LOCH LOMOND RESERVOIR SOURCE DEVELOPMENT STUDY

SAN LORENZO VALLEY WATER DISTRICT

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SAN LORENZO VALLEY WATER DISTRICT
BOULDER CREEK, CA

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SECTION 1
INTRODUCTION

STUDY PURPOSE

San Lorenzo Valley Water District (District) retains an existing allotment to a portion of the raw-water yield from Loch Lomond Reservoir. The purpose of this study is to investigate the utilization of this water source to improve, increase and enhance water supply reliability in the District's service area. Additional supply would be especially beneficial in the District's Southern Service Area where groundwater is the sole source for water supply. The District's Water Supply Master Plan (May, 2008) prepared by Nicholas M. Johnson, Water Resources Consultant, recommended that the District exercise its allocation from Loch Lomond to avoid overproduction from existing ground water sources and as a contributed supplemental water source.

The District retains a historical allocation of 313 acre feet per year of raw water from Loch Lomond Reservoir owned and operated by the City of Santa Cruz. This allocation permits the District to purchase and utilize raw water on a year around basis for treatment in District owned and operated facilities. Optionally in lieu of the District's allotment to purchase and treat raw water, the District has discussed the potential to purchase treated water from the City of Santa Cruz; however, the availability of treated water would be restricted to the period of the year the City uses Loch Lomond water and subject to curtailment during periods of drought.

STUDY GOAL

The goal of this study is to examine the technical feasibility and establish the costs of developing for comparative purposes, the two alternative plans for utilizing the District's Loch Lomond Reservoir allotment. The costs will be used to guide the District in selection of an appropriate plan to incorporate this source into future improvements to the District's water supply facilities. Such additional source capacity will better enable the District to withstand water shortages (caused by drought) or interruptions in supply from the District's current sources. Insuring system reliability is a major consideration in advocating the need for additional water supplies for the District.

SECTION 2
BACKGROUND INFORMATION

HISTORICAL BACKGROUND

In 1958 the District sold approximately 2,500 acres of property in the vicinity of the Newell Creek watershed to the City of Santa Cruz. As a condition to said sale, the District obtained a water service agreement to purchase up to 500 acre-feet per year (AF/yr) of raw water at a price to be determined by the City of Santa Cruz as the actual cost of production and transmission of water along Santa Cruz's Newell Creek pipeline to the point of diversion by the District. The purchase agreement maximum of 500 AF/yr was approximately 12.5% of the original estimated annual safe yield from a future Newell Creek reservoir. This percentage was roughly equivalent to the portion of the reservoir project area owned by the District.

The City of Santa Cruz created Loch Lomond Reservoir with completion of the Newell Creek Dam in 1960. Based on the 1958 agreement, the District began receiving deliveries of Loch Lomond water from the City in 1963. In 1965 the District constructed the Glen Arbor Treatment Plant for treating its Loch Lomond deliveries.

Toward the end of the 1976-77 drought, the City stipulated that the District was not entitled to an allocation of 500 AF/yr, merely 12.5% of the safe yield. This decision, based on a reduction to the estimated annual safe from the Newell Creek Reservoir, reduced the Districts contractual allocation. This determination lead to several years of water disputes between the City and the District. On June 7, 1977, the District filed a Complaint for Declaratory Relief, which requested the Court to make a judicial determination of the respective parties' duties and rights. In June 1980 a court order fixed the estimated annual safe yield from Newell Creek Reservoir at reduced quantity, which resulted in a reduction to the District's contractual allocation. The District can currently purchase up to 313 AF/yr.

At one time, the District owned and operated a small water filtration facility known as the Glen Arbor Water Treatment Plant that treated water from Loch Lomond Reservoir. This plant which was obsolete, and of limited capacity, was decommissioned and dismantled in 1998 and the property which had insufficient space for a new treatment plant was sold by the District in 2001. In 1981 the District acquired and developed an alternative ground water supply source (Olympic well field) and ceased utilization of Loch Lomond water. Currently, the District has no other infrastructure to treat and deliver Loch Lomond water in compliance with current federal standards.

LOCH LOMOND RESERVOIR SOURCE ALLOTMENT

The District is entitled to purchase 313 acre-ft per year available on a year-around 24/7 schedule if taken as raw water from the Loch Lomond reservoir pipeline. According to City staff, diversion of 313 AF/yr at the annual average rate of 300,000 gpd (208 gpm) would present no pipeline operating difficulties. It is anticipated that diversions from the pipeline of up to 0.5 million gpd (350 gpm instantaneous flow) could be tolerated without impacting supply availability to the Graham Hill WTP. Optionally, treated water purchased from the City of Santa Cruz's Graham Hill plant would only be available when the treatment plant is processing water from the reservoir. In contrast, utilization of treated water from the City would be subject to curtailment pursuant to drought restrictions with less of the allotment being available for District use, depending upon the drought severity.

SUPPLY AND TREATMENT CONSIDERATIONS

Raw water obtained along the Newell Creek pipeline to the City of Santa Cruz's Graham Hill Water Treatment Plant would require treatment prior to introduction into the District's system. Raw water is always available from the pipeline upstream of the City's Graham Hill pump station located at the intersection of Graham Hill Road and East Zayante Road in Felton or downstream during times Loch Lomond is being utilized as a source of supply for the City. Further, the pipeline downstream of the City's Graham Hill WTP is out of service during the time of the year (generally December through June), when the City does not utilize Loch Lomond Reservoir water. Access to the Newell Creek Pipeline for raw water must thus be in the vicinity of Felton and ideally places a possible pipeline connection in close proximity to the District's Kirby Street Water Treatment plant. The Kirby street plant has the available capacity and the necessary infrastructure to accommodate any improvements that may be needed to process additional raw water up to the annual 313 acre-feet allotment from Loch Lomond Reservoir. Based upon the advantages associated with utilization of the District's Kirby Street facility, the technical feasibility of expanding and using these facilities was evaluated in this study.

Table 1 provides a summary of peak production months over 10 years of record. Water production records for the Felton plant, indicate that July and August are generally the peak production months for the facilities. The greatest monthly production occurred in July of 2000 at 18,372,000 gallons amounting to an average daily production of 593,000 gallons. More recently, peak production requirements have dropped registering 11,110,715 gallons in 2009. A review of plant production data indicates that the 1 mgd capacity Felton Water Treatment plant appears to have reserve capacity to process additional water supply. Operating the facilities at full design capacity of 1,000,000 gpd would produce an additional 407,000 gallons per day. This presumption assumes that there are no limitations, which could be caused by source water quality characteristics on operating the plant up to the full "name plate" capacity of 1 mgd.

It should be noted that the 313 acre-ft of Loch Lomond Reservoir allotment represents approximately 14% of the District's total annual production. Having this additional water supply available will greatly enhance the District's overall water supply reliability, and could be particularly important in the Southern Distribution System.

TABLE 1
Felton Plant Production[1]
Peak Demand Month
San Lorenzo Valley Water District

Year	Peak Month	Water Source Production, Gallons: Fall Creek	Bull Springs	Bennett Springs	Production Felton WTP[2]	Felton System Total Production[3]	Percentage Fall Creek Of Total Production, %
2009	Jul	8,635,000	1,602,800	872,915	11,110,715	11,110,715	78
2008	Jun	6,590,830	3,300,500	2,455,553	12,346,883	12,346,883	53
2007	Aug	9,577,741	1,867,700	7,349,300	14,186,000	14,476,747	66
2006	July	8,524,830	4,391,400	6,130,800	16,841,000	17,156,272	50
2005	July	6,809,831	4,628,700	6,004,944	16,178,000	16,533,841	41
2004	Aug	10,749,290	1,190,500	3,295,688	16,300,000	16,666,549	64
2003	July	11,339,270	2,628,500	3,440,052	17,942,000	18,299,619	62
2002	July	9,858,560	4,148,100	4,113,252	18,006,000	18,282,386	54
2001	June	10,881,260	3,837,500	3,683,152	18,336,496	18,627,992	60
2000	July	7,855,840	5,049,300	6,154,936	18,372,000	18,647,713	42

[1] Total Production of Felton (Kirby Street) plant at peak demand month of the year. Includes processing of water from Fall Creek, Bennett Springs and Bull Springs.
[2] Actual net treated water production pumped into distribution system. Excludes water discharged from plant as treated backwash water.
[3] Total includes ground water not treated on Felton plant and unaccounted water due to metering discrepancies.

FALL CREEK SUPPLY DIVERSION LIMITATIONS

Water is diverted from Fall Creek into the Felton Water Treatment Plant under a permit (No 20123) issued from the Division of Water Rights of the State of California Water Resources Control Board. This permit states that water may be appropriated for municipal use up to a flow not exceeding 1.7 cubic feet per second from January 1 to December 31 of each year and may not exceed 1,059 acre-feet per year. Further restrictions limit the diversion by requiring that bypass flows in Fall Creek comply with the following under a normal rain fall year:

Time of Year	Bypass Flow
April 1 through October 31	1.0 cfs (450 gpm)
November 1 through March 31	1.5 cfs (675 gpm)

During a dry year the bypass flow in Fall Creek can be reduced to:

Time of Year	Bypass Flow
April 1 through October 31	0.5 cfs (225 gpm)
November 1 through March 31	0.75 cfs (338 gpm)

A dry year is one in which cumulative monthly runoff in the San Lorenzo River at the US Geological Survey gage at Big Trees is less than the amounts shown in the following schedule:

November 1 for the month of October ...... 500 acre-feet
December 1 for October and November..... 1,500 acre-feet
January 1 for October through December... 5,000 acre-feet
February 1 for October through January..... 12,500 acre-feet
March 1 for October through February...... 26,500 acre-feet

Further, the permit stipulates that when flow in the San Lorenzo River below the Felton Diversion Weir drops below the following amounts for the months listed, that no water may be diverted from Fall Creek to supply the Felton System. The District has installed a flow-measuring weir at the Fall Creek Water Treatment Plant intake and monitors flows in Fall Creek on a daily basis.

a. September – 10 cfs
b. October – 25 cfs
c. November through May 31 – 20 cfs

EXISTING FELTON WATER TREATMENT FACILITIES

The Felton WTP utilizes a two-stage filtration process in treatment units provided by Siemens Water Technologies marketed as the Trimite Package Plant product line. The Plant has two TM-350 units each rated at 350 gpm or 0.5 million gallons per day. With both units operating the total plant capacity is 700 gpm or 1 mgd. This "name plate" capacity is established by a nominal filtration rate of 5 gpm per square foot on the Trimite plant filter units. The maximum permitted filtration rate established by the Department of Public Health (DPH) is 6 gpm per square foot that translates into a TM-350 hydraulic capacity of 420 gpm. Under these conditions the total output capacity of the treatment plant would increase to 1.2 mgd. As a point of interest, it is possible to receive a greater hydraulic rating for a Trimite plant to be gained through a demonstration study approved by DPH thus potentially offering the option of even greater production from this facility. However, the two-stage filtration process employed in the TM-350 units has limitations with respect to the level of turbidity in the raw water and the associated chemical coagulant dosage needed for proper treatment. This process limitation could reduce the usable capacity of the plant during winter rainy season.

As discussed in more detail in the following section, Loch Lomond water quality presents some treatment challenges not related specifically to turbidity, as is the case with the District's current raw water supply from Fall Creek and Bennett Springs. Both of these sources are low in organic contaminants, most apparent in the absence of significant color, and only experience occasional high turbidity associated with rainfall events. However, Loch Lomond Reservoir has organic contaminants and experiences frequent algae blooms that impart taste and odor to the filtered water requiring the City of Santa Cruz to use activated carbon and potassium permanganate for removal of these contaminants in the Graham Hill Water Treatment plant. Although the existing Felton plant can effectively remove low levels of organic contaminants through use of relatively low dosages of powdered activated carbon, there is some uncertainty that it could effectively and efficiently process undiluted Loch Lomond Reservoir water, especially during late summer months. To overcome these potential difficulties, blending of the lower quality Loch Lomond water with higher quality Fall Creek water would be required to enable the Felton plant to meet current drinking water quality standards as well as more stringent District quality goals without installing specialized additional processes for removing organic contaminants.

To date, treatment experience with the two-stage filtration process on Fall Creek water has been good; however, the plant is operated considerably below design capacity much of the time, especially during winter months. There is some concern that these units would not be able to efficiently treat a high percentage blend of Loch Lomond water with water from Fall Creek, especially during summer months when organics levels in Loch Lomond are high. This limitation would be of particular concern at the greater flows when treating a higher percentage of Loch Lomond Reservoir water in the existing Felton plant. Under these circumstances, supplementary pre-treatment such as the MIEX process, discussed in a following section of the report, or perhaps post-filtration activated carbon may need to be incorporated into the treatment facilities to remove organic contaminants. Bench scale pilot studies, undertaken prior to design, would be required to establish process requirements and identify limitations enabling selection of appropriate pre- or post-treatment processes to be added to the Felton WTP.

SECTION 3
LOCH LOMOND SOURCE DEVELOPMENT

WATER QUALITY CHARACTERISTICS

Loch Lomond Reservoir water quality is seasonally variable, but generally contains more organic contaminants than does the other raw water sources treated in District facilities. Table 2 provides raw water characteristics for both Fall Creek and Loch Lomond reservoir. Of major concern are the high levels of organic contaminants characterized by the measurements for Total Trihalomethanes (TTHMs), Haloacetic Acids (HAA5s), Dissolved Organic Carbon (DOC), and Ultraviolet Light Absorbance (UVA). Loch Lomond water of this quality exceeds the USEPA Disinfectants-Disinfection By-Products (D/DBP) standards of 80 µg/L for TTHM's and 60 µg/L for HAA5's. In contrast, Fall Creek water after treatment in the Felton plant is well below the TTHM and HAA5 standards. Blending of the two sources with a significant portion of Fall Creek water would be a viable strategy to enable compliance with the D/DBP standards. If solely Loch Lomond Reservoir water were to be processed in the plant, removing these organics to conform to current USEPA drinking water quality standards would require some specific treatment process modifications to the Felton plant.

Color and Turbidity are higher in Loch Lomond water and more coagulant treatment chemicals would be needed to remove these contaminants. Removing color causing organics to meet the 15 color unit standard may require higher coagulant dosages than can be efficiently processed in the Trident units.

