Fluoridation Preliminary Engineering Design Report

November 2014

Prepared by

MWH

Presented to
Sonoma County Water Agency and the Department of Health Services

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LIST OF ABBREVIATIONS AND ACRONYMS

AACE	Association for the Advancement of Cost Engineering
AB	aggregate base
AC	asphaltic concrete
ACH	air changes per hour
ACI	American Concrete Institute
ADA	American Dental Association
AF	Acre-Feet
AIC	Ampere Interrupting Current
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
CBC	California Building Code
CCR	California Code of Regulations
CCTV	closed circuit television
CDC	Centers for Disease Control and Prevention
CDPH	California Department of Public Heath
CEQA	California Environmental Quality Act
CMU	concrete masonry unit
DHS	County of Sonoma Department of Health Services
EMT	electrical metallic tubing
FMP	Fluoride Monitoring Plan
FRP	fiberglass reinforced plastic
fpm	feet per minute
FSOCP	Fluoride System Operations Contingency Plan
ft	foot/feet
GFCI	ground fault circuit interrupter
gph	gallons per hour
gpm	gallons per minute
HDPE	high-density polyethylene
HOA	hand-off-auto
hr	hour
hp	horsepower
H2SiF6	fluorosilicic acid
HVAC	heating, ventilation, and air conditioning

IBC	International Building Code
IFC	International Fire Code
ISA	Instrumentation Society of America
kW-hr	kilowatt hour
lb	pound
L/R	local/remote
mA	milliamp
MCC	motor control center
MG	million gallons
MGD	million gallons per day
mg/L	milligram per liter
mph	miles per hour
MWH	MWH Americas, Inc.
NaF	sodium fluoride
NaOH	sodium hydroxide
Na2SiF6	sodium fluorosilicate
NAVD88	North American Vertical Datum of 1988
NC	Noise Criterion
NEC	National Electric Code
NEMA	National Electrical Manufacturer's Association
NETA	InterNational Electrical Testing Association
NFPA	National Fire Protection Association
NGVD29	National Geodetic Vertical Datum of 1929
O&M	operations and maintenance
OPCC	opinion of probable construction cost
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
P&ID	piping and instrumentation drawings
PLC	Programmable Logic Controller
ppm	parts per million
PRV	pressure reducing valve
psf	pounds per square foot
psi	pounds per square inch
psig	pounds per square inch gage
PVC	Polyvinyl Chloride
PW	potable water
Report	Fluoridation Preliminary Engineering Design Report

RTU	Remote Terminal Unit
SCADA	supervisory control and data acquisition
SCR	Silicon Controlled Rectifier
SMACNA	Sheet Metal and Air-Conditioning Contractors' National Association
SPPP	stormwater pollution prevention plan
TEFC	totally enclosed fan cooled
UL	Underwriters Laboratories
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
UW	utility water
XLHDPE	cross-linked high-density polyethylene

EXECUTIVE SUMMARY

The County of Sonoma Department of Health Services (DHS) has determined that dental disease is a major source of preventable suffering and expenditures for Sonoma County residents of all ages but particularly the County's low income and minority residents. Consequently, the Community Health Assessment 2008 and the Sonoma County Smile Survey 2009 recommended water fluoridation as a primary means of preventing tooth decay and improving oral health.

Fluoridation of public water systems in California was first required in 1976. Current law states that systems serving more than 10,000 connections must fluoridate if funding is made available to cover the capital expenses and twelve months of operations and maintenance. The law allows an exemption from the requirement in subsequent years if funding is not available.

The Sonoma County Water Agency (Water Agency) provides wholesale water, primarily from the Russian River, to more than 600,000 people in Sonoma and Marin Counties. The Water Agency provides water to the following cities and special districts:

- City of Cotati
- Marin Municipal Water District
- North Marin Water District
- City of Petaluma
- City of Rohnert Park
- City of Santa Rosa
- City of Sonoma
- Valley of the Moon Water District
- Town of Windsor

The Water Agency's projected future total water use is shown in **Table ES-1**.

Table ES-1 – Water Agency Projected Total Water Use*

Sales	2015	2020	2025	2030	2035
Total Water Use – Acre-Feet per Year	71,255	72,888	75,665	78,664	81,719
Total Water Use – Million Gallons per Year	22,217	23,749	24,653	25,631	26,626

*Acre-feet per year values taken from "2010 Urban Water Management Plan, Sonoma County Water Agency, June 2011 Draft" and converted to million gallons per year.

As a water wholesaler, the Sonoma County Water Agency (Water Agency) is not specifically required to fluoridate water delivered to its wholesale customers. That responsibility lies with the

Cities of Santa Rosa and Petaluma and the North Marin and Marin Municipal Water Districts, the only entities served by the Water Agency that have more than 10,000 retail service connections. However, given the large population served, fluoridation of water produced by the Water Agency would have a wide reach and could be more cost effective than having individual retailers fluoridate. Given the need for improved dental health and the potential for reaching a large population of Sonoma County citizens DHS, at the direction of the Board of Supervisors of Sonoma County (February 26, 2013), has initiated this project to evaluate the technical and economic feasibility of fluoridating the Water Agency's water supply.

The purpose of this report is to evaluate the technical and economic feasibility of fluoridation by outlining and establishing the preliminary basis of design for the facilities required to fluoridate the Water Agency's water supply. This report includes the results of an examination of existing water quality, flow and facility data provided by the Water Agency and a review of all existing treatment and well facilities information and drawings, to determine the fluoridation systems and operations that provide the optimum safety, system performance and minimized capital and operation and maintenance (O&M) costs to the Water Agency.

Analysis and Design

The Water Agency currently operates six radial collector wells located along the banks of the Russian River and has three groundwater wells located in the Santa Rosa Plain (Refer to **Figure ES-1**). Wohler Collectors 1, 2 and 6 are located north of the Wohler Bridge while the Mirabel Collectors (3, 4 and 5) are located several thousand feet to the south. Although the discharges from the two collector facilities are interconnected with a 54-inch Wohler-Forestville Pipeline (54-inch Intertie), typically, water from the Wohler Collectors is sent east via the 42-inch diameter Santa Rosa Aqueduct (Santa Rosa AQ), and water from the Mirabel Collectors is sent southeast through the 48-inch diameter Russian River - Cotati Intertie Pipeline (Cotati Intertie). The Water Agency also operates three vertical wells located on the Santa Rosa Plain along the alignment of the Cotati Intertie. The combined capacity of the wells is approximately 5.5 mgd. In recent years, although the wells are classified as production wells, they have not been used frequently and are not expected to be used often in the near future. Long-term use will be dependent on demand growth and operational preferences of the Water Agency.

Three chemicals, sodium fluoride (NaF), sodium fluorosilicate (Na2SiF6), and fluorosilicic acid (H2SiF6), were evaluated for use at the Water Agency's production facilities. Sodium fluoride is a dry chemical (powder or crystal) and is typically fed as a liquid via a saturator, where feed water passing up through the chemical is saturated and then metered into the water supply. Sodium fluorosilicate is available as a powder or as fine crystals and requires a dry feeder and mixing/dissolving chamber to feed a dilute fluoride solution into the water supply. Fluorosilicic acid is delivered in liquid form at approximately 23 percent solution strength and requires a metering pump feed system, similar to those used for other liquid systems, such as alum or caustic soda, to feed a concentrated fluoride solution into the process water.

