2	U4									
		300,000	200,000									500,000
Tank Rehabilitation and Seismic Upgrades (16 tanks)			Training	Pre Eng/Design	Pasatiempo (2)	Delaveaga (2)	SCGarden (2)	Carbonera	RW	UCSC&Coast(4)	Plant (4)	
			1,000	115,000	350,000	350,000	325,000	175,000	225,000	675,000	600,000	2,816,000
Tank Redundancy and Fire Storage (5) (U2, U4, U5, Rollingwood, Carbonera)				Pre Eng	Design1	Const1;Design2	Const2;Design3	Const3;Design4	Const4;Design5	Const5		
				50,000	50,000	550,000	550,000	550,000	550,000	500,000		2,800,000
Regulator Upgrades						Design and Construction						
		60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	600,000
Replace Hydropneumatics (2) Kite Hill, Springtree				Design 1	Const1/Design2	Consststruct2						
				50,000	125,000	125,000						300,000
University Pump Station Upgrades												
												0
Highway 9 Water Main Replacement			Model/Design	Construct								
				500,000								500,000
Improvements to Correct Water Age Problems (5) (Delaveaga, Rolling Woods, Carbonera, U5) (Decision Pending)				Design	Construct							
				200,000	900,000	900,000						2,000,000
NORTH COAST/RIVER SOURCES											Category Total	21,915,000
Upgrade Coast Pump Station (+ emerg. power)					Prelim Engineering	Design	CEQA/Permit	Construct				
					540,000	1,300,000	500,000	6,000,000				8,340,000
Modify River Intake		Study	Design	CEQA/Permits	Construct							
		125,000	200,000	50,000	1,200,000							1,575,000
North Coast System Rehab						Design/Construct in 6 sections						
	4,000,000			1,000,000		5,000,000		1,000,000		5,000,000		12,000,000

Figure 5-3
SCWD Long-Term CIP
Fiscal Years 2006-07 Through 2015-16
FY 2006-07 to FY 2015-16 Totals Do Not Include Project Costs From FY 2005-06

Projects	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-13	2013-14	2014-15	2015-16	Totals FY 2006-07 to FY 2015-16
	10-Year CIP 2006-07 through 2015-16											
NEWELL CREEK DAM/PIPELINE											Category Total	4,600,000
Rehab Effluent Gates at LL (5)	Inspect/Repair											
	175,000											0
Felton Diversion Pump Station Upgrades									Prelim Eng	Design/CEQA		
									100,000	500,000		600,000
Newell Ck Pipeline Rehab				Letter/Report			Pre Eng/EIR		Permits/RoW		Design/Construct	
				0			2,000,000		1,000,000		1,000,000	4,000,000
BELTZ GROUNDWATER											Category Total	7,950,000
Beltz TP Upgrades + Distribution Upgrades	Prelim Engineering	Design/CEQA/Permit	Construct TP & Mains									
	500,000	700,000	6,000,000									6,700,000
Add Standby Beltz Well (#11 & #12)		Investigate	Design/Permit/Property	Construct								
		250,000	600,000	400,000								1,250,000
GRAHAM HILL WTP											Category Total	28,650,000
Solids Handling Study		Planning/Pre-Design										
		100,000										100,000
Pasatiempo Interim UV Disinfection (Decision Pending)			Design/Construct									
			250,000									250,000
Grahm Hill WTP Regulatory and Reliability Improvements		Pre-Design/CEQA/Design		Construct								
		1,000,000	1,100,000	7,000,000	7,000,000	7,000,000						23,100,000
Graham Hill WTP Chloramine Conversion (Decision Pending)						Design	Construct					
						150,000	350,000					500,000
Graham Hill Enhanced Coagulation Improvements (Decision Pending)						Design	Construct					
						300,000	1,100,000					1,400,000
Power Management Study/Electrical Service Upgrade		Design	Construction									
		300,000	3,000,000									3,300,000
NEW WATER SUPPLY											Category Total	41,550,000
Desal	Pilot	lection/Design/intakestu	PrjEIR/Permits		Construct							
	4,000,000	4,500,000	2,000,000		35,000,000							41,500,000
Solar		Study										
		50,000										50,000
OTHER											Category Total	510,000
Road Maintenance/Rehab Program				Inventory/Evaluation	Design 1	Const1/Design2	Const2/Design3	Const3/Design4	Const4/Design5	Const5/Design6	Const6/Design7	
				20,000	10,000	80,000	80,000	80,000	80,000	80,000	80,000	510,000
RECREATION AREA											Category Total	1,035,000
All Planned Recreation Area Projects	All Recreation Area Projects											
	75,000	155,000	580,000	300,000								1,035,000
TOTAL	22,050,000	8,990,000	23,291,000	11,045,000	49,035,000	19,615,000	8,765,000	8,665,000	2,815,000	7,615,000	2,540,000	142,376,000
											Annual Average =	14,237,600