There are other water quality parameters that can impact the palatability of a treated water supply but have no impact on the potability of the source. Water temperature is one parameter, which could be affected by introducing the warmer Loch Lomond water into the Felton facility. A review of finished water records suggests that Loch Lomond water may be 2-4°F warmer than the received Fall Creek water. Although the impact may be regarded to be quite minor, it will be noticeable by some consumers as an undesirable trait.

A discussion of an adjunct treatment process (the MIEX Process for example) to remove organics, should it be determined through additional testing to be necessary, follows in this report. Post filtration treatment using Granular Activated Carbon (GAC) is another effective, but expensive, process for removing organics.

TABLE 2
Raw Water Source Characterization
Loch Lomond Reservoir[1] and Fall Creek[2]

Parameter	Units	Loch Lomond Reservoir	Fall Creek
TTHM's	µg/L	130.8	15-22[3]
HAA5's	µg/L	106.4	8-18[3]
DOC	mg/L	2.6	NA
UVA	cm^{-1}	0.134	NA
True Color	Pt-Co Units	15	0
Apparent Color	Pt-Co Units	36	0
pH	Units	7.5	7.5
Turbidity	NTU	2.9	0.62
Alkalinity	mg/L as $CaCO_3$	130	110
Ca Hardness	mg/L as $CaCO_3$	107	33
Total Hardness	mg/L as $CaCO_3$	145	110
TDS	mg/L	182	160
Conductivity	µmho/cm	384	260

[1] Source: SLVWD Fall Creek data provided by SLVWD and Loch Lomond Reservoir water quality data from "Results from MIEX Resin Jar Tests for Disinfection By-Product Removal from Santa Cruz Raw Water by WesTech and Orica Watercare, Inc.

[2] Samples collected 4/22/09 and 4/25/09

[3] Seasonal range. Worse cast sample location in system.

SOURCE ALTERNATIVES

Loch Lomond Reservoir offers the potential to provide an additional 313 acre-ft per year to the limited water sources available to San Lorenzo Valley Water District. As indicated previously, the options available to obtain this additional supply are both to purchase and treat the raw water in either new or existing water treatment facilities or purchase finished water from the City of Santa Cruz.

The second option involving purchase of treated Loch Lomond water from the City of Santa Cruz is discussed in Section 4 of the report.

TREATMENT PLANT SITING

It is presumed in this study that the Felton WTP site (Kirby Street) will be the location for facilities to treat the additional supply obtained from Loch Lomond Reservoir. The reasons for this presumption are the following:

- The District owns the site
- The infrastructure is in place and is suitable to support additional treatment process units (if required)
- The plant site is relatively close in proximity to the raw water pipeline.

At this time, no alternative treatment locations are under consideration.

ORGANIC REMOVAL TREATMENT STUDY – MIEX PROCESS

The City of Santa Cruz retained WesTech and Orica WATERCARE in October 2004 to perform a relatively comprehensive bench scale study of treatment strategies to remove organics from the Loch Lomond Reservoir source. This evaluation was undertaken to determine what modifications or additions to the Graham Hill WTP would be required to achieve consistent compliance with the D/DBP Standards of the current Federal and State water quality regulations. This study involved comparing processes of enhanced coagulation (addition of high dosages of aluminum sulfate coagulant – generally 2-3 times that needed to simply clarify the water) to a proprietary process (MIEX) that uses granular resin that has a specific affinity for adsorbing naturally occurring organic contaminants from a water supply. Whereas enhanced coagulation will potentially remove 25-35 percent of most organic contaminants, the MIEX process can remove as much as 80-85 percent when combined with alum coagulation at dosages considerably lower than needed for enhanced coagulation.

The findings of the MIEX bench scale studies are important to establish whether the two-stage filtration process (Tri-Mite) used in the Felton Plant is capable of operating in the enhanced coagulation mode of treatment. Enhanced coagulation appeared from these bench scale studies to be required to remove high levels of organics from Loch Lomond water. The Tri-Mite process employed in the Felton plant is not capable of operating in the enhanced coagulation mode. Unless the D/DBP standards can be met through blending of Loch Lomond with Fall Creek water and reliance on the capabilities and limitations of the two-stage filtration process, supplementary treatment with additional process equipment would be required.

The results of the comparative tests are provided in Table 3 and Table 4. These were excerpted from the pilot bench scale studies performed on Loch Lomond water for the City of Santa Cruz. The study also yielded results (Table 5), indicating that either enhanced alum coagulation or MIEX pretreatment followed by conventional alum coagulation would provide a treated water meeting the Total Trihalomethane (TTHM) standard of 80 µg/L and the Haloacetic Acid (HAA5) standard of 60 µg/L. Other parameters regarded as contaminants, such as color and Dissolved Organic Carbon (DOC) were adequately reduced by the two treatment processes.

The purpose of reporting the results from the MIEX bench study was to identify and substantiate the process chemistry necessary to remove the high levels of organics in Loch Lomond Reservoir water. Of particular interest was the evaluation of the enhanced coagulation process (high dosages of chemical coagulants), and the requirements relating to the capability of the Tri-mite units at Felton. . Although the study also extolled the capabilities of the MIEX process, it was not the intent to advocate use of this proprietary process as the only means of achieving D/DBP standards compliance. The process would be a possible candidate however, if solely Loch Lomond water were being considered for treatment at the Felton facility.

Should further testing to establish an appropriate process to meet D/DBP standards reveal that the MIEX process is viable, it should be noted that a facility using the MIEX process is relatively expensive to construct and operate. The process uses a resin specific for adsorption of organic contaminants and requires regeneration with a salt solution (brine), or optionally, a sodium bicarbonate solution. Typically, 350-400 gallons of waste regenerate solution is produced per million gallons of water processed. Those quantities can be reduced to 175 to 200 gallon per million gallons by a regenerate concentration process, which would certainly be employed in this application. This regeneration process adds significantly to capital as well as to operating costs. Waste regenerant solution would have to be disposed of either to a regional sanitary sewer (if permitted) or hauled to a wastewater treatment plant with a septage receiving facility. The only possible locations for regenerant disposal would be the City of Scotts Valley or City of Santa Cruz wastewater treatment plants.

It appears that the MIEX process may be technically feasible to achieve removal of organics to enable treatment of undiluted Loch Lomond Water, when used as a pretreatment process ahead of the existing Felton plant. A suitable location to dispose of the considerable quantities of resin regenerate must be found to make this process economically suitable for this application. The energy costs are considerable for brine concentration and evaporation to produce a solid suitable for land disposal. The costs of a suitable regenerant disposal method and/or a brine concentration procedure relegates the MIEX process only for serious consideration if the District finds that blending the poorer quality Loch Lomond water with higher quality Fall Creek water will not permit treatment of sufficient Loch Lomond water to fully utilize the seasonal allotment of 313 acre feet. The expected water supply yields from treatment alternatives of simple blending to meet D/DBF standards versus including a pretreatment process that can treat 100 percent Loch Lomond water to match that presently produced in the Felton Plant are described later in this report.

TABLE 3
Enhanced Coagulation Control Test[1]

Jar	1	2	3	4	5	6	7	8	9	10
Initial UVA	0.049									
Alum Dose (mg/L)	0	5	10	15	20	30	40	50	60	80
Polymer Dose (mg/L)	0	3	3	3	3	3	3	3	3	3
Treated UVA	0.049	0.041	0.040	0.039	0.039	0.036	0.031	0.024	0.022	0.019
True Color (Pt-Co)	5	5	5	5	4	4	3	3	3	3
Turbidity (NTU)	1.3	1.3	0.6	0.6	0.6	0.3	0.4	0.5	0.4	0.5
Final pH	8.3	8.1	7.9	7.8	7.6	7.4	7.4	7.3	7.1	7.0

TABLE 4
MIEX-Resin Pre-treatment followed by Alum Coagulation Jar Testing

Jar	1	2	3	4	5	6	7
MIEX Resin Conc. mL/L)	1.0 mL/L mixed for 90 min						
Initial UVA	0.010 (After MIEX® Pre-Treatment)						
Alum Dose (mg/L)	0	2.5	5	10	15	20	30
Polymer Dose (mg/L)	0	3	3	3	3	3	3
Treated UVA	0.010	0.010	0.008	0.008	0.008	0.008	0.007
True Color (Pt-Co)	2	2	0	0	0	0	0
Turbidity (NTU)	1.3	1.2	0.9	0.6	0.5	0.8	0.7
Final pH	8.2	7.8	7.8	7.7	7.7	7.5	7.4

TABLE 5
Loch Lomond Reservoir DOC and DBP Results

Parameter	Units	Raw Water	Alum Control	MIEX® Treated	MIEX® /Alum
DOC	mg/L	2.6	1.7	0.7	0.7
TTHM-SDS1	µg/L	130.8	58.9	23.8	23.0
HAA5-SDS1	µg/L	106.4	38	9.1	9.1

[1] Source: SLVWD Fall Creek data and Loch Lomond Reservoir water quality data from "Results from MIEX Resin Jar Tests for Disinfection By-Product Removal from Santa Cruz Raw Water by WesTech and Orica Watercare, Inc.

BLENDED SUPPLY TREATMENT CONSIDERATIONS

Based upon the indications from limited data on the organic contaminants in both Loch Lomond Reservoir and Fall Creek and from the MIEX bench scale studies, it appears treating a blended water supply involving a mixture of the above two sources will produce a drinking water meeting the Disinfectants/Disinfection By-Products (D/DBP) Standards. However, it should be noted that the District's present Fall Creek source after treatment has D/DBP concentration considerably lower (less than 30µg/L), than the current drinking water quality standard (80µg/L) of the current Federal and State drinking water quality regulations. With the limited water quality data available for both sources, and without testing, it is difficult to establish a precise blending ratio that would produce acceptable quality water and control disinfectant by-products. However, to establish a general relationship, a simple blending equation was prepared using available THM data (presented in Table 2), provided for both Fall Creek and Loch Lomond water source.

The blending analysis is presented in Table 6. Average THM values of 22µg/L and 130µg/L were used in the analysis for Fall Creek and Loch Lomond raw water respectively. Targeted blended finished water THM values ranged from 30 to 80µg/L in the analysis. Using this blending scenario, it would be possible to achieve a blended mixture of 80µg/L THMs (the maximum MCL) using 85 percent Loch Lomond water mixed with 15 percent Fall Creek water. Note that as mentioned above, the District would likely establish a much lower THM as the upper permissible level for this standard in their water supply, so that when the Loch Lomond water is introduced into the system the quality is similar to that presently being delivered to Felton customers. For example, if the THM MCL goal is established at 40µg/L in the blended and treated water, then only 17 percent of the water can be supplied from Loch Lomond requiring that the remaining 83 percent be obtained from Fall Creek. These blending ratios and the resultant projected water quality assume the existing Tri-Mite process in the Felton plant would not remove significant organics. The process is designed to provide conventional coagulation only to remove turbidity and, at the lower coagulant dosages will not remove a significant amount of organics from the finished water. In practice, a blending ratio of somewhere closer to 70% Fall Creek water and 30% Loch Lomond water would provide water consistent with District customer expectations and enable the Felton treatment facility to produce up to the maximum capacity of 1 mgd. Thus, to maximize the utilization of Loch Lomond water up to the full allotment of 313 acre-feet per year to be obtained generally during summer months of lower water quality, it is anticipated that Loch Lomond water would preferably have to be blended with 70% to as much as 85% Fall Creek water. Unknown at this time is whether taste and odor seasonally present in Loch Lomond water will require addition of powdered activated carbon for taste and odor removal which is possible with the Tri-Mite process.

The availability of Fall Creek water in late summer months may become a limiting factor of how much of the 313 acre-feet Loch Lomond allotment can be used during the Fall Creek low stream flow periods. As discussed in a previous section, Fall Creek water diversion restrictions limit the amount of water that can be withdrawn from Fall Creek and treated for use in the Felton service area. During summer months of a normal year (April 1 through October 31), the permit requires that a flow of 1.0 cfs (450 gpm) be maintained in Fall Creek downstream of the intake pump station. During the same period in a dry year, the diversion can be reduced to 0.5 cfs (225 gpm). A further complicating issue that could impact the amount of water that can be withdrawn from Fall Creek is the water diversion permit requirement that no water can be withdrawn from Fall Creek when the flow in the San Lorenzo River below the Felton Diversion drops below 10 cfs in September and 25 cfs in October. As a point of interest, the flow at this gauging site on September 28, 2010, was 15 cfs.

Historically, there have been numerous occasions when stream flows have been less than these diversion requirements essentially eliminating, or greatly reducing, the amount of water than can be appropriated from Fall Creek for blending with Loch Lomond water to serve the Felton area.

Stream flow records provided in Table 7 indicate that required bypass stream flows fall to below 1 cubic feet per second (450 gpm), during low flow periods generally in August, September and October. In 2009, the most recent year with available records through October, indicates that on an average flow basis, the bypass flow requirements (1 cfs) were not met during the months of August and September. Further, it can be seen that minimum flows dropped well below the 1 cfs bypass flow restriction, limiting the amount of water available for treatment in the Felton plant to less than 100 gpm on numerous days during the low flow months. Such minimal flow in Fall Creek greatly limits the amount available to mix with Loch Lomond water to meet blending ratios necessary to satisfy water quality goals.

Using the maximum 85 percent Loch Lomond/15 percent Fall Creek blending ratio established by the example above, to enable compliance with the THM MCL of 80µg/L, there appears to be sufficient flow in Fall Creek to provide the 105 gpm (0.23 cubic feet per second), that would be mixed with 595 gpm (1.3 cubic feet per second) of Loch Lomond water to match the maximum production capacity of the Felton plant. This blending ratio however would just meet the present 80µg/L THM MCL but would not satisfy the District's goal of 30µg/L.

From Table 6 it is indicated that to achieve the 30µg/L goal, the blending ratio must be met with 93 percent Fall Creek water and only 7 percent Loch Lomond water. At the full plant capacity of 700 gpm only 49 gpm of Loch Lomond water can be blended with 651 gpm (1.45 cfs) of Fall Creek water to meet the desired goal. It is clear from stream flow data in Table 7, that these requirements cannot be met during most of the summer months. Further, it points to the need to incorporate means to provide high levels of organic contaminant removal from Loch Lomond water to be able to effectively use the full 313 acre-feet per year allotment in the Felton plant. Blending does not appear to be a viable strategy to meet the District's water quality goals.