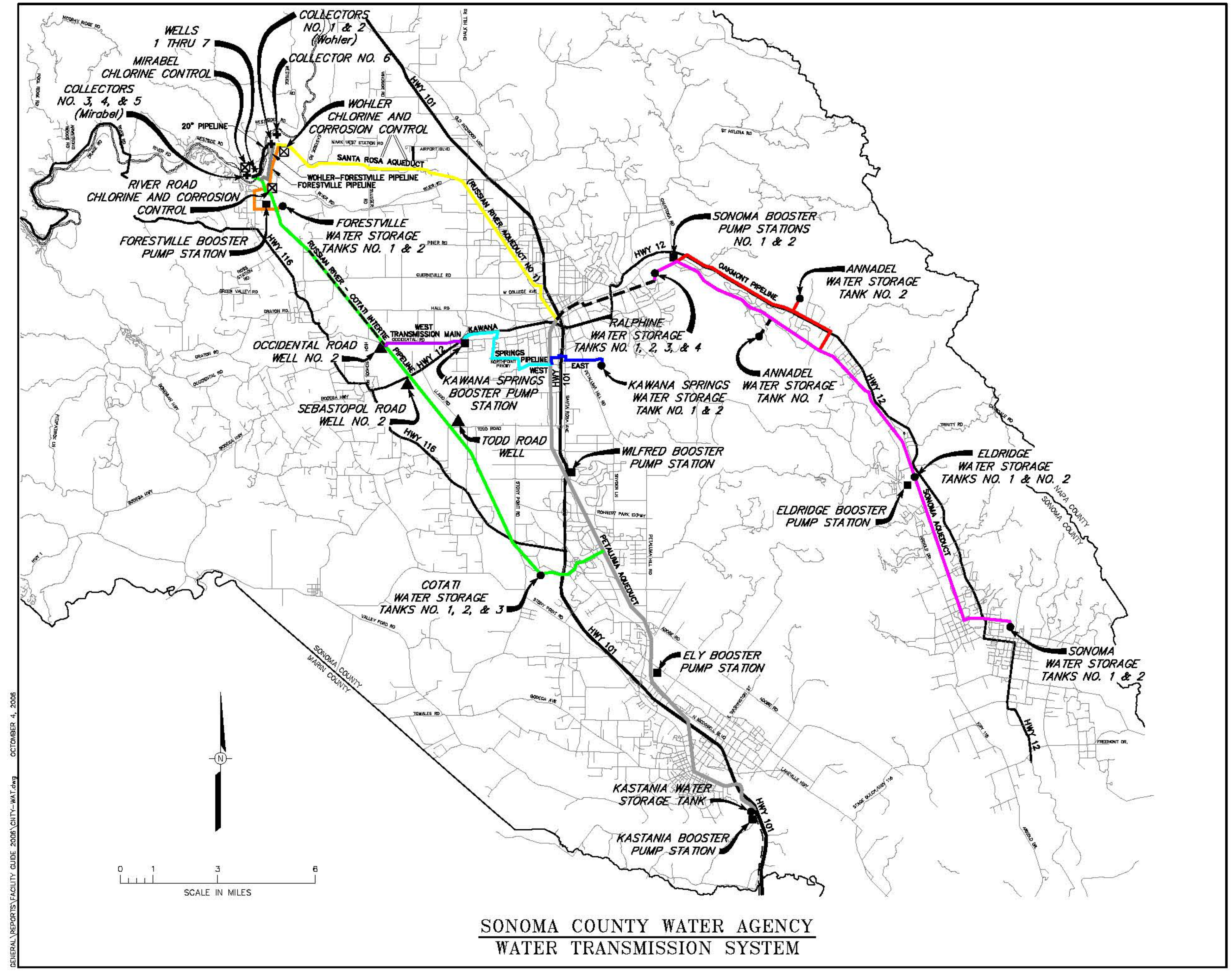

Figure ES-1 – Water Agency System Overview

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Several sites were considered for fluoride feed to the Cotati Intertie, with the existing River Road Facility site selected as the preferred site. The River Road Facility is downstream of the 54-inch Intertie and upstream of the first Cotati Intertie turnout at the Forestville BPS. Similarly, the existing Wohler Facility site was selected for fluoride feed to the Santa Rosa AQ. The Wohler Facility is also located downstream of the 54-inch Intertie. Both of the selected facilities have existing electrical, instrumentation, water, and drainage infrastructure and have sufficient space on site to accommodate new fluoridation buildings with adequate accessibility.

Sodium fluorosilicate and fluorosilicic acid were considered for use at the Wohler and River Road Facilities. A relative lifecycle cost analysis (refer to Appendix B for additional detail) indicated that the sodium fluorosilicate system was nearly 30 percent more expensive than the fluorosilicic acid system at the two facilities. The following factors contributed to the selection of fluorosilicic acid for use at the Wohler and River Road Facilities:

- Fluorosilicic acid system is less complex, requires less maintenance, and is more operator-friendly than the sodium fluorosilicate system.
- Fluorosilicic acid is the most commonly used fluoridation chemical in the greater San Francisco-Sacramento area.
- Use of fluorosilicic acid is less expensive than sodium fluorosilicate.

Sodium fluoride and fluorosilicic acid were considered for use at the smaller well site facilities. The following factors contributed to selection of fluorosilicic acid for use at the well sites:

- Sodium fluoride is more labor intensive for operations staff.
- Sodium fluoride has been reported to have had solubility and bridging problems which impact performance and reliability.
- Fluorosilicic acid is the most commonly used fluoridation chemical in the greater San Francisco-Sacramento area.
- The use of fluorosilicic acid at the well sites while also using it at the Wohler and River Road Facilities would simplify staff training for the single chemical.

While the relative lifecycle cost of a sodium fluoride system was approximately 11 percent less expensive than the fluorosilicic acid system (refer to Appendix B for additional detail), this fact was outweighed by the other factors listed above.

Following selection of the preferred fluoridation chemical, design criteria were developed and preliminary site layouts and piping and instrumentation drawings (P&IDs) were prepared. Unique layouts and a typical P&ID were prepared for Wohler and River Road Facilities, and layouts and a typical P&ID were prepared for use at the well sites. Drawings are attached in **Appendix A**. The preliminary designs were then used to prepare project cost estimates.

Project Cost Estimates

Both capital and operation and maintenance (O&M) costs were developed for project facilities. Costs were developed to an Association for the Advancement of Cost Engineering (AACE) International Class 3 Cost Estimate standard. Per the Class 3 definition, the expected accuracy range is from -10% to -20% on the low side and +10% to +30% on the high side.

The project capital costs were assembled for each facility. The costs were separated into the facility components. The costs were developed using the project design criteria, the facility layouts and P&IDs, costs obtained for similar projects, and the judgment of MWH's cost estimating staff. Escalation was not included in the cost estimates.

The project annual O&M costs were similarly assembled for each facility and were separated into the following components:

- Labor Costs (includes required testing, reporting, and monitoring)
- Energy Costs
- Chemical Costs
- Replacement Costs

An equivalent present value of the annual O&M costs for the project's 30-year design life cycle was calculated (i=3%, 30 years). Capital costs were added to present value of O&M costs to calculate total project present value cost.

While the well sites' usage at full capacity (during the summer months) is included in the Agency's current Urban Water Management Plan, the well sites have had limited use in recent years. Therefore, it is anticipated that construction of fluoridation facilities will occur in two phases. Phase 1 would include construction of the Wohler and River Road facilities. Phase 2 would include construction of the well site facilities. Following the completion of Phase 1, Phase 2 would be constructed when the Agency anticipates sustained use of the wells. Prior to the completion of Phase 2, use of the wells would require adjusting the target fluoride residual in the system, as discussed in the Design Criteria Technical Memorandum. This approach may require CDPH approval prior to implementation.

The Phase 1 costs are summarized in **Table ES-2** while the Phase 2 costs are summarized in **Table ES-3**.

The capital costs in **Table ES-2** can be compared to the Fluoridation Treatment Capital Cost Estimates provided to the California Department of Public Health by the Cities of Santa Rosa and Petaluma and the North Marin Water District. Those estimates were $5,363,000, $2,452,000, and $437,468 respectively. It should be noted that the current estimate and the Cities' estimates may not have been developed to the same scope and level of accuracy or the same level of fluoridation within the cities.

Table ES-2 – Phase 1 – Wohler and River Road Facilities - Conceptual Project Cost Estimate Summary(1)

Description	Total Annual O&M Cost	Equivalent Present Value of Annual O&M (30 yrs, i=3%)	Capital Cost	Total Present Value of Project O&M and Capital Costs (30-yr Life Cycle)
Wohler Facility	$193,000	$3,783,000	$1,770,000	$6,317,000
River Road Facility	$266,000	$5,213,000	$2,070,000	$8,420,000
Total Phase 1	**$459,000**	**$8,996,000**	**$3,840,000**	**$12,836,000**

(1)Capital Cost is AACE Class 3 Estimate, cost basis May 2013, and includes markups and project administration & management. O&M costs assume labor rate of $80/hr and power cost of $0.12/kW-hr.

Table ES-3 – Phase 2 – Well Sites and Project Grand Total- Conceptual Project Cost Estimate Summary(1)

Description	Total Annual O&M Cost	Equivalent Present Value of Annual O&M (30 yrs, i=3%)	Capital Cost	Total Present Value of Project O&M and Capital Costs (30-yr Life Cycle)
Total Phase 2 - **Well**	$122,000	$2,391,000	$660,000	$3,051,000
Grand Total Phase 1 & 2	**$581,000**	**$11,387,000**	**$4,500,000**	**$15,887,000**

(1)Capital Cost is AACE Class 3 Estimate, cost basis May 2013, and includes markups and project administration & management. O&M costs assume labor rate of $80/hr and power cost of $0.12/kW-hr.

The annual O&M cost estimates provided herein are conceptual only, and are based upon the data available at the time of the estimate. The estimates have been prepared to serve as a guide aid for project evaluation. Moreover, the actual costs will vary from these estimates. Funding and feasibility requirements must be carefully reviewed before making detailed financial decisions to ensure adequate project evaluation and appropriate funding.

Secondary Impacts

Fluoridation of drinking water will inevitably lead to higher concentrations of fluoride in wastewater effluent and in irrigation water emanating from either drinking water supplies or recycled water. Fluoridation is practiced extensively throughout California and many other parts of the country for more than 40 years. To the knowledge of the authors and representatives of several California water agencies contacted, fluoridation of drinking water has not created adverse impacts on landscape or crop irrigation or groundwater recharge facilities. Potential impacts on ecological conditions have been discussed with fisheries experts preliminarily by a separate working group of the Agency and DHS with National Oceanic and Atmospheric Administration's National Marine Fisheries Service staff. While there are a number of studies on fluoride, the number relating to salmon species is very small. The working group is reviewing approaches to further external consultation to assess potential impacts.