Figure 5-3
SCWD Long-Term CIP
Fiscal Years 2006-07 Through 2015-16
FY 2006-07 to FY 2015-16 Totals Do Not Include Project Costs From FY 2005-06

Table 5-3. Potential Impacts of Recommended Projects on Ongoing and Future Projects

W SIS Pro ects	Ongoing Pro ects	uture Pro ects	Considerations
Distri ution Storage System			
1. Upgrade Hydraulic Model	• Beltz GWTP Rehabilitation Project • Ongoing Main Replacement	• Phase 1 Distribution Mains • BSR Booster Pump Station • Transmission Main to Soquel Creek Water District • BSR Upgrades and Distributed Storage Reservoirs	• Accurate model will be critical to optimize design of new pipelines and reservoirs.
2. Main Replacement Study	• Beltz GWTP Rehabilitation Project • Ongoing Main Replacement	• Upgrade Hydraulic Model • Phase 1 Distribution Mains • BSR Booster Pump Station • Seawater Desalination Plant • Transmission Main to Soquel Creek Water District • BSR Upgrades and Distributed Storage Reservoirs	• Prioritize construction of new mains and replacement of old mains. • Configuration of the Beltz GWTP (e.g., raw or treated water pumping) will influence decisions. • Identify benefits of distributed storage and determine if BSR booster pump station can be delayed or eliminated. • Coordinate with Seawater Desalination Plant and transmission main to Soquel Creek.
3. Phase 1 New Distribution Mains	• Same as Item 2.	• Same as Item 2.	• Same as Item 2.
4. Ongoing Main Replacement	• Beltz GWTP Rehabilitation Project	• Same as Item 2.	• Same as Item 2.
5. Phase 1 Improvements to Bay Street Reservoir	• None	• None	• No significant impacts.
6. Recoating Steel Tanks (U2 and U4)	• None	• None	• No significant impacts.
7. Tank Rehabilitation and Seismic Upgrades (16 Tanks)	• None	• None	• No significant impacts.
8. Tank Redundancy and Fire Storage (5 Tanks)	• Ongoing Main Replacement	• Upgrade Hydraulic Model	• Accurate allocation of flows will provide basis of design.
9. Regulator Upgrades	• Ongoing Main Replacement	• Chloramine Conversion • Improvements to Correct Water Age	• Accurate simulation of system performance will help to optimize design.
10. Replace Hydropneumatics (Kite Hill and Springtree)	• None	• None	• No significant impacts.
11. Highway 9 Water Main Replacement	• Ongoing Main Replacement	• Upgrade Hydraulic Model	• Accurate model will help to optimize design of new pipelines and reservoirs.
12. Improvements to Correct Water Age	• Beltz GWTP Rehabilitation Project	• Upgrade Hydraulic Model • Graham Hill WTP Regulatory, Capacity and Reliability Improvements • Chloramine Conversion	• Accurate simulation of system performance will help to optimize design. • Graham Hill WTP process improvements and chloramines may mitigate problems and eliminate need to modify tanks.