TABLE 6
Fall Creek/Loch Lomond Water Blending Ratios*
Felton Treatment Plant
San Lorenzo Valley Water District

Targeted Finished Water THM level, µg/L[1]	Percentage Flow Fall Creek, %[2]	Percentage Flow Loch Lomond, %[3]
30	93	7
40	83	17
60	65	35
80[4]	15	85

* Computation of approximate percentages of raw water from each source that must be mixed together to yield a targeted THM value in the blended finished water.

[1] Selected maximum THM of blended water assuming little or no removal in Felton treatment plant. Raw water THM for Fall Creek Water assumed to be 22µg/L. Raw water THM in Loch Lomond water assumed to be 130 µg/L.

[2] Required percentage of Fall Creek water that must be blended with Loch Lomond water to yield a 30µg/L TTHM concentration in finished water

[3] Maximum allowable percentage of Loch Lomond water to be blended with Fall Creek water to yield given THM in Felton WTP finished water

[4] Present Maximum Contaminant Level (MCL), 80µg/L, for organic contaminants expressed as Total Trihalomethanes (TTHM)

TABLE 7
Fall Creek Stream Pumping/Bypass Diversion Records[1]

		Flow Values in GPM and CFS					
		Average		Maximum		Minimum	
Year	Month	Flow Diverted to Felton WTP gpm[2]	Bypass flow, cfs[3]	Flow Diverted to Felton WTP gpm[2]	Bypass flow, cfs	Flow Diverted to Felton WTP gpm[2]	Bypass flow, cfs
2007	June	471	0.56	471	1.9	124	0.56
	July	250	0.90	350	1.2	162	0.69
	Aug	239	0.68	272	0.89	188	0.56
	Sept	170	0.63	272	0.97	98	0.41
	Oct	125	0.96	226	3.42	90	0.62
2008	June	176	1.94	278	2.4	103	1.37
	July	171	1.38	272	1.67	130	1.19
	Aug	185	2.41	272	4.85	112	0.53
	Sept	156	0.77	231	0.84	133	0.53
	Oct	121	0.73	147	1.53	147	0.36
2009	June	182	1.77	258	2.48	160	1.48
	July	225	1.19	272	1.65	167	0.89
	Aug	212	0.90	250	1.10	166	0.69
	Sept	202	0.80	270	1.26	21	0.50
	Oct	156	1.83	250	9.7	90	0.36

[1] Flow data compiled for Fall Creek stream flow diverted to treatment facility and bypassed to maintain permitted stream flow downstream of intake pumps
[2] Flow pumped from Fall Creek Intake to Felton Water Treatment plant and distributed to Felton service area
[3] Fall Creek stream flow bypassed intake facility to maintain required 1.0 cfs minimum flow in stream to comply with diversion permit requirements.

FULL UTILIZATION OF LOCH LOMOND SOURCE

It appears from reviewing Fall Creek stream flow and water quality data that in order to be able to utilize the entire 313 acre feet yearly allotment of Loch Lomond water, a supplemental treatment system capable of meeting the District's water quality goals must be placed in service at the Felton Water Treatment plant. Previously in this study, the MIEX process that can remove as much as 85 percent of the organic contaminants in Loch Lomond water has been discussed. Treated water quality standards without blending with superior quality Fall Creek water would be possible with the MIEX pretreatment process. Although initially regarded as being too expensive and not necessary, it now appears more attractive as an alternative, which would permit full utilization of the 313 acre-feet per year allotment from Loch Lomond available to SLVWD. Rather than relying on blending of Fall Creek water with Loch Lomond water to meet District water quality goals, the Felton plant, with a MIEX pretreatment process can treat Loch Lomond water directly to a quality matching that currently achieved in the Felton system utilizing Fall Creek water.

The key to being able to effectively and efficiently incorporate the MIEX process into the Felton facility is to be able to locate the necessary process equipment on the existing Felton treatment plant site. To verify the feasibility of accomplishing this necessary requirement, design information on the MIEX equipment was obtained from the manufacturer. Technical information on the MIEX system is provided in the Appendix. This information was used to create a preliminary conceptual facilities design to establish installation feasibility and to enable preparation of a planning level cost estimate to incorporate the MIEX pretreatment equipment into the existing plant site

KIRBY STREET PLANT

Introducing a blended supply of Loch Lomond and Fall Creek water into the Kirby Street water treatment plant in Felton will require construction of new facilities to handle the changed treatment requirements. A site plan, showing the proposed location for the pretreatment equipment is provided as Figure 1. As discussed in the previous section, the MIEX process will require additional process equipment. The need for other improvements is also impacted by the expanded flow through the facilities.

A major feature will be a tank to collect and permit blending of water from the three sources, Fall Creek, Bennett Springs, and Loch Lomond Reservoir. Blending is needed to even out water quality to provide a stable treatment condition. This blending tank would be required for the MIEX pretreatment process as well. As a preliminary recommendation, a tank providing about 90,000 gallons (about 2 hours detention time), would be installed upstream of the plant to meet blending requirements. An additional benefit of the tank will be to provide detention time to relieve dissolved air from incoming water, which has contributed an operating problem since the plant was constructed. Also, a 90,000-gallon tank with dimensions of 25 feet in diameter by 24 feet tall will fit on the existing site and will permit supplying the plant by gravity, eliminating an additional pumping step if the blending only alternative is selected. With the MIEX

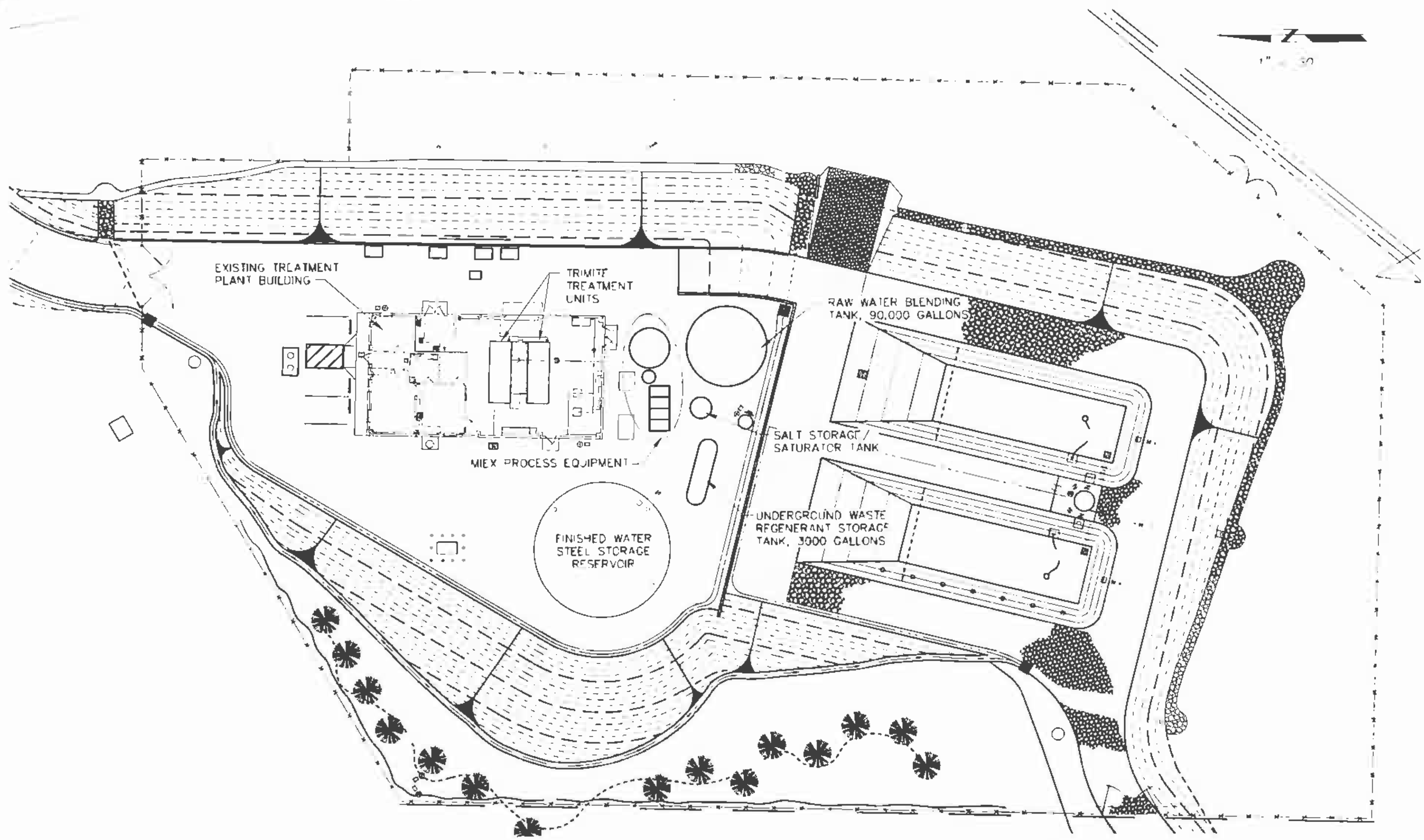

FIGURE 1 – PROPOSED SITE LAYOUT
MIEX PRETREATMENT FACILITIES
FELTON WATER TREATMENT PLANT
SAN LORENZO VALLEY WATER DISTRICT

SPH associates
Consulting Engineers

process an intermediate feed water pump station is required. The estimated cost of the blending tank is incorporated into both raw water treatment alternatives.

Also as a minimum, powdered activated carbon (PAC) feed facilities should be provided to contend with possible seasonal taste and odor conditions, which result when large percentages of Loch Lomond water is being processed in the plant. The existing Trimite equipment can accept PAC dosages up to 10-15 mg/L without major impact on operating efficiency. The capability to apply PAC would be recommended for both the blending alternative and the MIEX pretreatment alternative.

Existing wash water recovery basins are designed for processing backwash water and concentrating solids for the 1 mgd capacity existing facilities while treating Fall Creek water. It is expected that at the increased operating flows and with perhaps more than a proportionate increase in waste solids production (due to higher coagulant dosages), more frequent solids removal from the recovery basins will be required. Also reduced drying time will result in solids of higher moisture content potentially requiring more labor for removal and disposal to a satisfactory location. Rather than land spreading of the relatively dry, soil-like solids that is the current practice, the waste solids may have to be handled in a semi-liquid form and hauled by tanker to a municipal wastewater treatment plant. Alternatively, on site solids dewatering facilities could be constructed using a variety of processes and equipment suitable to application for small plants. Such facilities are expensive to construct and maintain. Because there is considerable uncertainty on future solids handling requirements at an expanded Kirby Street plant, it is unrealistic to attach a cost of some unknown potential solids handling improvement to the Loch Lomond water treatment alternative in this preliminary study.

Finished water disinfection requirements at increased plant production capacity can be provided satisfactorily by the existing 250,000-gallon finished water storage tank. No increased contact time over that provided for the original 1 mgd capacity facility is expected to be required. Contact time (CT) requirements can be met even when processing Loch Lomond water either simply blended with Fall Creek water or as undiluted raw water obtained directly from Loch Lomond reservoir

The existing plant finished water pumping capacity may have to be expanded to contend with possible change in the diurnal system demand pattern, especially if the service area is expanded. Replacing one of the can-mounted finished water pumps with one of greater capacity could accommodate this modification relatively easily. Since the specific additional pumping capacity needs are uncertain at this very preliminary planning stage, no costs for this item are included in this study.

Another possible plant upgrade that would provide greater removal of organic contaminants and taste and order substances would be the installation of post-filtration GAC adsorption equipment. Carbon adsorption would be equally beneficial even if the MIEX pretreatment process is incorporated into the plant. This additionally effective, but expensive process would only be beneficial if blending and treatment with powdered activated carbon (PAC) is not effective in achieving drinking water quality standards and producing finished water matching taste and other aesthetic qualities expected by consumers. Only actual plant operating experience with treatment of the new blended supply or perhaps pre-design bench scale laboratory or pilot studies would validate the effectiveness and establish the possible benefits of using post-filtration GAC. A more detailed assessment of the efficacies of PAC versus GAC is beyond the scope of this study. Consequently, costs for incorporating GAC treatment to the Kirby Street plant are excluded from this study.

For the MIEX pretreatment alternative a waste regenerant storage tank would be required. A buried fiberglass tank with 2,500-3,000 gallons of storage capacity would provide 9-10 days of storage before the regenerant must be removed and hauled to disposal at a local sewage treatment plant. Optionally, an above grade polyethylene tank of similar or larger volume could be used for this purpose.

SITE SELECTION

As mentioned previously, the favored location for treatment of water from Loch Lomond Reservoir (either through the existing or a modified Felton plant with MIEX pretreatment) would be at the Kirby Street site. Figure 1 mentioned previously illustrates the orientation of the MIEX equipment on the site. The proposed blending tank could be located adjacent to the existing finished water tank. MIEX process equipment would be located in the area between the building and the solids drying beds. The generator would be relocated. The infrastructure is adequate to accommodate the additional facilities and the plant is situated in the portion of the system where additional water supply can be extended to areas where supply is limited.

LOCH LOMOND RESERVOIR PIPELINE ACCESS

The Felton plant is located in relatively close proximity to the Newell Creek Pipeline, which conveys raw water from the reservoir to the City of Santa Cruz's Graham Hill WTP. The logical routing of an interconnecting pipeline from the raw water transmission line to the Felton WTP would involve an alignment across the Rose Acres Lane bridge over the San Lorenzo River, crossing beneath Highway 9 and entering Felton on Cooper Street. See Figure 2 for the proposed routing of an intertie pipeline. The pipeline alignment would follow Cooper Street to the intersection with Farmer Street and then travel about 600 feet connecting with the existing 8-inch raw water line leading from the Fall Creek intake to the Felton WTP. An 8-inch line would easily accommodate flows approaching 1,000 gpm, which exceeds the present treatment capacity (700 gpm), of the Felton plant.