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INTRODUCTION

The background and the purpose and report organization for this Fluoridation Preliminary Engineering Design Report are presented below.

Background

The County of Sonoma Department of Health Services (DHS) has determined that dental disease is a major source of preventable suffering and expenditures for Sonoma County residents of all ages but particularly the County's low income and minority residents. Consequently, the Community Health Assessment 2008 and the Sonoma County Smile Survey 2009 recommended water fluoridation as a primary means of preventing tooth decay and improving oral health.

Fluoridation of public water systems in California was first required in 1976. Current law states that systems serving more than 10,000 connections must fluoridate if funding is made available to cover the capital expenses and twelve months of operations and maintenance. The law allows an exemption from the requirement in subsequent years if funding is not available.

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As a water wholesaler, the Sonoma County Water Agency (Water Agency) is not specifically required to fluoridate water delivered to its wholesale customers. That responsibility lies with the Cities of Santa Rosa and Petaluma, and the North Marin and Marin Municipal Water Districts, the only retail entities served by the Water Agency that have more than 10,000 retail service connections. However, given the large population served, fluoridation of water produced by the Water Agency would have a wide reach and could be more cost effective than having individual retailers fluoridate. Given the need for improved dental health and the potential for reaching a large population of Sonoma County citizens DHS, at the direction of the Board of Supervisors of Sonoma County (February 26, 2013), has initiated this project to evaluate the technical and economic feasibility of fluoridating the Water Agency's water supply.

Purpose and Report Organization

The purpose of this report is to evaluate the technical and economic feasibility of fluoridation by outlining and establishing the preliminary basis of design for the facilities required to fluoridate the Water Agency's water supply. This report includes the results of an examination of existing water quality, flow and facility data provided by the Water Agency and a review of all existing treatment and well facilities information and drawings, to determine the fluoridation systems and operations that provide the optimum safety, system performance and minimized capital and operation and maintenance (O&M) costs to the Water Agency.

The report is organized under four key areas. A review of regulatory requirements is provided, followed by a description of the selection process for the preferred fluoride chemical form and associated storage and feed facilities. This is followed by an inventory of the design criteria for the fluoridation facilities and then presentation of both their capital and operation and maintenance costs. Drawings of proposed facilities are attached in **Appendix A**, the final design criteria technical memorandum is attached in **Appendix B**, and detailed capital costs for the proposed facilities are attached in **Appendix C**.

REGULATORY REQUIREMENTS

Specific fluoridation and general project regulatory requirements are described below. Specific engineering and construction code requirements are presented later in the Design Criteria and Facility Improvements section of the report.

Regulatory requirements for fluoridation are defined under the California Code of Regulations (CCR) Title 22, Chapter 15, Article 4.1 Fluoridation. The optimum fluoride level is determined using the temperature-appropriate levels listed in Table 64433.2-A in Article 4.1. With an annual average of maximum daily temperatures of 70.4 degrees Fahrenheit (source USA.com), Sonoma County requires an optimum fluoride level of 0.9 mg/L with control range of 0.8 to 1.4 mg/L.

It should be noted that the U.S. Department of Health and Human Services (HHS) has recently proposed the revised recommendation of a single 0.7 mg/L fluoride level to replace the current temperature-based variable fluoride levels. The new proposed recommendation was published in the Federal Register on January 13, 2011, and was scheduled to accept comments from the public and stakeholders for a period of 30 days. HHS has not yet published final guidance on this issue, so the CCR has not been changed and the temperature-based fluoride requirements remain in effect. However, CDPH is currently recommending that fluoridating water systems operate toward the lower end of their prescribed dose range (California Division of Drinking Water website). Therefore, although the CDPH optimum fluoride level is still in effect and was used in the earlier work of the Design Criteria Technical Memorandum (Appendix B), facilities and costs developed in this report reflect the proposed 0.7 mg/L standard in anticipation of an official change to fluoride regulations. The tables and calculations currently presented in this report have been changed from the earlier draft version which included both 0.9 mg/L and 0.7 mg/L results.

The Water Agency would be required to coordinate with the CDPH and complete an Application for Domestic Water Supply Permit Amendment. Before submitting the application, the Water Agency would also need to develop a Fluoride Monitoring Plan (FMP) and Fluoridation System Operations Contingency Plan (FSOCP). These plans would typically include the following key elements:

- Daily Distribution System Grab Sample Testing (FMP) – This would include fluoride testing of a samples taken from approved locations in the system.
- Monthly Distribution System Split Grab Sample Testing (FMP) – This would include sending a split sample of a daily grab sample to an outside lab for fluoride testing once per month.
- Annual Raw Water Sample Testing (from each collector and well) (FMP) – This would include annual fluoride testing of all raw water sources to confirm background fluoride levels.
- Daily Calculated Fluoride Dose for Wohler and River Road Facilities and Each Well (FMP) – This would include calculating the fluoride dose at each fluoridation facility based on the flow and quantity of chemical used.
- Monthly Calculated Fluoride Dose for the System (FMP) - This would include calculating the fluoride dose for the water system based on the flow and quantity of chemical used.
- Reliability Measures (FSOCP) – This would include installation and maintenance of such elements as on-line fluoride analyzers and fluoride tank liquid level indicators in the fluoridation system.

- Action Plan for Non-Optimal Fluoride Levels (FSOCP) – This would include an action plan for operators to follow in the event of fluoride overfeed or underfeed conditions.
- Action Plan for Spill/Leak (FSOCP) – This would include an action plan for operators to follow in the event of a fluoride chemical spill or leak.
- Procedures for Fluoridation System Shutdown (FSOCP) – This would include an action plan for operators to follow when shutting down the fluoridation system in the event of an overfeed.
- Notification and Reporting Procedures (FSOCP) – This would include establishing procedures for reporting routine test results and notifying CDPH in the event that sample results are not in compliance with the requirements described in Article 4.1.

All associated recordkeeping, evaluation, and reporting would be the responsibility of the Water Agency. CDPH would be responsible for monitoring and inspection of the project fluoridation facilities to confirm continued compliance with the requirements of Article 4.1.

General Requirements

Other general project requirements would include compliance with the California Environmental Quality Act (CEQA). While fluoridation facilities at the Water Agency's wells would cause minimal disturbance, fluoridation facilities to serve the Water Agency's transmission pipelines would require site grading and tree removal. The Water Agency would need to complete a CEQA checklist and appurtenant documentation. Costs for this environmental work have been included in cost estimates presented later in this report. No costs for environmental mitigation have been included.

In addition, while a building permit is generally not required, a fire department plan review of the fluoridation facilities would be required. Costs for fire department plan check have been included in cost estimates presented later in this report.

FLUORIDATION SYSTEM SELECTION

A draft technical memorandum (Design Criteria TM) presenting a review of existing Water Agency production facilities and selection of fluoride feed locations as well as an evaluation and selection of the preferred fluoridation chemical form, was prepared in April 2013. The Design Criteria TM was reviewed and the final version is attached as **Appendix B**. A brief summary of the Design Criteria TM is provided here for convenience. Please refer to **Appendix B** for further detail.

Review of Existing Facilities

The Water Agency currently operates six radial collector wells located along the banks of the Russian River and has three groundwater wells located in the Santa Rosa Plain (Refer to **Figure ES-1**). Wohler Collectors 1, 2 and 6 are located north of the Wohler Bridge while the Mirabel Collectors (3, 4 and 5) are located several thousand feet to the south. Although the discharges from the two collector facilities are interconnected with a 54-inch Wohler-Forestville Pipeline (54-inch Intertie), typically, water from the Wohler Collectors is sent east via the 42-

inch diameter Santa Rosa Aqueduct (Santa Rosa AQ), and water from the Mirabel Collectors is sent southeast through the 48-inch diameter Russian River - Cotati Intertie Pipeline (Cotati Intertie). The minimum, maximum, and average flows, in million gallons per day (MGD), for the two pipelines projected for the years 2015 and 2035 are shown in **Table 2**. The 2015 flows have been reported by Water Agency staff to be very close to current flow rates and were assumed as current for this report.

Table 2 – Water Agency Production Flow Rates*

Pipeline	Minimum Daily Flow Rate (MGD)	Maximum Daily Flow, 2015 (MGD)	Average Daily Flow Rate, 2015 (MGD)	Maximum Daily Flow, 2035 (MGD)	Average Daily Flow Rate, 2035 (MGD)
Santa Rosa Aqueduct	5.0	31.7	18.6	40.0	23.3
Cotati Intertie Pipeline	5.0	54.8	27.7	59.8	34.9

*Flow rates from correspondence with Water Agency staff.

Average 2012 water quality values for raw water routed to the Santa Rosa AQ and Cotati Intertie are shown in **Table 3**.