This location is also advantageous for connecting the Felton Plant to the existing distribution system. An 8-inch finished water line leads from the treatment plant to the Felton system and has a capacity of approximately 1,000 gpm. It is well situated to supply the South System with significant additional water from a plant expansion using Loch Lomond water. The high service pumps at the plant have a pumping capacity of 1,000 gpm from the existing 250,000-gallon onsite storage reservoir and have the

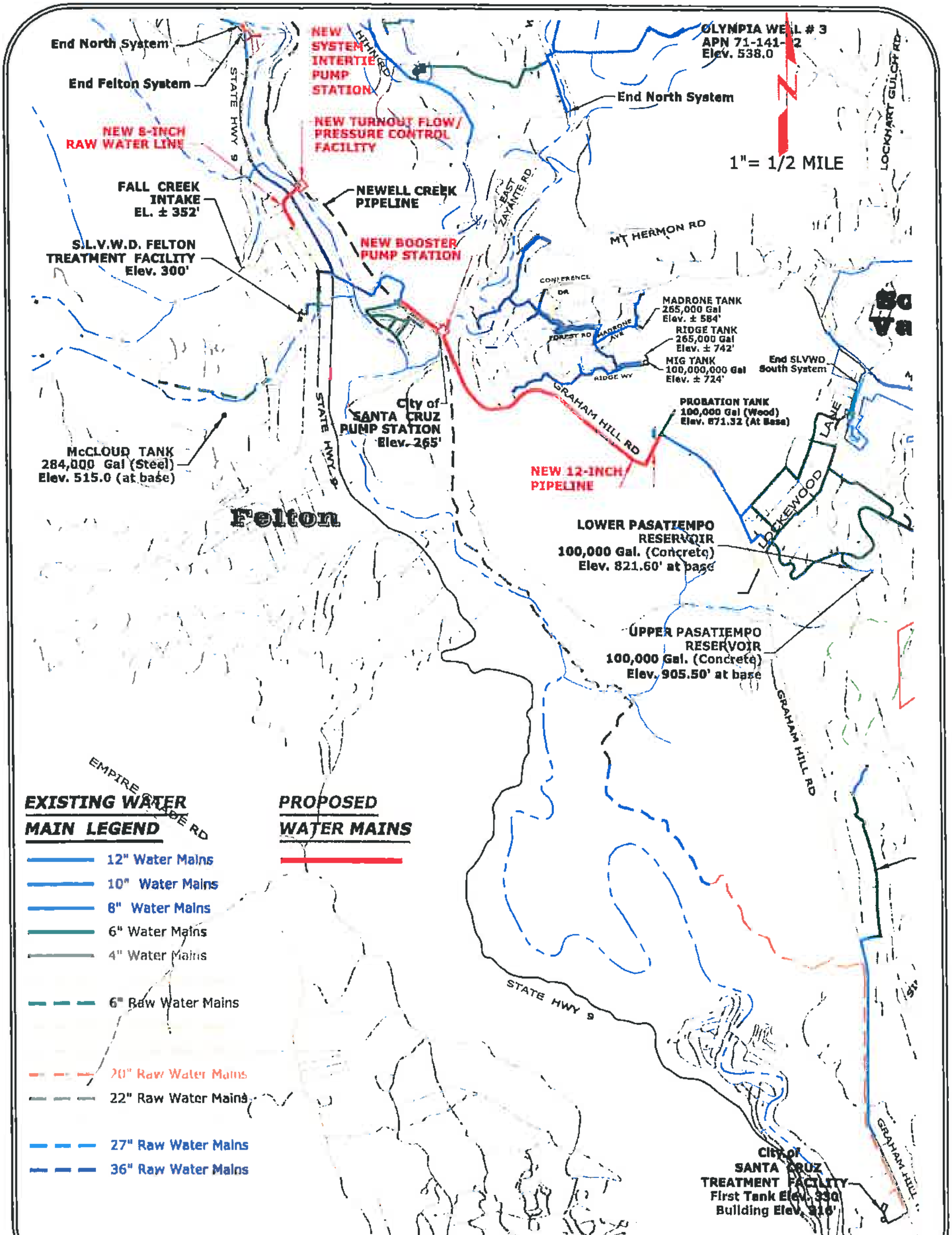

FIGURE 2 – PROPOSED IMPROVEMENTS RAW WATER PURCHASE/TREATMENT ALTERNATIVE

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capability of delivering water to match the hydraulic grade line of the McCloud tank that has a base elevation of 515 feet.

The cost estimate presented in a following paragraph also includes facilities to interconnect the Felton system with the North System through a pump station and short section of interconnecting pipeline along Highway 9. The pump station is required to overcome a pipeline pressure differential of about 75 feet (32 psi) between the baseline pressure established by the McCloud tank and that provided by the higher elevation Brookdale Tank. For preliminary costing purposes, it is assumed that an in-line pump installed in a vault, placed essentially in the pipeline right-of-way would be suitable for a booster pump. To meet pressure and flow requirements, a 500-gpm pump would be about 20 Hp.

The Loch Lomond raw water treatment alternative would also involve facilities to connect the Felton system with the South Area consisting of a booster pump station and about 11,000 feet of 12-inch pipeline connecting to the Probation Center Tank. The booster pump station would be designed to deliver water into the Probation Center Tank, which requires a lift of about 360 feet (154 psi). Assuming use of two 500-gpm pumps, each pump would probably be a 75 Hp unit. For preliminary cost estimating purposes, the South Area pump station is assumed to use can-style, vertical turbine pumps, in a non-housed installation to be located on City of Santa Cruz property at their existing Newell Creek pipeline booster pump station site.

LOCH LOMOND WATER TREATMENT PROJECTED COST ESTIMATES

Blended Water Alternative

Planning level cost estimates have been prepared for the two alternatives of treating raw water from Loch Lomond Reservoir in the Felton Water treatment plant. The costs also cover delivering the additional water for supplementing current supplies in both the North and South Service Area. Note that these costs are to be regarded as planning level estimates with an anticipated accuracy of plus 25 percent and minus 15 percent of future construction costs. The costs presented in Table 8 are for the blending only alternative. The associated improvements to access the raw water and treat it along with Fall Creek water blended to reduce levels of organic contaminants for use in the Felton service area; and including facilities to deliver supplemental supply into the North Area and the South Area, would be $3,748,000 in 2010 first quarter dollars. This cost estimate is subject to the preliminary conceptual design condition assumptions described in a previous paragraph and further provided in the footnotes of Table 8.

MIEX Pretreatment Alternative

Incorporating the MIEX pretreatment process equipment into the Felton plant would add significant additional cost. However, as discussed previously, the necessary pretreatment facilities can be installed on the present site with no anticipated need to purchase additional property.

Table 9 presents an accounting of the anticipated additional costs for incorporating the MIEX pretreatment facilities into the Felton plant. The projected cost in 2010 dollars for the pretreatment facilities is $2,625,000. Adding the additional cost to those provided in Table 8, yield a total project capital cost of the $6,373,000 for a Felton treatment plant improvement project that will permit unrestricted treatment of Loch Lomond water over the full range of seasonal raw water quality.

TABLE 8
Projected Capital Costs
Raw Water Treatment Alternative-Blending Option
Loch Lomond Reservoir Allotment

Component	Estimated Cost
Pipeline turnout connection[1]	$25,000
Pressure/flow control/metering vault[2]	$220,000
Pipeline river crossing[3]	$110,000
Raw water pipeline[4]	$128,000
Boring under Highway 9[5]	$80,000
Intertie connection to Fall Creek line[6]	$35,000
Powdered activated feed facility[7]	$400,000
Blending/constant head tank[8]	$130,000
North System connection/pumping Station[9]	$200,000
South System connection[10]	$1,300,000
Booster pumping station[11]	$300,000
Subtotal Construction Cost	$2,608,000
Estimating Contingency @ 20%	$520,000
Total Estimated Construction Cost	$3,128,000
Engineering, Administration and Legal Services	$470,000
Land/Easement Acquisition Allowance	$150,000
TOTAL PROJECTED CAPITAL COST	$3,748,000

[1] Estimated cost of 8-inch connection to the raw water pipeline done on hot tap basis
[2] Precast vault with PRV/flow control valves, meter, fittings and valves, controls, SCADA etc.
[3] Exposed steel pipe with cable stays and security fencing
[4] Approximately 1,600 feet of 8-inch pipeline
[5] Boring assumed to be required to minimize traffic disruption
[6] Buried valves to permit isolating two different sources at connection to the treatment plant and Fall Creek
[7] Preparation and feed facility for PAC including dry feeder and controls
[8] Bolted steel 90,000 gallon tank, 25 ft diameter by 24 ft tall
[9] Booster pump station and 200 ft 8-inch pipeline
[10] Cost projection assumes that no major changes are made to the treatment facilities other than addition of a blending/constant head tank at the Felton WTP.
[11] Can-style, vertical turbine high-lift pumps placed within property containing City of Santa Cruz's raw water booster pump station. Pumps required to supply South System and assumed to be not housed.

TABLE 9
Projected Capital Costs
MIEX Pretreatment Process Addition
Loch Lomond Reservoir Allotment

Component	Estimated Cost
MIEX Equipment Package[1]	$1,100,000
Install MIEX Equipment[2]	$310,000
Concrete Foundations[3]	$15,000
Waste Regenerate Storage Tank[4]	$80,000
Yard Piping[5]	$45,000
Treatment Plant Supply Pumps[6]	$35,000
Electrical	$160,000
Instrumentation	$60,000
Subtotal Construction Cost	$1,805,000
Estimating Contingency @ 20%	$560,000
Total Estimated Construction Cost	$2,365,000
Engineering, Administration and Legal Services	$260,000
TOTAL PROJECTED PRETREATMENT ADDITION CAPITAL COST	$2,625,000

[1]Includes regenerate concentration unit, local and state taxes and 15 percent construction markup
[2] Install and assemble equipment on concrete foundation
[3] Pads for MIEX chemical feed and process unit
[4] Buried fiberglass storage tank
[5] Interconnecting piping with raw water supply lines and waste lines
[6] New pumps to deliver MIEX process effluent to existing treatment units

SECTION 4
TREATED WATER PURCHASE

AVAILABILITY CONSIDERATIONS

The District has discussed with the City the option to exercise their allotment to Loch Lomond Reservoir by purchasing treated water. Loch Lomond water is treated seasonally typically June-November in the Graham Hill Water treatment plant located at 715 Graham Hill Road. It is understood that the City of Santa Cruz will supply water to the District through this connection to their system only when raw water is being acquired from Loch Lomond Reservoir due to water rights restrictions. This condition generally prevails only during about 6 months of the year. The source would be also subject to supply restrictions in periods of drought.

WATER QUALITY

Previously in the report, water quality concerns have been identified and discussed with respect to the differing quality between Loch Lomond water and that produced by the Felton plant and how this would impact the system customers, if at all. As noted in Table 2, the Loch Lomond water processed in the Graham Hill plant will contain more organic contaminants, but will generally comply with the present D/DBP standards developed by USEPA. The treated water will be slightly higher in inorganic mineral content indicated by the higher hardness and alkalinity of the water from the Graham Hill Plant. The difference is slight however and should cause no major problem with scaling or disposition in customer's piping systems. Unknown will be the impact of the occasional taste and odor problems that develop in treated Loch Lomond water. The City has focused previously on applying treatment strategies to remove taste and odor causing organics and it is expected that continued use of activated carbon and other process modifications will minimize the occurrence of taste and odor problems in the future.

It is expected that Loch Lomond water will be warmer than that obtained from Fall Creek and treated in the Felton plant. This slightly warmer water may be noticeable to some customers and may prompt limited complaints but will have no impact on the safety of the treated water. The City of Santa Cruz is considering changing from chlorine to chloramines to meet distribution system disinfection requirements while maintaining THM and HAA5 levels below the D/DBP standards. If the City proceeds with those plans, comingling chlorinated water in the District system with chloramine treated City water will contribute to water quality problems that could be troublesome to District customers. The required addition of ammonia to react with chlorine to produce the residual disinfectant chloramine also causes nitrification of the water that degrades system water quality. Further, it is widely accepted industry practice to not comingle chlorinated with chloraminated water. Most likely the District would be compelled to switch from chlorine to chloramines in their distribution system at substantial capital costs to convert all chlorine application equipment and operate the more expensive chloramination facilities. It is difficult to assign a specific cost if the conversion must be made, but conceivably, it could be in the tens of thousands of dollars. The current status of the City plan is unknown.

TREATED WATER SUPPLY ACCESS

Interconnecting the City of Santa Cruz water distribution system with the District's South Distribution System presents no unusual engineering problems. Presently, the City distribution system extends northward on Graham Hill Road from the water treatment facilities to serve the Rollingwood development. This development is served by an 8-inch water main located along Graham Hill Road entering the development on Treetop Drive. The logical location for an intertie connection would be at the intersection of Graham Hill Road and Sims Road. From this connection point, the 8-inch pipeline could be extended up Graham Hill Road for a distance of about 8,500 lineal feet to a connection to the Lockwood Lane system. The additional transmission pipelines required to implement this alternative are identified on Figure 3.

Other improvements required to implement this system interconnection plan would be a booster pump station placed at some location along the 8-inch transmission line between the Lockwood Lane system and the connection to the City of Santa Cruz System. The booster pump would be required to match the hydraulic grade line of the system established by the Probation Center tank. Additionally, a meter and associated vault to house the equipment would be needed at the connection between the two systems.

Integrating the water supply from the City of Santa Cruz system into the Felton System will require significant transmission pipeline and a pressure reducing station. At the connection to the Felton System of the 11,000-foot long 12-inch pipe following Graham Hill Road, a pressure control station will be needed to reduce the pressure sufficiently to match that of the Felton system. The differential head between the two systems is almost 360 feet that translates into 155 psi. The pressure control station would contain pressure-reducing values needed to dissipate the 155 psi to provide acceptable pressures within the Felton System.

As with the raw water treatment alternative, interconnecting the Felton system with the North System will require a booster pump station along Highway 9 and interconnecting piping to deliver the finished water purchased from the City of Santa Cruz into the North System.

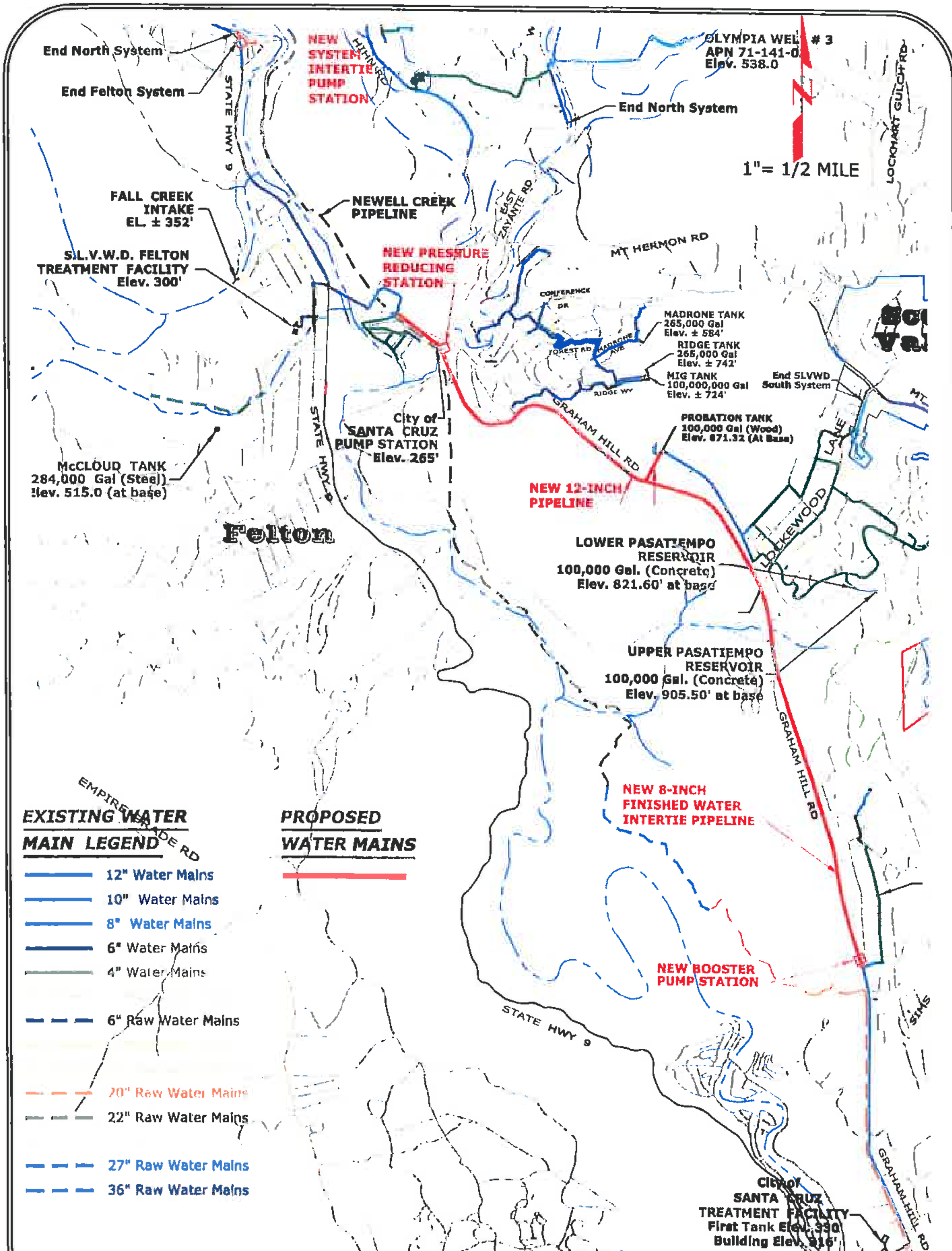

FIGURE 3 – PROPOSED IMPROVEMENTS FINISHED WATER PURCHASE ALTERNATIVE

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PROJECT COSTS

The estimated costs for the improvements needed to connect to the City of Santa Cruz system are presented in Table 10. The total projected capital cost of this alternative is $4,271,000. Preliminary system design assumptions noted at the bottom of Table 10 were used in preparing these costs. These costs are to be regarded as planning level estimates that have an accuracy of plus 25 percent, minus 15 percent of actual overall project costs.

TABLE 10
Projected Capital Costs
Finished Water Supply Alternative
Loch Lomond Reservoir Allotment

Component	Estimated Cost
Pipeline connection/metering facility[1]	$120,000
Transmission pipeline to Lockwood Lane System[2]	$680,000
Booster pump station[3]	$300,000
Transmission pipeline from Lockwood to Felton[1]	$1,300,000
Tie-in connection to Felton System[2]	$40,000
Pressure reducing station of 12-inch line[3]	$100,000
North System connection/pumping station[4]	$300,000
Subtotal Construction Cost	$2,840,000
Estimating Contingency @ 20%	$578,000
Total Estimated Construction Cost	$3,408,000
Engineering, Administration and Legal Services	$613,000
Land/Easement Acquisition Allowance	$250,000
TOTAL PROJECTED CAPITAL COST	$4,271,000

[1] Pipeline connection to City of Santa Cruz 8-inch line at Rollingwood Estates with flow metering vault and associated flow monitoring SCADA instrumentation

[2] Approximately 8,500 feet 8-inch transmission line from connection to existing 8-inch line from City of Santa Cruz's Graham Hill WTP

[3] Booster pump station on Graham Hill Road along route of 8-inch system interconnecting transmission line. In-line style pumps in below grade vault to be placed in pipeline easement right-of-way.

[1] 11,000 feet of 12-inch and 10-inch interconnecting transmission pipeline along Graham Hill Road between tie-in to Probation Center tank and the terminus of a 10-inch line near intersection of Mt. Hermon and Graham Hill Roads.

[2] Vault and fittings to connect new 12-inch line to existing 10-inch line

[3] Pressure control station to reduce pressure to match grade line of Felton system

[4] Booster pump station and 200 feet of interconnecting pipeline between North System and Felton system

SECTION 5
COMPARATIVE EVALUATION OF SUPPLY ALTERNATIVES

INTRODUCTION

In previous sections, the most apparent supplemental water supply alternatives for using the District's allotment to Loch Lomond water were described and developed. The two viable options are: 1) access and treatment of raw water in the District's Felton plant and 2) purchase of treated Loch Lomond water through a connection to the City of Santa Cruz's distribution system. A sub alternative involving the addition of pretreatment to insure full utilization of the Loch Lomond allotment is also developed in the study. It is referred to as the MIEX pretreatment alternative.

CAPITAL COSTS

Implementation costs of both alternatives and the pretreatment sub alternative were provided in Section 4. The cost analyses using pre-planning level project cost estimating procedures yielded the following costs as presented in Table 11.

TABLE 11
Projected Project Implementation Cost
Water Supply Alternatives
Loch Lomond Reservoir Allotment

	Supply Alternative	Projected Project Implementation Cost
1	District purchase of raw water for treatment in the Felton WTP	$3,748,000
1a.	Addition of MIEX Pretreatment facilities to Felton Plant	$6,173,000
2.	District purchase of treated water from City of Santa Cruz	$4,271,000

WATER PURCHASE COST COMPARISON

The City of Santa Cruz can provide either raw or treated Loch Lomond water to the District, up to the allotment of 313 acre-ft per year. Based upon preliminary discussions with city staff, raw water would be available for around $0.85 per hundred cubic feet (Ccf) and finished water would costs $1.35-$1.40 per Ccf. Raw water could be available essentially 12-months of the year and finished water could be provided only during the portion of the year that the City is processing Loch Lomond water at the Graham Hill Water Treatment Plant. Note that the forgoing costs are based upon estimates provided by the City for feasibility planning purposes only, and do not represent an actual contractual agreement.

Presuming full utilization of the 313 acre-ft per year allotment, the purchase cost of the full amount of raw water would be about $115,890. The purchase cost of finished water using a unit cost of $1.40 per Ccf would be $190,880 leaving a differential cost of $74,990 per year if the full 313 acre-ft allotment is utilized. This differential cost of $74,990 per year would be available to the District to pay for access and treatment of the raw Loch Lomond water in the Felton plant.

OPERATING COST PROJECTION FOR TREATING ADDITIONAL LOCH LOMOND WATER

Treatment Costs-Blended Supply Option

The current yearly cost to operate, maintain, and deliver approximately 136 million gallons (416 acre ft) of treated water from the Felton plant is not precisely known; but from experience elsewhere at similar facilities is estimated to be about $150,000. The yearly production costs on an acre-foot basis using the value above is thus $360 per acre-ft. Accommodating an additional 313 acre-ft from Loch Lomond would not add to the treatment costs proportionately. Labor costs would essentially be unchanged. Rather, the additional production would likely add costs only for chemicals and treated water pumping. For the purpose of this cost analysis for the blending only alternative, it is projected that the unit cost of treatment for the 313 acre-foot allotment would be about $60 per acre-foot. The $60 per acre-foot estimate was derived from a similar installation where detailed operation and maintenance costs were available. At this unit cost, approximately $20,000 per year would be expended to process the additional 313 acre-feet allotment of Loch Lomond water.

Treatment Costs-Pretreatment Option

Incorporating the resin based MIEX pretreatment process into the Felton treatment facilities will increase treatment costs significantly. Additional pumping energy will be needed to supply water from the MIEX pretreatment process to the existing filtration plant. Transferring the organic absorbing resin between process tanks and regeneration facilities require energy as well. Purchase of regenerate chemical and resin media lost during treatment are costs that must be considered with the MIEX process. The manufacturer indicates that operating costs including the above items could approach $0.10 to $0.12 per 1,000 gallons of water processed.

A major additional operating cost component is that associated with the transportation and disposal of spent regenerate to a wastewater treatment facility. The manufacturer projects that even with a regenerate concentration process, that waste brine (if salt is used as the regenerate), or sodium bicarbonate production would be about 175 - 200 gallons per million gallons of water processed through the plant.

Using estimated operating costs provided by the supplier of the MIEX process, processing 313 acre-feet per year of Loch Lomond water could fall within a cost range of $33 to $40 per acre-feet. At these unit costs, the additional yearly production costs for 313 acre-feet of Loch Lomond water could amount to about $12,000. These costs would be additive to the $20,000 yearly cost estimated above for processing Loch Lomond/Fall Creek water using a "blending only procedure" to maintain the level of organic contaminants at the current regulated standards.

Additional operating and maintenance costs would be associated with spent regenerate disposal. At a brine production of 200 gallons per 1 million gallons of water treated, approximately 20,000 gallons of waste would be produced during the processing of 313 acre-feet per year. Using an estimated disposal cost of $0.25 per gallon, the yearly costs would amount to $5,000 or about $16 per acre-foot.

Total yearly costs for production, including labor, power, chemicals and spent regenerate disposal would then amount to about $116 per acre-foot. This cost is to be compared to an amount of $60 per acre-foot for a Felton plant operated without pretreatment where blending of Loch Lomond with Fall Creek water is depended upon solely to meet water quality standards. However, it should be noted that blending will not always be possible because of inadequate flows in Fall Creek as discussed extensively previously in this report.

Further, pumping energy requirements to transfer water from the Felton System into both the North and the South Services Areas, and from the City of Santa Cruz into the Felton system need to be factored into the cost comparison of alternatives. Delivering finished water into the South Area from the Felton system would result in increased in operating costs for the raw water treatment alternative due to the requirement to pump water to a higher head (375 feet), from the Felton System (McCloud tank, elevation 535 ft), into the Probation Center tank (elevation 892 feet). An estimate of electrical requirements to pump finished water from the Felton system to the South system was prepared where costs are expressed on a per acre-foot unit cost basis. Assuming a pumping rate of 500 gpm into the Probation Center Tank, the computations yielded a unit cost of about $122 per acre-foot using an electrical power unit cost of $0.20 per kilowatt-hour. On the other hand, purchasing finished water from the City of Santa Cruz and delivering it into the Felton System would require less energy because pumping head requirements are substantially less (approximately 100 feet versus 375 feet). Again, assuming a pumping rate of 500 gpm (limited by the City of Santa Cruz Pipeline size), from the City of Santa Cruz's system into the Felton system, the unit water pumping energy cost would be about $33 per acre foot. However all 313 acre feet of finished water delivered into the Felton system would incur this annual cost of $10,330 per year (313 acre feet x $33 per acre-foot). Whereas, to supply the assumed 100 acre feet per year to the Lockwood Lane subdivision at a projected water pumping energy cost of $122 per acre-foot, the $12,200 year cost is essentially equivalent to the $10,330 per year cost to obtain water from the City of Santa Cruz. It appears from this analysis, considering the foregoing assumptions, that there is little additional energy cost liability to the District to pump as much as 1/3 of the 313 acre feet of water treated in the Felton plant, into the South Area pressure zone served by the Probation Tank.

SUMMARY COMPARISON OF ALTERNATIVES

The findings of this study indicate that it would be advantageous for the District to purchase raw water directly from the City and process it in the improved and upgraded Felton water treatment plant either employing the alternative of simple blending of Loch Lomond water with Fall Creek water (when available) or preferably, providing a pretreatment process (MIEX) to reduce organic contaminants from Loch Lomond to match the levels in Fall Creek water, thereby permitting unrestricted use of the full amount of this source. As presented in Table 12, the estimated cost of treating an additional 313 acre-feet in the Felton plant (utilizing blending only to meet basic D/DBP standards), and pumping 100 acre-feet to the Lockwood Lane subdivision would be about $148,090 ($115,890 purchase cost + $20,000 treatment cost + $12,200 pumping cost).

Employing pretreatment involving the MIEX process would increase the annual costs to $164,000.

The cost of purchasing water from the City and pumping it into the Felton system would be about $201,210 per year ($190,800 purchase cost plus $10,330 pumping cost).

The unit costs included in Table 12 illustrate that even with inclusion of the relatively expensive pretreatment process, that it is advantageous to the SLVWD to adopt a project to utilize their Loch Lomond allotment as a supplemental raw water source for the Felton service area.

Table 13 has been created as a summarization of the advantages and disadvantages of the various parameters that highlight the features of the two selected alternatives. It is intended that this summary, which also includes subjective information, be used as a guide in selecting the best alternative to utilize the Loch Lomond Reservoir water allotment to provide additional reliable supply to the District's North and South service area.