Table 3 – 2012 Average Water Quality Values*

Element	Santa Rosa AQ	Cotati Intertie
pH (unit)	7.2	7.5
Fluoride (mg/L)	0.17	0.15
Total Dissolved Solids (mg/L)	146.7	146.7
Alkalinity (mg/L as $CaCO_3$)	106.7	103.3
Calcium (mg/L)	23.7	24.3
Chloride (mg/L)	5.5	5.7
Sulfate (mg/L)	13.0	12.7
Temperature, Avg. (Celsius)	17	17

The Water Agency also has three groundwater wells located in the Santa Rosa Plain: Occidental Road Well, Sebastopol Road Well, and Todd Road Well. These wells feed into the Cotati Intertie downstream of the Forestville BPS. The capacities of the Occidental Road and Sebastopol Road wells are estimated at approximately 2 MGD each and Todd Road well has an estimated capacity of 1.5 MGD. This yields a total capacity of approximately 5.5 MGD. Naturally occurring fluoride levels for the Occidental Road, Sebastopol Road, and Todd Road Wells in 2012 were reported as 0.2 mg/L, <0.10 mg/L, and 0.14 mg/L, respectively. The production wells are not frequently used at the present time but are planned for use to meet future system seasonal demands. The annual water production of the Santa Rosa Plain wells was estimated at 2,300 acre-feet (749.4 MG) for all years through 2035. (Source: 2010 Urban Water Management Plan, Sonoma County Water Agency, June 2011 Draft).

Selection of Fluoride Feed Locations

Several sites were considered for fluoride feed to the Cotati Intertie, with the existing River Road Facility site selected as the preferred site. The River Road Facility is downstream of the 54-inch Intertie and upstream of the first Cotati Intertie turnout at the Forestville BPS. Similarly, the existing Wohler Facility site was selected for fluoride feed to the Santa Rosa AQ. The Wohler Facility is also located downstream of the 54-inch Intertie. Both of the selected facilities have existing electrical, instrumentation, water, and drainage infrastructure and have sufficient space on site to accommodate new fluoridation buildings with adequate accessibility.

Evaluation and Selection of Fluoridation Chemical Form

Three chemicals, sodium fluoride (chemical formula: NaF), sodium fluorosilicate (chemical formula: Na2SiF6), and fluorosilicic acid (chemical formula: H2SiF6), are commonly used for the fluoridation of drinking water. Refer to Appendix B for detailed chemical characteristics and depictions of typical facilities. In the greater San Francisco - Sacramento area, fluorosilicic acid is the most common fluoridation chemical used. The City of Fairfield uses fluorosilicic acid at their Waterman and North Bay regional WTPs, and it is also used by the Marin Municipal Water District at their two WTPs and the Ignacio Pump Station. East Bay Municipal Utility District uses fluorosilicic at its six WTPs, and the San Francisco Public Utilities Commission uses fluorosilicic acid at its two WTPs and the Tesla Treatment Facility which feeds chemicals to the Hetch Hetchy supply. Both the City of Roseville and the City of Sacramento use fluorosilicic acid at their surface water treatment plants. Both the Sacramento Suburban Water District (South Service Area) and California American Water Company use fluorosilicic acid at their well sites. Sacramento County Water Agency is currently completing the addition of fluorosilicic acid feed systems to all of their groundwater wells and treatment facilities. Sacramento County Water Agency currently uses sodium fluorosilicate at their Vineyard Surface WTP, one of the few facilities to do so.

Sodium fluoride is a dry chemical (powder or crystal), and is typically dissolved via a saturator, and then metered into the water supply as a liquid. Saturator installations are limited to smaller systems (less than approximately 3 MGD) due to practical size limitations of the saturators, therefore use of sodium fluoride would not be practical at the larger Wohler and River Road sites and was only considered for use at the well sites. Sodium fluoride dust is harmful to human health and, consequently, safety equipment including goggles, gloves, aprons, dust masks, and respirators, as well as good ventilation system are recommended when handling this chemical.

Sodium fluorosilicate is available as a powder or as fine crystals and requires a dry feeder to meter the applied dose and mixing/dissolving chamber to feed a dilute fluoride solution into the water supply. The key elements of a mechanical dry feed system are a bag-loading system with hopper, dust collection system, volumetric dry chemical feeder, and dissolving tank with mixer. The dilute sodium fluorosilicate solution is pumped or conveyed by gravity to an appropriate injection point in the treated water system. Dry feeder operations are generally more complex, more maintenance intensive, and more costly compared to a saturator system or a liquid fluorosilicic acid system. This type of complex system was not considered for use at the smaller well sites. Similar to sodium fluoride, sodium fluorosilicate dust is harmful to human health and requires appropriate safety equipment and a robust dust collection and ventilation system.

Fluorosilicic acid is delivered in liquid form at approximately 23 percent solution strength and requires a metering pump feed system, similar to those used for other liquid chemical systems, such as caustic soda, to feed a concentrated fluoride solution into the process water. The key elements of a liquid feed system at a larger installation, such as would be required for the Wohler and River Road Facilities, are the bulk storage tank and the metering pumps. At smaller installations, such as the well sites, a single storage/feed tank providing a 7- to 14-day supply is typically used. Fluorosilicic acid is a highly corrosive liquid that requires proper safety gear and continuous ventilation. Fluorosilicic acid also requires the use of acid-resistant materials for storage, pumping, and piping of the chemical. The off-gas from tank storage is corrosive to glass and metals and must be vented to the outside atmosphere if stored indoors.

Tables 4 and 5 summarize the advantages and disadvantages of the chemicals for both the Wohler and River Road facilities and the well sites.

Table 4 – Wohler and River Road Facilities - Operational Advantages and Disadvantages of Fluoride Feed System Chemicals

Compound	Advantages	Disadvantages
Sodium Fluorosilicate (Na_2SiF_6) (Powder/Crystal)	Chemical has less acute health impact from occupational exposure than fluorosilicic acid Fewer pounds of chemical shipped and reduced storage area due to greater concentration of fluoride ion per pound.	More mechanically complex system Chemical must be kept in dry indoor storage area Need to properly dispose of chemical containers Requires dust control system - dust is toxic, handling requires respirator and full chemical suit Requires more routine chemical handling by staff Requires more routine maintenance by staff Solubility is temperature dependent Decreases pH, requiring additional caustic soda usage (roughly half the pH reduction caused by fluorosilicic acid)
Fluorosilicic Acid (H_2SiF_6) (Liquid)	Less routine chemical handling for staff Less routine maintenance for staff Consistent solubility and chemical strength Chemical widely available and used by other local water	Highly corrosive/hazardous agent Larger storage volume required due to lower fluoride ion concentration in liquid form Decreases pH, requiring additional caustic soda usage Requires double-containment system and ventilation

Table 5 – Well Sites - Operational Advantages and Disadvantages of Fluoride Feed Systems Chemicals

Compound	Advantages	Disadvantages
Sodium Fluoride (NaF) (Powder/Crystal)	Chemical has less acute health impact from occupational exposure than fluorosilicic acid No impact on pH Fewer pounds of chemical shipped and reduced storage area due to greater concentration of fluoride ion per pound.	Requires more routine chemical handling by staff Dust is toxic, handling requires respirator and full chemical suit Chemical must be kept in dry indoor storage area Need to properly dispose of chemical containers
Fluorosilicic Acid (H_2SiF_6) (Liquid)	Less routine chemical handling for staff Chemical widely available and used by other local water purveyors including City of Fairfield and Marin County	Highly corrosive/hazardous agent Larger storage volume required due to lower fluoride ion concentration in liquid form Decreases pH, which may impact process water corrosion potential Requires double-containment system and ventilation

Sodium fluorosilicate and fluorosilicic acid were considered for use at the Wohler and River Road Facilities. A relative lifecycle cost analysis (refer to Appendix B for additional detail) indicated that the sodium fluorosilicate system was nearly 30 percent more expensive than the fluorosilicic acid system at the two facilities. The following factors contributed to the selection of fluorosilicic acid for use at the Wohler and River Road Facilities:

- Fluorosilicic acid system is less complex, requires less maintenance, and is more operator-friendly than the sodium fluorosilicate system.
- Fluorosilicic acid is the most commonly used fluoridation chemical in the greater San Francisco-Sacramento area.
- Use of fluorosilicic acid is less expensive than sodium fluorosilicate.

Sodium fluoride and fluorosilicic acid were considered for use at the smaller well site facilities. The following factors contributed to selection of fluorosilicic acid for use at the well sites:

- Sodium fluoride is more labor intensive for operations staff.
- Sodium fluoride has been reported to have had solubility and bridging problems which impact performance and reliability.

- Fluorosilicic acid is the most commonly used fluoridation chemical in the greater San Francisco-Sacramento area.

- The use of fluorosilicic acid at the well sites while also using it at the Wohler and River Road Facilities would simplify staff training for the single chemical.

- While the relative lifecycle cost of a sodium fluoride system was approximately 11 percent less expensive than the fluorosilicic acid system (refer to Appendix B for additional detail), this fact was outweighed by the other factors listed above.

Phasing of Fluoridation Facility Construction

While the well sites' usage at full capacity (during the summer months) is included in the Agency's current Urban Water Management Plan, the well sites have had limited use in recent years. Therefore, it is anticipated that construction of fluoridation facilities will occur in two phases. Phase 1 would include construction of the Wohler and River Road facilities. Phase 2 would include construction of the well site facilities. Following the completion of Phase 1, Phase 2 would be constructed when the Agency anticipates sustained use of the wells. Prior to the completion of Phase 2, use of the wells would require adjusting the target fluoride residual in the system, as discussed in the Design Criteria Technical Memorandum. This approach may require CDPH approval prior to implementation.

DESIGN CRITERIA AND FACILITY IMPROVEMENTS

Preliminary fluoridation facility design criteria and concept designs were developed in the Design Criteria TM. Further design developments are presented in this section of the report. Project design criteria and fluoridation facility designs were refined for the Wohler and River Road Facilities (Phase 1) and the well sites (Phase 2), which include the Todd Road, Sebastopol Road, and Occidental Road Wells. A summary of major design criteria is provided below, followed by detailed design criteria and facility improvements discussions, grouped by engineering discipline. Preliminary design drawings are attached at the end of this report.

Summary of Major Design Criteria

The major design criteria established for fluoridation facilities at the Wohler facility are summarized in **Table 6**, and at the River Road facility in **Table 7**. Major well site design criteria are summarized in **Table 8**.

Table 6 – Wohler Fluoridation Facility Design Criteria (Phase 1)

Description	Criteria
Fluoride chemical form	Fluorosilicic Acid
Maximum daily water production rate (Year 2035)	40.0 MGD
Average daily water production rate (Year 2035)	23.3 MGD
Minimum daily water production rate (Year 2035)	5.0 MGD
Design fluoride dose	0.7 mg/L
Additional caustic soda dose required for pH neutralization	1.2 mg/L
Fluoride storage requirements	Minimum 30 day supply at average flow and design dose or 4,000 gallon truckload plus 1,000 gallon buffer.
Fluoride storage tank size	One 5,000 gal tank.
Fluoride storage tank type	Double-contained cross-linked polyethylene
Fluoride feed building type	CMU block building, mechanically ventilated
Fluoride feed building size	20 ft x 26 ft
Metering pump type	Hydraulically actuated diaphragm
Metering pump maximum flow range	Approx. 0.51 to 4.1 gallons per hour (gph)
Fluoride injection location	New vault @ existing backup chlorine injection vault. Feed pipe to be double contained schedule 80 PVC.
SCADA requirements	Existing SCADA to be modified
Fluoride residual measurement	Fluoride analyzer with sample piping tap at current pH analyzer tap

Table 7 – River Road Fluoridation Facility Design Criteria (Phase 1)

Description	Criteria
Fluoride chemical form	Fluorosilicic Acid
Maximum daily water production rate (Year 2035)	59.8 MGD
Average daily water production rate (Year 2035)	34.9 MGD
Minimum daily water production rate (Year 2035)	5.0 MGD
Design fluoride dose	0.7 mg/L
Additional caustic soda dose required for pH neutralization	1.2 mg/L (maximum , dependent upon downstream well status and need to compensate for pH depression of wells due to addition of fluoride at downstream wells)
Fluoride storage requirements	Minimum 30 day supply at average flow and design dose or 4,000 gallon truckload plus 1,000 gallon buffer.
Fluoride storage tank size	One 5,000 gal tank.
Fluoride storage tank type	Double-contained cross-linked polyethylene
Fluoride feed building type	CMU block building, mechanically ventilated
Fluoride feed building size	24 ft x 30 ft
Metering pump type	Hydraulically actuated diaphragm
Metering pump maximum flow range	Approx. 0.52 to 6.3 gallons per hour (gph)
Fluoride injection location	New manhole near existing chlorine and caustic soda injection manholes. Feed pipe to be double contained schedule 80 PVC.
SCADA requirements	Existing SCADA to be modified
Fluoride residual measurement	Fluoride analyzer with sample piping tap at current pH analyzer tap

Table 8 – Well Sites Design Criteria (Phase 2)

Description	Criteria
Fluoride chemical form	Fluorosilicic Acid
Well flow rate	1.5 MGD (Todd Road) to 2.0 MGD (Sebastopol Road and Occidental Road)
Design fluoride dose	0.7 mg/L
Fluoride storage requirements	Minimum 10-day supply at design flow and dose, target 14-day supply
Fluoride storage tank type	Double-contained cross-linked polyethylene
Fluoride storage tank size	100 gallons
Fluoride building type	CMU block building (or alternate prefabricated fiberglass), mechanically ventilated
Fluoride building sizes (ID)	Maximum 6' by 8'
Metering pump type	Solenoid actuated diaphragm
Metering pump design flow rate	0.16 gph (Todd Road), 0.27 gph (Sebastopol Road) 0.19 gph (Occidental Road)
Fluoride injection location	Well discharge piping, exact location to be determined. Feed pipe to be double contained schedule 80 PVC.
Fluoride mixing requirement	Fluoride fed neat. Wafer-type static mixer may be required depending on individual site conditions.
SCADA requirements	Existing SCADA to be modified
Fluoride residual measurement	Fluoride analyzer to be provided at each well site

Phase 1: Wohler and River Road Facilities – Design Criteria and Facility Improvements

Civil Design

The civil design mainly consists of locating the new Fluoride Building, and locating injection, potable water (PW), and utility water (UW) piping to and from the building at each site. Site work involved at either site will consist of preparation of the site for installation of the building, yard piping, contractor's laydown area, and restoration of the site paving surrounding the building and over all newly constructed piping and electrical trenches. General civil design criteria will be per the following:

• Trench/Building Site Restoration Paving:	3-1/2" minimum asphaltic concrete (AC) top layer with 9" minimum aggregate base (AB) layer in areas with existing AC pavement. 9" minimum aggregate base (AB) layer in areas with existing gravel paving.
• All Buried Piping:	Traffic areas - minimum 36" cover Non-traffic areas - minimum 24" cover Non-traffic areas - concrete encase when less than 24" of cover
• PW / UW Piping:	Schedule 80 PVC
• Chemical Piping:	Schedule 80 PVC pipe inside PVC containment pipe

Location and Siting

The new concrete masonry unit (CMU) Fluoride Building will be located adjacent to the existing Caustic Building at each site. The buildings will be sited and oriented to be conducive to chemical deliveries.

The buildings will be suitably sized to house the storage tank and equipment. Each building will have a separate electrical room which will house electrical and any control related equipment not required to be inside the chemical storage room to reduce the risk of corrosive fumes from attacking the equipment.

A contractor's staging area will be provided at each site, and will have a site specific location that will be determined during final design.

Site Piping

At each site new double contained piping is required from the new Fluoride Building to the points of injection. The site piping will be schedule 80 PVC piping within a schedule 80 containment pipe, and it will be buried.

Floor sumps in the Fluoride Buildings will be provided at the tank floor level to contain spilled chemical. To minimize risk, storage of chemical will be double contained through the use of double-walled tanks, and piping to and from the metering pumps will be double contained to the extent practical.

A single potable water service pipe will be supplied to each Fluoride Building, and a backflow preventer will be provided to isolate UW from PW. The PW is assumed to be routed from existing service at the site. PW will be the supply water for the emergency eyewash and shower only, and UW will be made available to allow flushing of the metering pump skids for maintenance.

Process Design

Dosing and Monitoring

Fluoride will be injected in the site's transmission pipeline near the existing chlorine injection point. A new precast concrete vault will be constructed adjacent to the existing injection vault at the Wohler Facility, with the fluoride and chlorine injectors separated from the caustic soda injector. A new precast manhole will be constructed near the existing injection manholes at the River Road Facility for the fluoride injection. Injection must occur downstream or significantly upstream from magnetic flow meters to avoid inaccurate meter readings caused by inadequately mixed fluid passing through the meters. The fluorosilicic acid is heavier than water and will impact the meter's sensor readings if not fully in solution. The location of existing flow meters should not be of concern but should be confirmed in the next phase of design. At the Wohler and River Road locations, the larger diameter pipes should allow for use of injection quills that project into the pipelines approximately one-third of the diameter. This will allow for dilution of the chemical to avoid damage to the pipe walls. Dosing calculations are based on transmission pipeline water flow rates for each site. **Table 9** shows the fluoride requirements for each site.

Both sites will be equipped with continuous, online analyzers to measure the fluoride concentrations downstream from injection. This equipment will provide for accurate chemical feeding and recordkeeping and also provide another level of protection against overfeeding of fluoride. The fluoride concentration signal will be tied into each facility's supervisory control and data acquisition (SCADA) system in the future for remote monitoring of status and alarms. The analyzer model will not use reagents.

The analyzers should receive the samples of treated water from a sample point as close as possible to the injection locations at each plant to minimize the lag and response time for operator intervention in case of a misfeed situation. However, the sample point also needs to be located such that there is assurance that proper mixing has occurred throughout the entire area of the pipeline/conduit. A distance of approximately 50 pipe diameters downstream of the furthest injection point is recommended in a straight run of pipe.

Both sites have existing sampling stations that are used to continuously monitor the chlorine residual and pH. These sampling stations may be ideal for fluoride sampling upon verification that they are adequately downstream from the planned fluoride injection points.