TABLE 12
Summary Cost Comparison
Loch Lomond Supply Development

	Raw Water Treatment Alternative-Blending Only	Raw Water Treatment Alternative-MIEX Pretreatment Option	Finished Water Purchase Alternative
Water Cost[1]	$115,890	$115,890	$190,900
Treatment Cost[2]	$20,000	$36,000	-
Pumping Cost[3]	$12,200	$12,200	$10,330
Total Cost	$148,090	$164,090	$201,210
Unit Cost[4]	$473 per acre-foot	$524 per acre-foot	$643 per acre-foot

[1] Purchase cost for 313 acre feet of raw and finished water from the City of Santa Cruz
[2] Projected cost to treat 313 acre-feet of additional water in Felton treatment plant
[3] Estimated pumping cost to serve Lockwood Lane in higher-pressure zone than Felton zone with 100 acre-ft per year.
[4] Unit cost for additional 313 acre-feet of water supply

TABLE 13
Discussion of Advantages/Disadvantages of Water Supply Alternatives Loch Lomond Reservoir Allotment

Comparison Parameter	Treat Loch Lomond Raw Water with Blending Only	Treat Loch Lomond Raw Water with MIEX Pretreatment	Purchase Loch Lomond Finished Water
Construction Cost	Lowest cost alternative at $3,748,000	Most expensive capital cost of $6,173,000	Capital Cost estimated at $4,271,000
Operational Cost	Operational costs including purchase cost of raw water ($473 per acre-ft) are less than purchase cost of finished water from the City of Santa Cruz.	Pretreatment increases unit O&M cost to $524 per acre-ft	Finished water purchase cost of $643 per acre-ft exceed other alternatives
Reliability	District treatment alternative somewhat less reliable because all water is treated in one plant (Felton).	Same disadvantage as Blending Only alternative	Larger (21 mgd) Graham Hill WTP has more than adequate reserve capacity to serve entire District service area and provides backup source. Finished water received from two sources.
Water Quality	Combating seasonal taste and odor (T&O) problems even with blending may require additional treatment processes increasing capital and operating costs beyond those included in this study.	Greater removal of organics by MIEX pretreatment process will reduce use of powdered activated carbon for T&O control	Graham Hill WTP has existing processes to remove T&O causing contaminants and with possible improvements being considered by the City, could provide better control of T&O in the finished water provided to the District.
Environmental Issues	Environmental issues could be less since the Loch Lomond allotment to the District is a documented contractual agreement and is dedicated to the District for use in their service area, which is believed to include Felton through annexation.	More Loch Lomond water could be used in service area permitting more Fall Creek water to flow into San Lorenzo River	Finished water from the City of Santa Cruz's Graham Hill WTP may be purchased in lieu of raw water from Loch Lomond reservoir.

TABLE 13 (continued)

Construction Considerations	Implementation of the District's Loch Lomond raw water treatment alternative would involve less construction disturbance. Much of the pipeline work will be in lightly used Felton streets. However, the intertie pipeline (8,500 feet) to the Probation Center follows heavily used Graham Hill Road.	Construction activities will have same level of disturbance as blending only alternative	Extensive pipeline construction will be involved in Graham Hill Road (19,500 feet) leading to traffic interruptions adding to potential public access complaints, and traffic disruptions. Mitigation costs could be greater with this alternative.
Disinfection Method	SLVWD use chlorine as a disinfectant in the Felton system and elsewhere in the North and South Service Areas.	Chlorine used as finished water disinfectant same as blending only alternative	The City of Santa Cruz is seriously considering replacing chlorination with Chloramination as a distribution system disinfectant method. Chloramination is incompatible with chlorine disinfection.
Capability to Maximize utilization of 313 acre-ft allotment	Availability of Fall Creek water for TTHM reduction by blending, could impact amount of 313 acre-ft allotment used seasonally within service area	With pretreatment the entire 313 acre-ft allotment would be available for use within service area	Treated water availability could be restricted by drought conditions but the full 313 acre-ft would be seasonally available to the District.

LOCH LOMOND RESERVOIR SOURCE DEVELOPMENT STUDY

SAN LORENZO VALLEY WATER DISTRICT

APPENDIX

Technical Note

Chloride-Free Bicarbonate Regeneration of MIEX® Resin

V0908

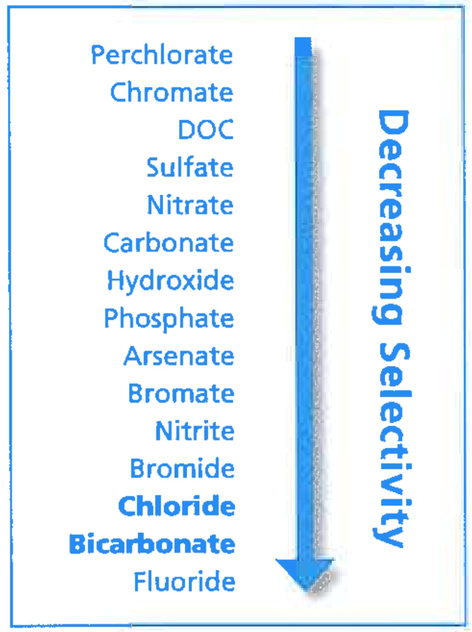
Introduction

The regenerant typically used to restore the ion exchange capacity of MIEX® Resin is a concentrated sodium chloride brine solution. The resulting waste stream is therefore high in conductivity and chlorides, which can present problems with sewer disposal due to potential impacts on downstream biological processes and TDS limits on discharges from wastewater treatment plants.

Where chloride is problematic in the waste from regeneration, sodium bicarbonate, commonly referred to as 'baking soda', can be used to regenerate the resin, which completely eliminates the presence of chloride and significantly reduces the conductivity of the waste.

This technical note summarizes how MIEX® Resin can be regenerated with sodium bicarbonate as well as impacts on costs and waste disposal compared to sodium chloride brine.

Figure 1: Anion selectivity chart for MIEX® Resin



Chemistry of Bicarbonate Regeneration

When sodium bicarbonate ($NaHCO_3$) is used for regeneration of the MIEX® Resin the bicarbonate (HCO_3^-) ion rather than the chloride (Cl^-) ion is exchanged for target anions such as organic acids and nitrate. The bicarbonate ion is actually below the chloride ion in terms of affinity towards the MIEX® Resin (Figure 1), which means the selectivity of the MIEX® Resin for target anions is not impacted when the MIEX® Resin is in the bicarbonate form.

A bicarbonate regenerant solution is prepared by dissolving sodium bicarbonate in water at near the saturation point (78 g/L at @ 18 deg C). This is diluted to around 50 g/L before being used for regeneration of MIEX® Resin. The small particle size and high surface area of the MIEX® Resin, which results in anion removal occurring mostly via surface exchange, makes the MIEX® Resin relatively easy to regenerate compared to larger resins that rely on most of the ion exchange occurring within the resin bead. The high surface area allows the MIEX® Resin to be effectively regenerated using a regenerant such as sodium bicarbonate, which has a relatively low ionic strength.

Waste Disposal Considerations

When there is insufficient dilution available for NaCl brine waste at the discharge point, the resulting increase in chloride concentration and conductivity may be of concern for downstream biological treatment processes or for TDS limits in final discharges. Waste from sodium bicarbonate regeneration does not contain any chloride ions and has a significantly lower conductivity, TDS and sodium concentration than waste from brine regeneration (Table 1).

In many cases, bicarbonate regeneration waste can actually be of benefit to the sewerage system and downstream biological treatment processes. Bicar-

MIEX®

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bonate adds buffering capacity to the waste stream, which is generally desirable at wastewater treatment plants. Increasing the buffering capacity and pH of the waste stream produces the following benefits:

- Minimizes the vaporization of odors, particularly hydrogen sulfide.
- Easier treatment by biological processes.
- Compensates for alkalinity consumed during nitrification.
- Decrease the potential for corrosion of iron or cement pipes.

Table 1: Comparison of Waste Characteristics from Chloride and Bicarbonate Regenerants

Parameter	Regenerant Waste Concentration (Average)	
	NaCl	$NaHCO_3$
TDS (mg/L)	120,000	30,000
Conductivity (ms/cm)	220	50
Chloride (mg/L)	65,000	0
Sodium (mg/L)	52,000	9,000

Reduced Treated Water Corrosivity

When MIEX® Resin is used in the bicarbonate form a bicarbonate ion is released into the treated water in exchange for the target ion that is removed from the water. The resulting slight increase in alkalinity from the bicarbonate release, plus no increase in chloride ions will result in a reduction in corrosiveness of the treated water, which could be a significant benefit for low alkalinity water sources.

Operational Considerations

At a maximum $NaHCO_3$ saturation level of 8% and a pH of around 8.5, biological growth can occur in a bicarbonate regenerant solution whereas biological activity cannot occur in a 10% NaCl solution. A bicarbonate regeneration system must therefore be configured to prevent the risk of biological growth in the regeneration system and biological fouling of the resin. Saturated regenerant solution is made up from dry $NaHCO_3$ on a daily basis only. The resin should also periodically be regenerated with sodium chloride to prevent any long-term biological growth or build-up of organics on the MIEX® Resin. The same regeneration equipment can be used for each regenerant. A separate salt saturator will be required however it will be relatively small due to only occasional use of this regenerant.

Cost Comparison

Although the cost per ton of $NaHCO_3$ is more than that of NaCl, the reduced usage offsets much of the higher regeneration chemical cost.

As the regeneration chemical is only a minor component of the total MIEX® Process operating cost, the overall operating cost increased is less than 10% when using $NaHCO_3$ compared to using NaCl for regeneration.

Conclusions

- Sodium bicarbonate can be effectively applied to regenerate MIEX® Resin thereby eliminateing chloride from the waste regenerant solution.
- Although the cost of sodium bicarbonate regeneration is higher than sodium chloride, the overall MIEX® Process operating cost increase will be less than 10% since regeneration is only a minor component of the overall operational cost.
- The presence of bicarbonate, which increases pH and buffering in a wastewater stream, would be beneficial for reducing odours, minimizing pipe corrosion, and allowing easier treatment under biological conditions.
- Treated water impacts of bicarbonate regeneration include a slight increase in alkalinity and no increase in the chloride level, which can result in a reduction in treated water corrosivity.

Equipment Brochure

EcoRegen™

Low Waste MIEX® Regeneration System

The EcoRegen™ System is a low salt, low-waste resin regeneration system that further reduces the ecological footprint of the MIEX® Process.

A scarcity of new, high quality water sources to meet demand from a growing population has led to an increasing need for advanced water treatment technologies. In addition, water utilities are looking for more sustainable treatment processes to reduce the strain on the environment.

The EcoRegen™ Solution

The MIEX® Process is known to have the smallest carbon footprint of the advanced TOC removal technologies. In an effort to further minimize the impact on the environment, Orica Watercare has developed the EcoRegen System which allows for the recycling of up to 70% of the spent brine regenerant that is typically sent to waste.

The low salt consumption and waste volumes acheived with the EcoRegen™ System further reinforce the MIEX® Process as having the smallest ecological footprint of any ion exchange process.

EcoRegen™ System Features

- Salt consumption reduced to as low as 150 lb/MG
- Waste volume reduced to as low as 100 gal/MG (0.01% of plant throughput)
- Significantly reduced waste disposal costs
- Lower overall MIEX® System operating costs
- Small footprint, skid mounted systems
- Simple operation

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How the System Works

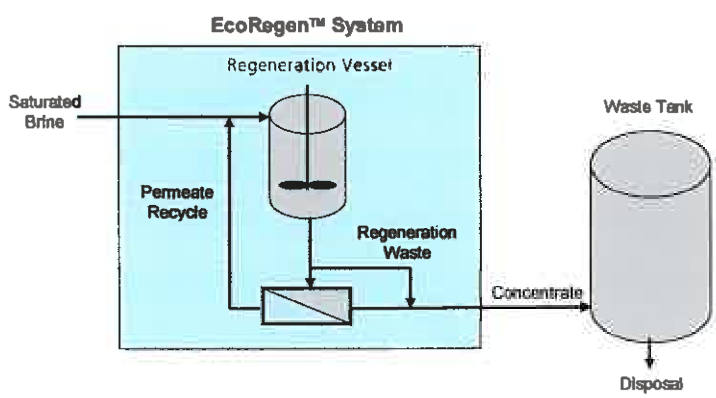
In the MIEX® Process, resin is regenerated in a regeneration vessel by passing a NaCl brine solution through a bed of loaded resin. After each regeneration, a fraction of the brine solution must be wasted to remove accumulated TOC and sulfate from the regeneration circuit.

The EcoRegen™ System is designed to pass waste brine solution through a nanofiltration membrane where TOC and sulfate are filtered from the brine (Figure 1).

Figure 1: Samples from EcoRegen™ System: feed to nanofiltration (L), concentrate sent to waste (C), and filtered brine (R)

The filtered brine [permeate] can then be reused in the regeneration process while the concentrate is sent to waste (Figure 2), resulting in a significantly smaller waste volume. This volume of brine that can be removed ranges from 140 to 280 gal/MG of plant throughput, depending on the MIEX® Process treatment rate.

Figure 2: EcoRegen™ System Brine Flow Diagram



This recycling of waste brine also reduces the salt make-up rate in the salt saturator. An example of reduced waste volumes and salt consumption that can be acheived using the EcoRegen™ System is shown in Table 1.

Table 1: Mass Balance for 30 MGD MIEX® System using EcoRegen™ System

Parameter	Value
Treatment Rate	1000 BV
Salt Usage	150 lb/MG
Waste Recycled	140 gal/MG
Waste Discharged	100 gal/MG

Operator Requirements

The EcoRegen™ System is fully automated. The membranes require periodic chemical cleaning which can be manual or automated.

The cost of slightly higher power consumption (<5 kWh/MG) and cleaning chemicals for the EcoRegen™ System are nominal compared to savings achieved in reduced salt consumption and waste disposal costs.

Contact Us

Visit our website at www.miexresin.com or contact your nearest Orica Watercare office for more information or to inquire about a specific application.

MIEX

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Case Study

Green Valley Water Treatment Plant

Client

Green Valley Water Treatment Plant

Project

TTHM Reduction

Location

Suisun, CA

Commission Date

January 2006

Figure 1: MIEX® Installation (foreground) at the Green Valley WTP

"We are relieved to be back in compliance with the Stage 1 Disinfection By-Product Standard so quickly. Also, the comfort margin will allow us to easily meet the Stage 2 requirements."

Franz Nestlerode, Deputy Water Superintendent.

Project Summary

The Green Valley Water Treatment Plant (WTP) draws its water from two sources to supply Suisun, CA and surrounding communities. The WTP's distribution system is very long resulting in lengthy detention times where free chlorine used for disinfection reacts with total organic carbon (TOC) to form high levels of Total Trihalomethanes (TTHMs). The Green Valley WTP was unable to adequately reduce the source water TOC levels to achieve compliance with the Environmental Protection Agency (EPA) TTHM regulations.