Utility Water/Carrier Water

Utility water connections should be provided adjacent to fluoridation systems. Utility water will be needed to flush piping systems and for possible wash-down requirements. Wash-down water will routed to piping from existing chlorination facilities.

Injection piping runs are relatively short; therefore, carrier water will not be used and the fluoridation chemical will be fed undiluted ("neat").

Equipment

Metering Pumps

Chemical metering pumps will be provided for the chemical feed system at each site. Metering pumps will need to be manufactured from materials that are compatible with H2SiF6. Compatible materials include hastelloy C, polyvinylidene difluoride (PVDF), PVC, Viton, Hypalon, Teflon, rubber, and polypropylene.

The metering pumps used are of the motorized hydraulic diaphragm type. Motorized mechanical and hydraulic diaphragm type metering pumps are the typical pump type for dosing H2SiF6 at the larger flow rates required at similar sized water treatment facilities for many other agencies. The available capacities of this type of pump are suitable for both sites.

Each site requires one duty and one standby metering pump, capable of the turndown required to deliver the required dose for the entire flow range. Pump capacity requirements are shown in **Table 9**.

For the Wohler Facility, the total H2SiF6 flow range per metering pump at the required 0.7 mg/L dose is from 0.51 gallons per hour (gph) minimum to 4.1 gpm maximum, for a total turndown of approximately 8:1. For the River Road Facility, the total H2SiF6 flow range per metering pump at the required 0.7 mg/L dose is from 0.52 gph minimum to 6.3 gph maximum, for a total turndown of approximately 12:1.

Each metering pump will have variable frequency drive and manual stroke adjustment. With variable frequency drive in combination with the manual stroke adjustment, pump turndown can be as much as 40:1, which would more than cover the turndown required. Manual stroke may be adjusted to reduce maximum flow capacity and prevent the metering pump from overdosing H2SiF6. Moreover, the same model metering pump can be used at both sites, which simplifies spare parts and interchangeability. Hydraulic diaphragm pumps are recommended to accommodate the transmission pipeline pressures of up to 210 psi into which they will discharge. Evenly distributed pressure from the hydraulic reservoir used to actuate the diaphragm allows very high discharge pressure. The pumps are made by several manufacturers including Prominent and Pulsafeeder.

Table 9 – Fluorosilicic Acid Dosing and Monitoring

Facility	Flow Type	Fluorosilicic Acid Dosing Calculations[1]									Metering Pump Capacity		Storage Requirements	
		Daily H2O Production (gpm)	Daily H2O Production (MGD)	F Dosage Required (mg/L H2O)	Natural F Detected (mg/L H2O)	F Dosage Needed (mg/L H2O)	LB F/DAY Dosage	LB Solution per DAY	GAL Solution per DAY	Nominal GAL Solution per Hour	Required Range MIN GPH	Required Range MAX GPH	Bulk Liquid (gallons)	Days of Storage
Wohler (Santa Rosa AQ)	Min Day	3,472	5.00	0.70	0.170	0.53	22.2	122	12	0.51	0.51	-	5,000	411
	Avg Day	16,146	23.30	0.70	0.170	0.53	103.4	568	56	2.4	-	-	-	88.5
	Max Day	27,778	40.00	0.70	0.170	0.53	177.9	977	97	4.1	-	4.1	-	51.5
River Road (Cotati Intertie)	Min Day	3,472	5.00	0.70	0.150	0.55	22.9	126	13	0.52	0.52	-	5,000	399
	Avg Day	24,242	34.90	0.70	0.150	0.55	160.1	879	87	3.6	-	-	-	57.2
	Max Day	41,667	59.80	0.70	0.150	0.55	275.2	1,511	150	6.3	-	6.3	-	33.3
Occidental Road Well	Max Day[2]	1,388	2.00	0.70	0.200	0.50	8.3	45.8	4.6	0.19	-	0.19	100	22.0
Sebastopol Road Well	Max Day[2]	1,388	2.00	0.70	0.000	0.70	11.7	64.1	6.4	0.27	-	0.27	100	15.7
Todd Road Well	Max Day[2]	1,042	1.50	0.70	0.140	0.56	7.0	38.5	3.8	0.16	-	0.16	100	26.1

[1]Fluorosilicic Acid (H2SiF6) Properties
- mw (H2SiF6) – 144.08
- mw (H2O) – 18
- F Available (%) – 79.2
- Solution Strength (%) – 23
- Density (g/ml) – 1.2047; (lb/gal) – 10.05

[2]Max Day indicated for well pumps since they operate at a single constant flow rate.

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Storage Tanks

Compatible materials for the chemical storage tanks include fiberglass reinforced plastic (FRP), and cross-linked high-density polyethylene (XLHDPE). The expected lifetime of XLHDPE for this application is approximately 10 years. FRP tanks will be slightly (approximately 20 percent) higher in cost, but the tanks are field-repairable and should have a longer usable life. However, only XLHDPE tanks are available in a double contained construction arrangement, which simplifies building construction by eliminating the need for a chemical containment sump and thereby reduces project cost. Therefore XLHDPE has been selected for tank material.

A minimum of 30 days storage capacity based on design dose and future (2035) average daily flow is recommended for storage tank sizing. Additionally, it is recommended that each tank be sized to accept a complete 4,000-gallon delivery from a bulk tanker truck, with an additional storage buffer of 1,000 gallons minimum. Each tank will have a magnetic sight indicator to allow easy checking of the level inside, which may also be used to compare with the ultrasonic level indicator. The ultrasonic level indicator will have local display readout to cover the entire volume range of the tank. Since the amount of chemical stored indoors is above 500 gallons, an active fire suppression system within the building is required.

For the storage requirement at each site, see **Table 9**. Tank capacities will be 5,000 gallons at both sites to maintain the desired days of storage under future flow conditions and accept full bulk tanker truck deliveries. The tanks to be installed at each site and the corresponding days of storage are also shown in **Table 9**.

Process Piping

Process piping will be a double contained system of schedule 80 PVC carrier pipe within schedule 80 PVC containment pipe, from the metering pumps to the point of injection. Schedule 80 pipe is recommended to accommodate the transmission pipeline pressures of up to 210 psi.

To prevent the atmosphere from becoming corrosive, ventilation piping on the fluoride system will not be allowed to terminate inside the building. All vent piping shall penetrate the roof or wall, and terminate outside. Vent pipe scrubbing is not a regulatory requirement, but a passive water bath type fume scrubber may be provided to reduce acid fume exhaust during tank refills if desired, and can be addressed during final design.

Electrical and Instrumentation Design

The electrical and instrumentation design criteria will be industrial, heavy duty style and will match existing installations at the Water Agency facilities.

Power and Grounding

All required power will be drawn from existing power distribution equipment. An uninterruptible power supply (UPS) will be provided for the PLC and HMI. It is understood that the existing River Road service is 208V, 3-phase and the existing Wohler service is 480V but should be evaluated for sufficient capacity in the next phase of design. Any new electrical design shall meet the latest National Electric Code (NEC) requirements. Equipment shall maintain working clearances per the NEC. The electrical equipment shall meet applicable standards of National Electrical Manufacturer's Association (NEMA) and be Underwriters Laboratories (UL) rated. In general, the design will be heavy duty industrial with emphasis placed on safety, reliability, maintainability, and economics. Electrical enclosures will be NEMA 4X fiberglass, unless otherwise noted. Areas designated as splash proof will have the same requirements as outdoor locations except the enclosure will be NEMA 4X. The 480 volt distribution panel boards and 208Y/120 volt lighting panel boards shall use molded case, bolted in place circuit breakers. Asymmetric short circuit ratings shall be panelboards (480 volts) 65,000 Ampere Interrupting Current (AIC) and (120/208 volts) 22,000 AIC.

Grounding shall conform to NEC Article 250. Grounding loop conductors will be bare annealed copper conductors suitable for direct burial. Conductors will be No. 4/0 unless sized otherwise on contract drawings. Ground rods will be 3/4 inches diameter and 10 feet long. Connection to ground electrodes and ground conductors will be exothermic welded where concealed, and will be bolted pressure type connections where exposed. There will be a grounding electrode system that ties into the existing grounding system. For new buildings, a ground ring of rods and cables encircling the building will tie into embedded cables in foundation slabs (Ufer ground). The grounding system will provide a maximum resistance to ground of 1 ohm.

Conduit and Cable Requirements

All exposed conduits shall be PVC-coated galvanized rigid steel, ¾ inches diameter minimum. All underground conduits shall be non-metallic Schedule 40 PVC, 1 inch diameter minimum, embedded in sand with a minimum of 24 inches cover. Flexible conduit will be liquid tight with integral ground. Electrical metallic tubing (EMT) will not be permitted. All electrical raceway hardware and fittings will match conduit materials. Where conduit emerges from underground or from concrete encasing to exposed, a PVC coated galvanized rigid steel elbow will be used for the transition, and PVC coated galvanized rigid steel conduit will be routed 18 inches minimum above the floor. All conduit systems will be installed with full length insulated copper grounding conductor, sized in accordance with NEC Article 250.