A MIEX® Treatment System was installed in January 2006 to reduce the treated water TOC level prior to disinfection. This resulted in over a 65% decrease in distribution system TTHM levels, allowing the Green Valley WTP to easily meet the EPA TTHM standard.

Challenge

The Green Valley WTP operated by the City of Vallejo, sources raw water from Lakes Frey and Madigan, and the Solano Irrigation District supplied from Lake Berryessa.

The WTP's long distribution system includes a 9-mile long, 24-inch main that serves only 62 connections. As a result, distribution detention times range from two weeks to as long as four weeks, thus providing more time for the chlorine to react with TOC and form TTHMs.

The plant's previous coagulation treatment using alum and a cationic polymer had little impact on treated water TOC levels for either water source. The WTP was therefore unable to reduce TTHMs to below the EPA standard.

MIEX

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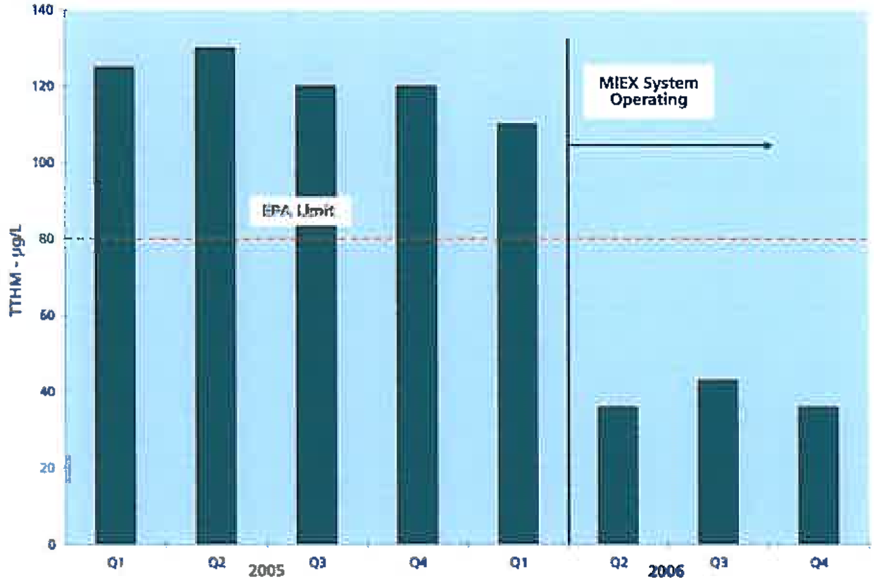
Figure 2: System Wide TTHM Averages



Solution

The City of Vallejo considered several technologies to address the TTHM problem at the Green Valley WTP, including the MIEX® Process, Granular Activated Carbon (GAC) and enhanced coagulation. Based on capital and operating costs the net present worth of GAC was significantly higher than the alternatives. Enhanced coagulation was not effective in providing enough TOC removal to reduce TTHMs below the EPA standard.

In May 2004, a MIEX® Pilot was conducted which indicated that TOC levels could be significantly reduced, providing a large comfort margin for the WTP to meet current and future EPA TTHM standards.

As a result the City of Vallejo decided to install a 1 million gallon day (MGD) MIEX® treatment system as a pretreatment step to the existing treatment plant.

Project Outcomes

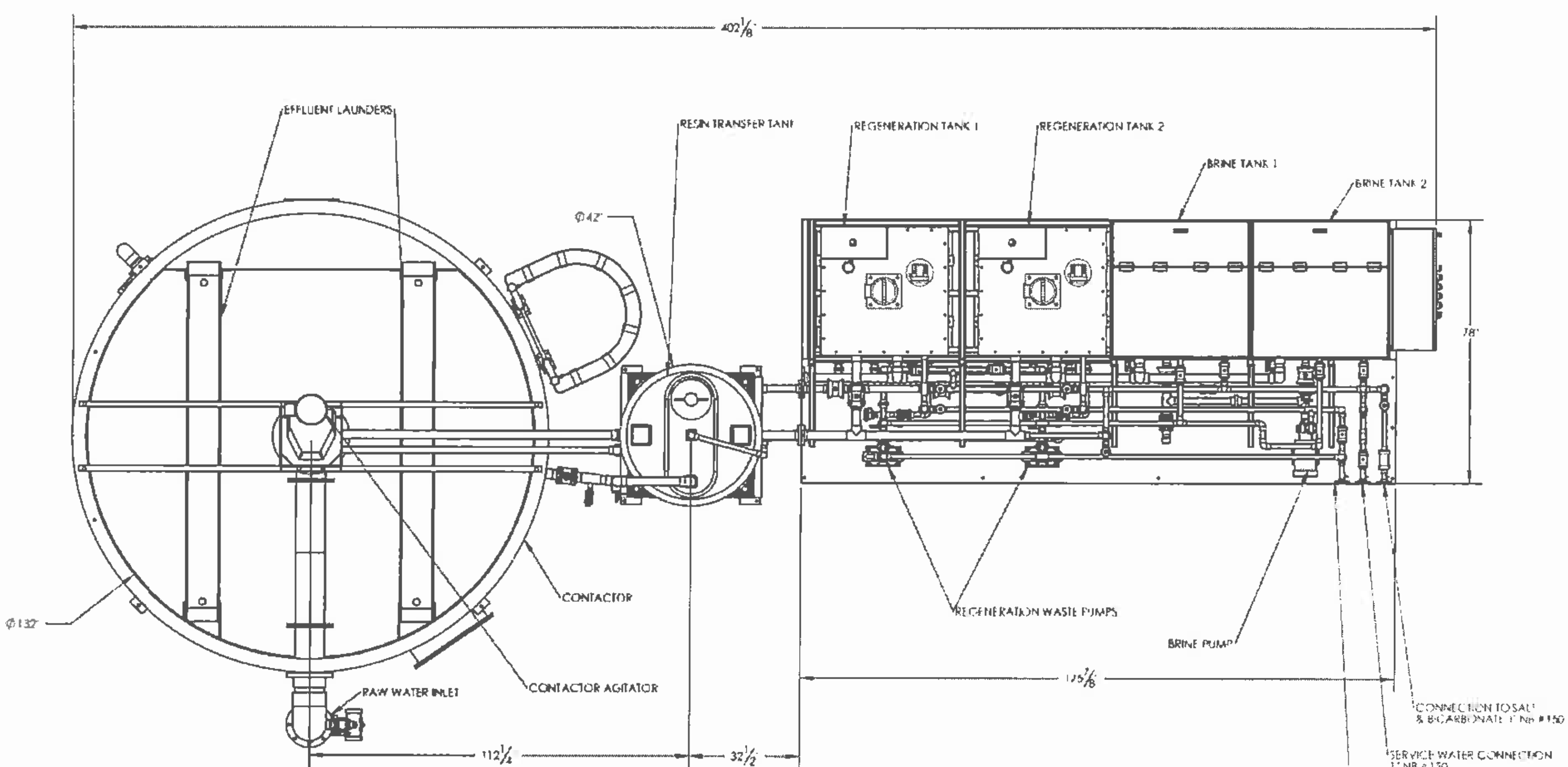
- Full-scale treatment results mirrored pilot trial results for TOC removal and Simulated Distribution System TTHM reductions.
- Treated water TOC levels have been reduced by 60 to 70%.
- System wide average TTHM levels have been reduced from 119 µg/L to 38 µg/L after MIEX® System start-up.
- Coagulants (alum and polymer) have been replaced by an ACH/polymer blend at less than 10% of the previous dose rate.
- Chlorine dose for disinfection has been reduced by 40%.
- Algae growth has been significantly reduced in downstream treatment processes.
- Chlorine residuals can now be achieved at the furthest points of the distribution system.

MIEX

Visit our website at www.miexresin.com or contact your nearest Orica Watercare office for more information or to inquire about a specific application.

VCS0607US

PLAN VIEW



NOTES:
1. DIMENSIONS ARE APPROXIMATE. CONTRACTOR TO VERIFY.
2. CONTACTOR AND REGENERATION SKID TO BE INSIDE BUILDING.

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PROJECT MANAGER: N. WILLIAMS

STATUS: RELEASED

GENERAL ARRANGEMENT
MP700 MAGNAPAK™
CONTACTOR AND REGENERATION SKID
PLAN VIEW

FRONT ELEVATION

NOTES:
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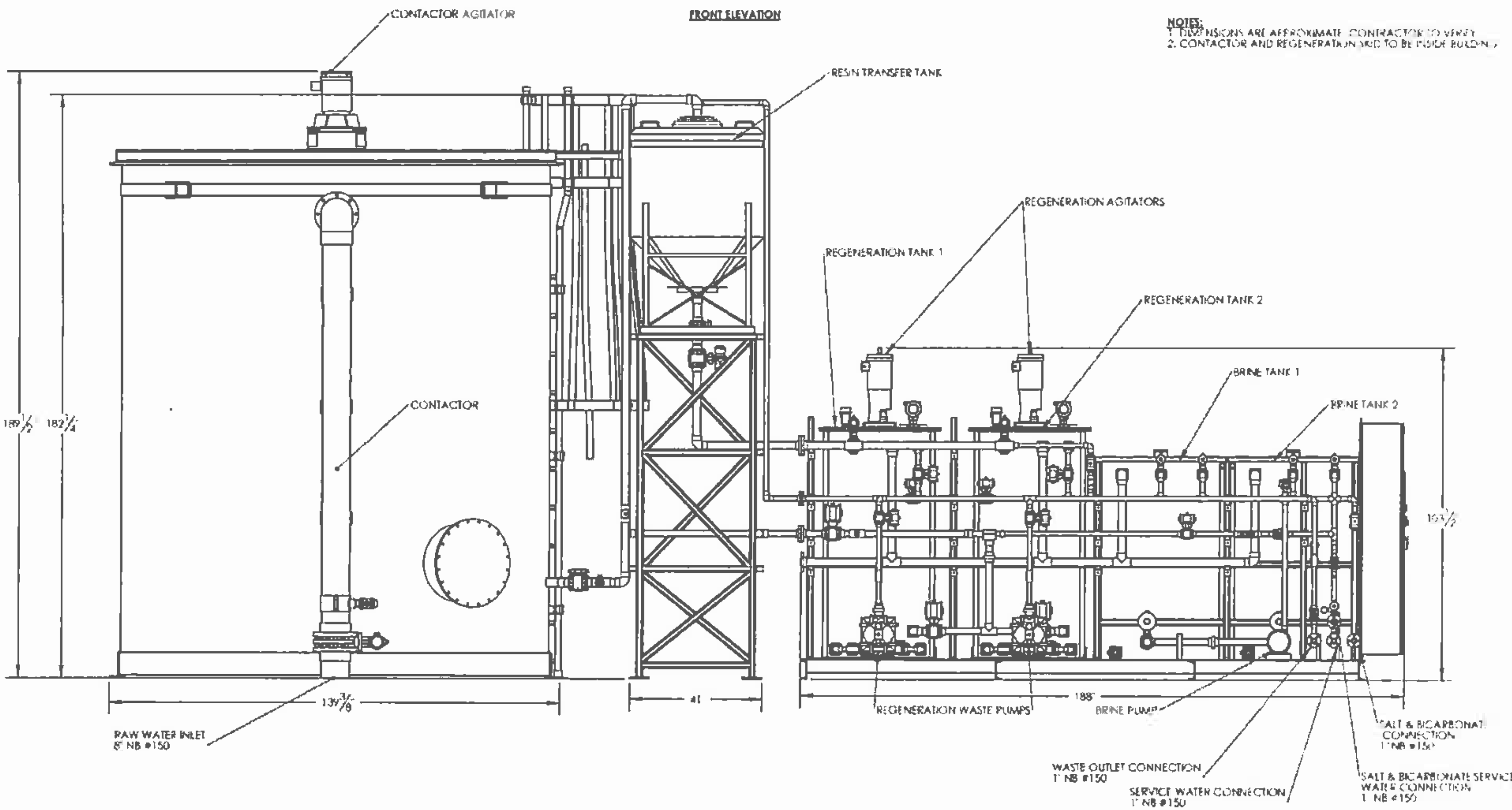
2. CONTACTOR AND REGENERATION SKID TO BE INSIDE BUILDING.