Wire fills will not exceed 40 percent of the allowable per Table 4, Chapter 9, of the NEC. This table is for Schedule 40 PVC and shows the basis for conduit cross sectional area for all wiring on the project, since it has the smallest available cross section for all types of conduit. All power and control wiring shall be XHHW insulation rated 90 degrees Celsius (°C), copper conductors. Aluminum or non-stranded wire will not be permitted. Wire size for power and lighting circuits will not be smaller than No. 12 American Wire Gauge (AWG). Control wiring will not be smaller than No. 14 AWG. Instrumentation cables will be composed of the individual conductors, No. 16 AWG, an aluminum polyester foil shield, a No. 20 AWG stranded tined copper drain wire, and a PVC outer jacket rated 600 volts. Shielded instrumentation cable will be grounded at one end only; this will typically be at the "receiving" end of the signal carried by the cable at the Programmable Logic Controller (PLC) Panel. Cable identification shall be "ZZY 1" where ZZ: Source equipment number per Cable Schedule, Y = P for power, C for control (120 volts), J for instrument (low level DC).

Power conductor identification shall be color coded as shown in **Table 10**.

Table 10 – Power Conductor Identification

	240/120 Volts	208Y/120 V	480Y/277 V
Phase A	Black	Black	Brown
Phase B	Red	Red	Orange
Phase C		Blue	Yellow
Neutral	White	White	Gray
Ground	Green	Green	Green

Lighting and Receptacles

Lighting will be designed in compliance with the energy conservation standards set forth in the California Administrative Code Title 24. Below 12-foot mounting height, fluorescent, energy saving fixtures with T-5, 32 watt, 48 inch white color lamps with electronic ballasts will be used. Fixtures will be enclosed and gasketed. Maintained illumination levels of the Fluoride Buildings will be 30 foot-candles for indoor areas, and 0.5 to 1.0 foot-candles outdoors. Indoor areas will have switched circuits with a minimum number of non-switched lighting fixtures for personnel safety. Lighting circuits will be 120 volts. Emergency and exit lights will be provided per NEC, and National Fire Protection Association (NFPA) 101. Emergency lights will be hard wired. Outdoor lighting will incorporate architectural poles and high cutoff type luminaries. No lighting of grassy areas or landscape lighting will be done.

Receptacles will be spaced such that any location can be accessed with a 25 foot extension cord in all areas. Covers will be hinged and weatherproof in damp and outdoor areas as per the NEC. All exterior receptacles shall be protected from ground faulting by a ground fault circuit interrupter (GFCI) breaker.

Motors

Motors less than 1/2 horsepower (hp) will be 115 volts and single phase, unless otherwise specified. Motors greater than 1/2 hp will be 460 volts and three phase, unless otherwise specified. Motors will be totally enclosed fan cooled (TEFC) unless otherwise specified. All motors will be "premium efficiency" and rated for 1.15 service factor, class F insulation without exceeding class B temperature rise. Motor specifications shall state copper windings only.

Instrumentation and Special Systems

Instrumentation design shall be governed by the Instrumentation Society of America (ISA).

Individually wired analog loop signals transmitting data between field devices and control panels will be 4-20 milliamps (mA). Each control circuit and loop will be individually fused. All instruments provided will be calibrated according to manufacturer's recommended procedures.

Each instrument will be calibration checked at 0, 10, 25, 50, 75, 90, and 100 percent of span with test instrument accuracy according to the National Institute of Testing Standards.

Instrument types shall be defined by process measurement and service as shown in **Table 11**.

Table 11 – Instrumentation Requirements for Wohler and River Road Facilities

Process Measurement	Service	Instrument Type
Level - Continuous	Fluoride storage tanks	Ultrasonic type
Level switches	Chemical containment pipe	Mercury free, level detection
Fluoride residual	Finished potable water	Ion-specific fluoride sensor
Flow switches	Emergency Showers	Liquid flow, 316 SS
Pressure switches	All	Diaphragm type, adjustable set point, fixed deadband
Gauge seals	Water Chemicals	Annular seal Diaphragm type

Preferred engineering units for process parameters are as shown in **Table 12**.

Table 12 – Preferred Engineering Units for Process Parameters

Parameters	Units	Abbreviations
Level (elevation or absolute)	Foot/feet	ft
Volume	Million gallons	MG
	Gallon(s)	G
Flow Rate	Million gallons per day	mgd
	Gallons per minute	gpm
Pressure	Pounds per square inch gage	psig
	Feet (or inches) of water	ft (in) of H_20
Concentration	Parts per million	ppm
	Milligrams/liter	mg/L
Mass or weight	Pound(s)	lb

Indicating light colors will be as follows:

- Power on - white
- On/running/energized - red
- Off/stopped/deenergized - green
- Caution conditions - amber
- Abnormal/alarm condition - amber (flashing)

There will be no closed circuit television (CCTV), intercom, or telephone system design except as an extension of an existing system if required. Intrusion alarms will be limited to magnetic switches on the man-doors, and series connected to a digital input on the PLC. Fire alarm systems will be designed where automatic fire suppression systems are required.

PLC and SCADA Requirements

PLC and SCADA equipment will match Water Agency current standards. Interlocks deemed critical to the protection of personnel and major equipment will be hardwired for continuous protection regardless of local and SCADA operation. In general, hardwired interlocks will be implemented through fail safe logic, and isolated alarm contacts from the interlock device will be provided to the PLC system. Non critical interlocks will be implemented via PLC logic. Local control stations or control panels will be provided near the equipment, including a hand-off-auto (HOA) and local-remote (L/R) selector switches. For metering pumps, direct current Silicon Controlled Rectifier Drives (SCR Drives), with a local speed potentiometer will be provided on the control panel.

The control panels will include “running” and “power on” status indicating lights.

The interface between the motor controls and the PLC will be via hardwired inputs and outputs. The motor control center (MCC)/PLC interface will use interposing relays solely for the purpose of voltage conversion and isolation. Existing spare PLC inputs and outputs will be used where available. Typically, SCADA will monitor the following items for each motor controlled device:

- Run status
- Local (L/R) status
- Auto (HOA) status
- Motor fault status

Fire System monitoring and smoke detector alarms will be hardwired to the PLC and available at SCADA.

Chemical Monitoring and Control

The fluoride metering pumps at the Wohler and River Road Facilities will be flow paced off total flow through the site's treated water transmission pipeline. The metering pump speed will be adjusted based on fluoride residual analyzer feedback versus desired set-point. Fluoride metering pumps can be started and operated locally from the pump's control panel or automatically from the plant's PLC. A local HMI shall be provided for pump control. Pump stroke can only be set locally. The fluoride metering pumps will start based on commands from the PLC, originating from the following permissives:

- Pump is "Ready" based on the field Start/Stop hand switch in "Auto," and field Speed Control hand switch in the "Remote" position. "Ready" status is viewable at SCADA.
- Pump is in "Lead" position based on PLC auto alternation logic. "Lead" position is viewable at SCADA.
- PLC "Call to Start" is given.
- The Fluoride Metering Pump speed command will come from the PLC based on desired dosage and expected residual. Speed will be flow-paced controlled and trimmed based on feedback from fluoride analyzer.

The fluoride system at the Wohler and River Road Facilities will include the following points connected to the PLC for monitoring and control:

- Metering Pumps – Auto status, Remote Speed status, Running status, Fault alarm, Diaphragm Leak alarm, Metering Pump Start command, Metering Pump Speed command signal, Metering Pump Speed feedback
- Fluoride Storage Tanks – Tank Level continuous signal
- Fluoride Residual – Fluoride ppm continuous signal
- Miscellaneous – Fluoride Storage and Feed Room Flood alarm, Storage Tank rate of change alarm (SCADA-derived), Fluoride Storage and Feed Room intrusion alarm, fire system alarm, HVAC smoke detector alarm.

Testing and Start-Up

The contractor will be required to perform installation checks per manufacturers' written instructions. The contractor must test all power and control wiring below 600 volts with a 500 volt megger. Minimum acceptable megger resistance is 20 mega-ohms. The contractor must test ground resistance of each grounding electrode system to determine compliance with the 1 ohm specified. The contractor must test all GFCI receptacles and circuit breakers for proper connection and operation. Acceptance tests will be per current InterNational Electrical Testing Association (NETA) Acceptance Test Specifications, including cables, circuit breakers, metering, grounding systems, and ground fault protection. The contractor must conduct an operational test of all control systems and electrical equipment in the presence of the field engineer or Water Agency representative. All non-witnessed tests will be considered invalid.

Architectural Design

The architectural design criteria will result in creating a safe, low maintenance, highly functional facility that will be acceptable to Water Agency, and suitable for the water treatment facility location.

Functionality and Space Planning

The primary purpose for the Fluoride Buildings at each site is to house the chemical equipment to provide shelter from the weather, to create a controlled interior environment, and to provide for visual screening of the pumps, motors, and equipment.

There will be a specific floor plan for each Building that will be based on the space requirements needed for the equipment, the clearances necessary for access and egress, local topography, and monitoring and maintenance for use. Potential functional spaces include a Chemical Room and an Electrical Room. It is assumed that the feed facilities will not be open to the public, and access will be limited to trained and authorized Water Agency personnel for occasional monitoring and maintenance of equipment. Roofs will be designed with removable sections to allow replacement of chemical storage tanks.