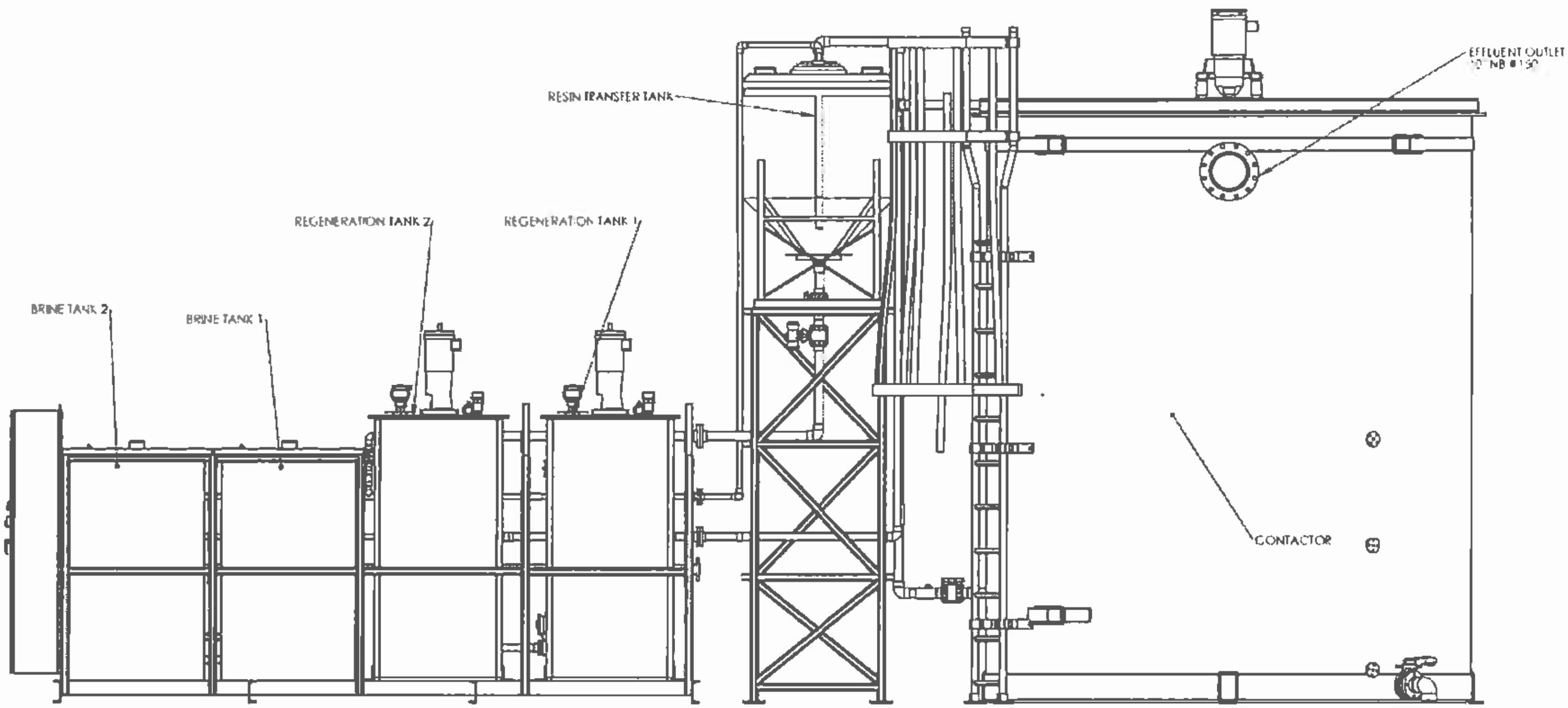
REV	REVISION DESCRIPTION	DATE	DRAWN BY	CHECKED BY	SUPPORTED BY

PROJECT MANAGER: N. WILLIAMS
STATUS: RELEASED

ORICA WATERCARE

GENERAL ARRANGEMENT
MP700 MAGNAPAK™
CONTACTOR AND REGENERATION SKID
FRONT ELEVATION

REAR ELEVATION



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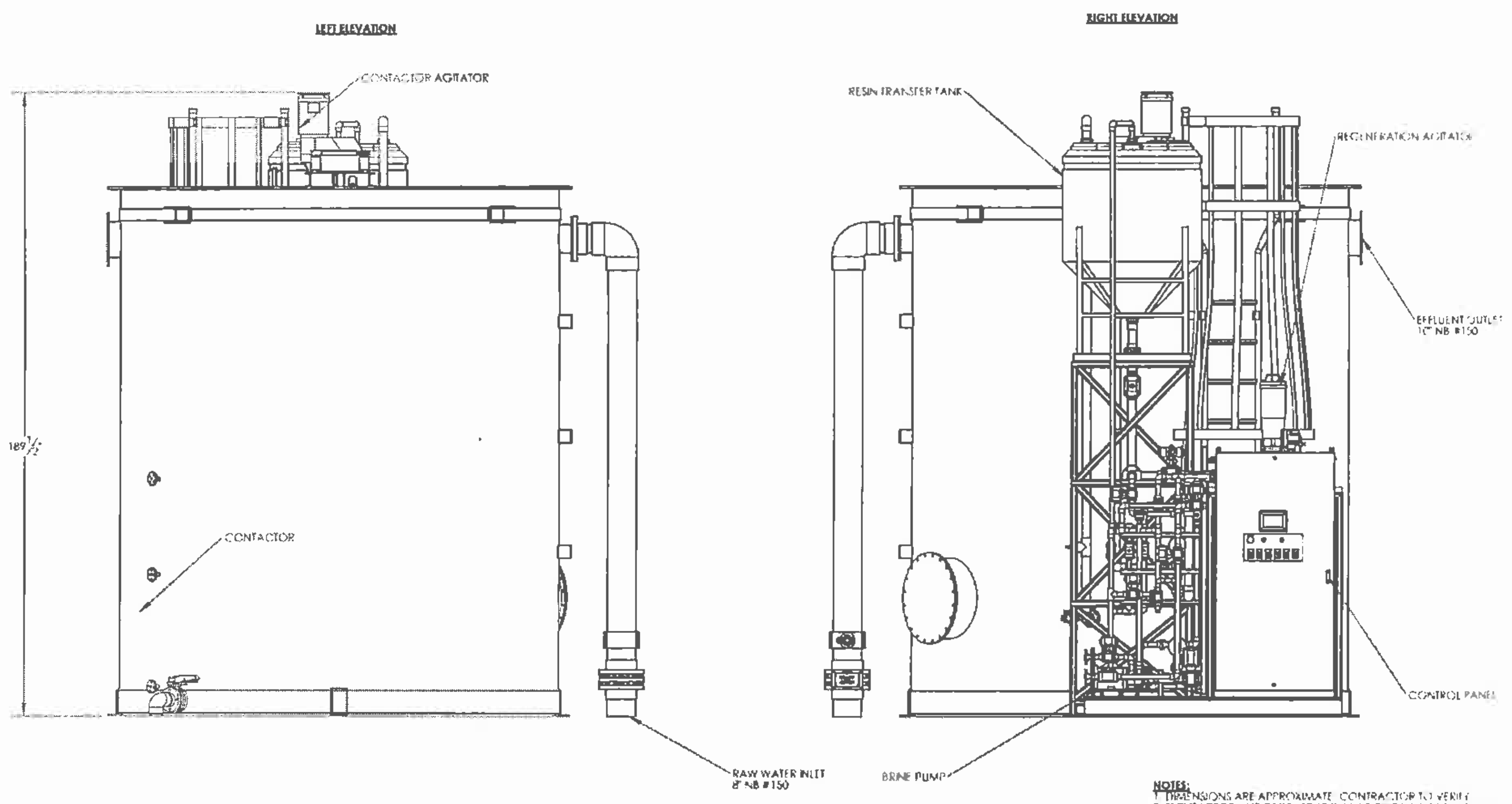
2. CONTACTOR AND REGENERATION SKID TO BE INSIDE BUILDING

ORICA WATERCARE

GENERAL ARRANGEMENT
MP700 MAGNAPAK™
CONTACTOR AND REGENERATION SKID
REAR ELEVATION



NOTES:
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2. CONTACTOR AND REGENERATION SKID TO BE INSIDE BUILDING.

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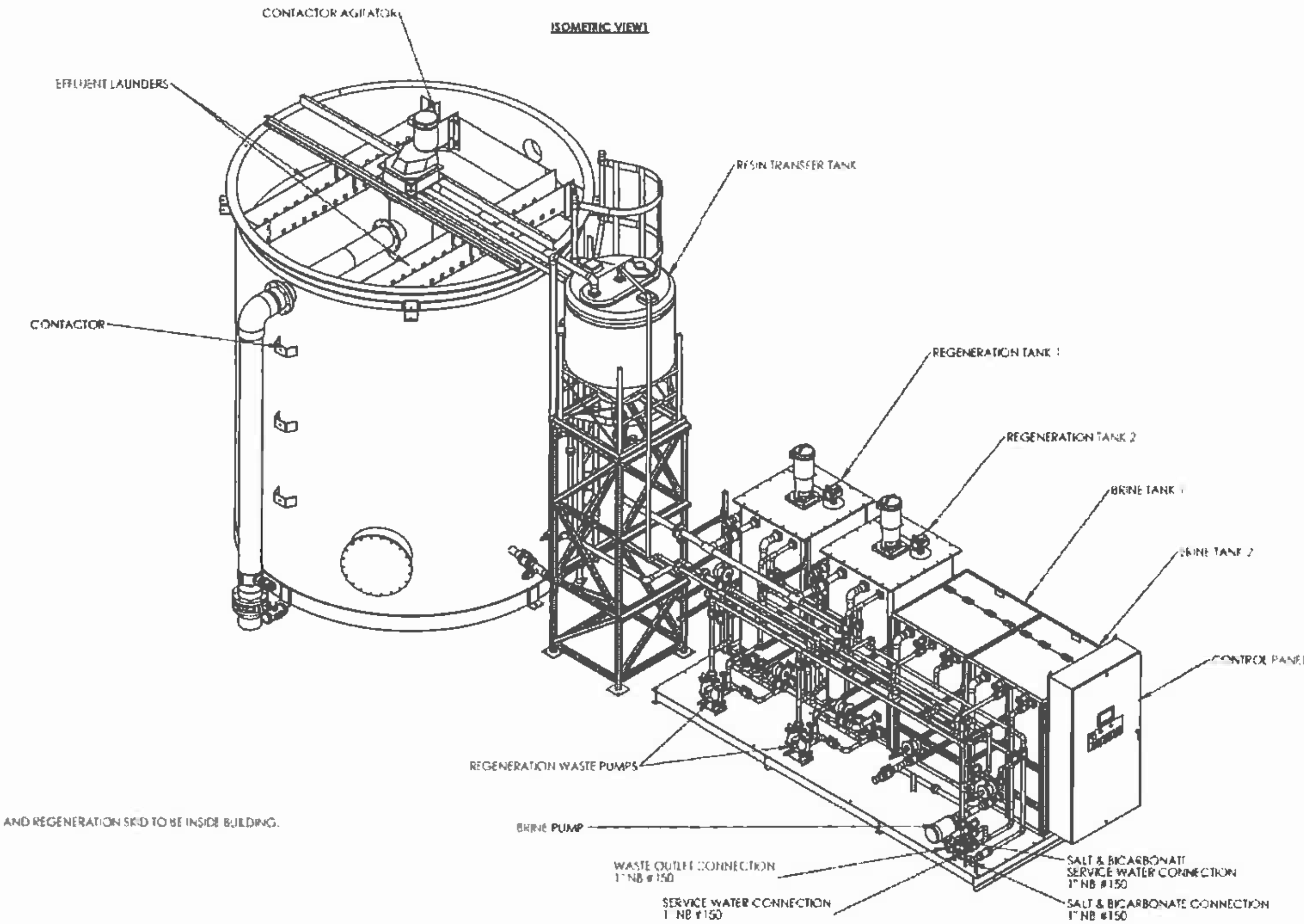
GENERAL ARRANGEMENT
MP700 MAGNAPAK™
CONTACTOR AND REGENERATION SKID
RIGHT AND LEFT ELEVATIONS

ORICA	SIGNATURE	DATE
DRAWN BY		
DESIGNED BY	R. WILLIAMS	
PROJECT MANAGER		

PROJECT MANAGER: N. WILLIAMS
STATUS: RELEASED
SCALE: 1:30

ISOMETRIC VIEW1



NOTES:

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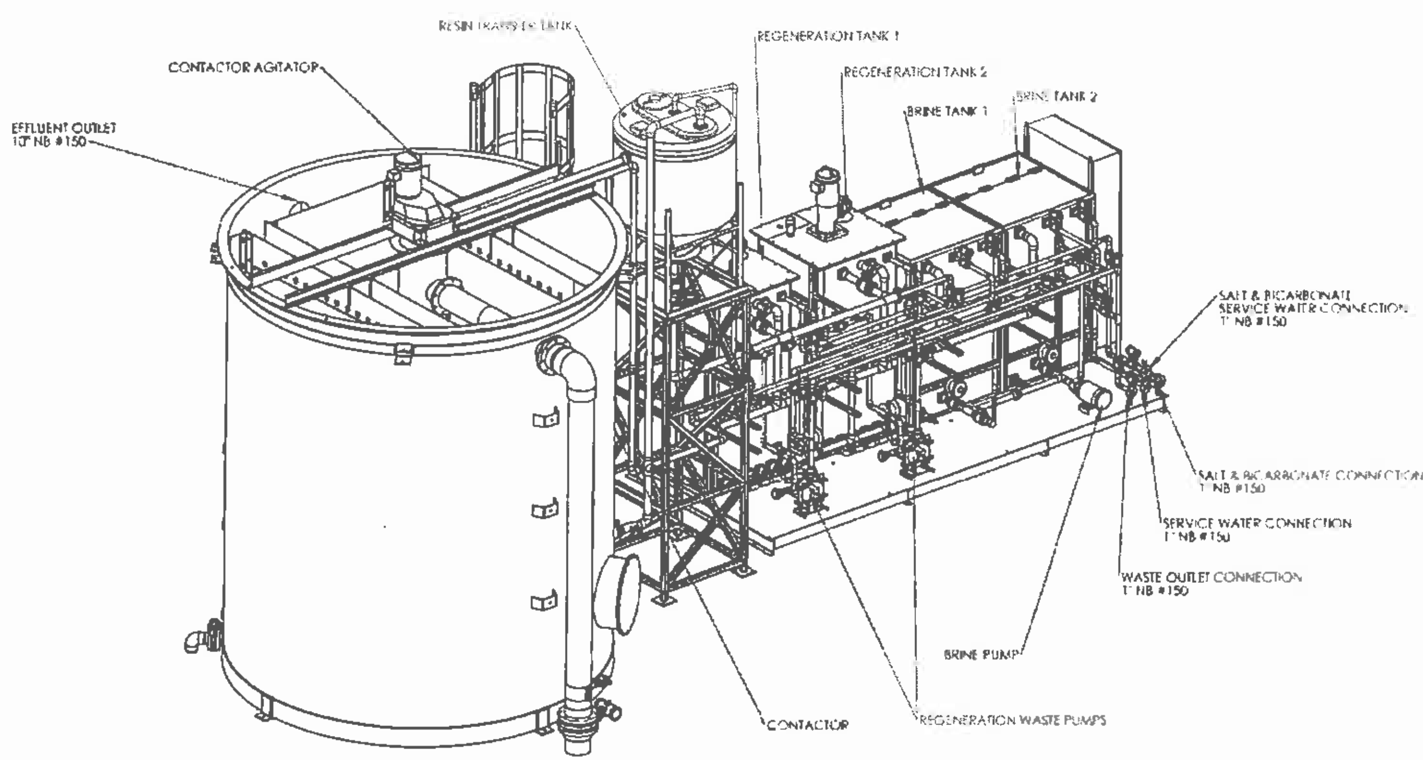
GENERAL ARRANGEMENT
MP700 MAGNAPAK™
CONTACTOR AND REGENERATION SKID
ISOMETRIC VIEW 1

ISOMETRIC VIEW 2



NOTES
1. CONTACTOR AND REGENERATION SKID TO BE INSIDE BUILDING

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GENERAL ARRANGEMENT
MP700 MAGNAPAK™
CONTACTOR AND REGENERATION SKID
ISOMETRIC VIEW 2

SHEET SCALE: 1:40