Code Compliance

The Fluoride Buildings will meet the most current versions of the California Building Code and the International Fire Code (IFC). Occupancy will be H-4 Hazardous Occupancy when the total indoor storage of H_2SiF_6 which is classified as a corrosive is more than 500 gallons.

Handicapped Accessibility

The Fluoride Buildings will not be open to the general public and full handicapped accessibility is not expected to be required. However, to comply with the minimum requirements of the Americans with Disabilities Act, “approach, enter, and exit provisions” will be considered in the design.

Building Materials

Each proposed Fluoride Building will consist of a combination of formed concrete and CMU block building construction on a structural concrete slab foundation, with drilled concrete piles at the River Road facility. To match existing building construction, the roof will be sloped metal decking with a composition roofing shingle overlay. A corrosion resistant coating will be applied to all interior exposed decking and steel framing to protect all steel work from the potentially corrosive interior environment.

HVAC, Plumbing and Fire Protection Design

The purpose of this section is to establish the appropriate heating, ventilation, and air conditioning (HVAC), plumbing and fire protection configurations to meet the following objectives:

- Provide an operable, maintainable, and economical HVAC system design that meets all code requirements.
- Provide building plumbing and fire protection systems design that conforms to the requirements of all codes and standards and any supplementary requirements of the authorities having jurisdiction.

HVAC Design

The HVAC design of the Fluoride Buildings will be based on the most recent version of the standards set forth below.

Governing Codes and Standards

- California Building Code
- International Fire Code with County Amendments
- Uniform Mechanical Code with County Amendments
- Uniform Plumbing Code with County Amendments
- NFPA 90A Air Conditioning and Ventilating System
- NFPA 13 Fire Sprinkler Systems, Installation
- NFPA 70, National Electrical Code
- Occupational Safety and Health Administration (OSHA)

Design References

- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbooks – Latest Editions – Fundamentals, Systems, Equipment
- ASHRAE Std. 62.1- 2004 Ventilation Systems
- Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA) Duct Design Standards - Latest Edition
- Industrial Ventilation - Latest Edition

Design Methods and Assumptions

- Exhaust fans will be located on the roof.
- HVAC design will be based on outdoor temperatures in winter of 30 degrees Fahrenheit (ºF) and in summer of 100ºF dry bulb and 70ºF wet bulb.
- Minimum ventilation rates cited as air changes per hour (ACH) are code required outdoor supply air.

- HVAC equipment, ductwork, and air distribution devices serving corrosive areas will have protective coatings and/or will be constructed from corrosion resistant materials such as fiberglass reinforced plastic (FRP).
- A portable overhead ventilation system will be provided to facilitate maintenance work on pumps and piping.
- Control systems will be of the direct digital control type, as required to accomplish system sequences. Control panels in outside areas, wet areas, or corrosive areas will be corrosion proof, NEMA 4X, 316 stainless steel.
- All electric motors will be high efficiency types, where available.
- All heating units will be gas-fired or electric heat, as indicated in this report.

Service Categories

Fluoride Buildings will be ventilated with a minimum of 12 ACH when the indoor temperature is above 45ºF, and with a minimum of 6 ACH when the indoor temperature is 45ºF or lower. Upon leak detection the buildings will be ventilated with a minimum of 30 ACH under any indoor temperature scenario.

Airflow Velocities

- Louvers face velocities not more than 500 feet per minute (fpm).
- Exhaust duct velocities of approximately 1,000 to 1,500 fpm.
- Ventilation duct velocities of approximately 750 to 1,500 fpm.
- Tempered air duct velocities of approximately 600 to 1,200 fpm.

Environmental

Outside design conditions:

- Summer: 100ºF (Dry-Bulb), 70ºF (Wet-Bulb)
- Winter: 30ºF
- Elevation: 70 feet above sea level

HVAC Equipment

Will supply 100-percent outside air into the motorized intake louvers. The amount of supply air will be calculated based on maintaining the number of ACH when required based on the indoor temperature, and upon leak detection the buildings will be ventilated with a minimum of 30 ACH under any indoor temperature scenario.

Controls

Self-contained thermostat control loops will be included for ventilation fans. A fluorosilicic acid leak detector connected to ventilation system will be provided as applicable. Upon activation of the leak detector the ventilation system will run at high speed to maintain a 30 ACH.

Materials of Construction

- Exposed ductwork in process areas will be FRP, PVC, or stainless steel with 316 SS supports.
- Ventilation fans will be of FRP or stainless steel construction.
- Electric motors less than ½ horsepower will be 115 volts and single phase. Motors ½ horsepower and greater will be 460 volts and three phase. Motors will be totally enclosed fan cooled (TEFC), premium efficiency, and rated for 1.15 service factor, class F insulation without exceeding class B temperature rise.

Basis of Design for Fluoride Facilities

Heating for the indoor areas of the Fluoride Buildings will be via gas-fired or electric unit heaters. Indoor design criteria are presented in **Table 13**. Refer to the Indoor Heating Design Criteria and Ventilation Requirements tables (**Tables 14 and 15**) for basis of design regarding ventilation rates and heating requirements for Fluoride Buildings. Criteria are derived from referenced governing codes and standards.

Table 13 – Indoor Heating Design Criteria

	Temperature (degrees Fahrenheit)			
Area Designation	**Summer**	**Winter**	**Relative Humidity (percent)**	**Noise (maximum) (NC)**
Fluoride Storage	95	45	Not applicable	57

Fresh air ventilation rates are presented in **Table 14**.

Table 14 – Ventilation Requirements

Area Designation	Minimum Total Air Volume	Percent Outside Air	Room Pressurization
Fluoride Storage	12 ACH when room temperature is above 45 degrees Fahrenheit 6 ACH if room temperature Drops below 45 degrees Fahrenheit	100	Negative

Ventilation Method:

- Continuous via intake air louvers, exhaust through roof mounted FRP axial fan. The exhaust fan will be variable speed to conserve energy and will be interlocked with the room thermostat and fluorosilicic acid leak detector.
- The fresh air requirement will be calculated according to ASHRAE requirements for ventilation air.

The environments of the Fluoride Building indoor area is considered “corrosive”. Ductwork will be fiberglass reinforced plastic air ductwork. Smoke detection will be used if applicable, and in the event of a smoke alarm, the duct smoke detectors will shut down the HVAC system, sound a local alarm, and send a signal to SCADA.

Equipment Selection

Table 15 presents acceptable manufacturers for the equipment in this section.

Table 15 – Acceptable Ventilation Equipment Manufacturers

Equipment	Manufacturer
Fans	Greenheck, Penn, NY Blower, Cook
Louvers	Ruskin, Greenheck, Industrial Louvers, Inc.
Heaters	Choromalox, Reznor, Markel
Grilles, registers, diffusers	E.H. Price, TItus

Plumbing Design

The plumbing design of the Fluoride Buildings will be based on the most recent version of the standards set forth below.

Codes, Standards and Regulations

- International Plumbing Code
- International Fire Code
- National Fire Code (NFPA)

General Standards

- Water pressure from the potable water system to the buildings should be a minimum of 50 pounds per square inch gage (psig).
- Separate metered and reduced pressure zone backflow protected water services will be required for potable building water and fire protection.

- Light duty hose valves for building interior and exterior wash down will be 3/4-inch globe valves with hose thread adapters.
- Medium duty hose valves for interior and exterior wash down will be 1-inch globe valves with hose thread adapters.
- Hose valves subject to freezing will be non-freeze types.
- A minimum of two hose valves per wall will be provided in process areas.
- Floor drains and hub drains that are infrequently used will have primed P-traps. The water source for trap priming will be protected by a reduced pressure zone backflow preventer.

Potable Water (PW)

- Pipe 3-inch and smaller, above floor: Type K copper tube with soldered fittings.
- Pipe 3-inch and smaller, below floor: Type K copper tube with soldered fittings.

Non-Potable Water (UW)

- Downstream from reduced pressure zone backflow preventer.
- Pipe 3-inch and smaller, above floor: Type K copper tube with soldered fittings.
- Pipe 3-inch and smaller, below floor: Type K copper tube with soldered fittings.

Sanitary Drain (SD)

- Above floor: Hubless cast iron soil pipe.
- Below floor: Hub and spigot cast iron soil pipe.

Sanitary Vent (SV)

- Above floor: Hubless cast iron soil pipe.
- Below floor: Hub and spigot cast iron soil pipe.

Wet Pipe Fire Sprinkler System

- All sizes: Schedule 40 black steel pipe; painted.

Building Plumbing Fixtures and Equipment

- Safety showers/eyewashes will be Speakman, Haws, or equal.
- Piping interior service valves, 2-inch and smaller, will be ball valves; 3-inch and larger will be gate valves.
- Floor drains, roof drains, and cleanouts will be JR Smith, Josam, or equal.

Safety Showers/Eyewashes

- Combination safety shower/eyewash units will be installed in all chemical areas.
- Access to these units will be unobstructed.
- At least one self-contained breathing apparatus (SCBA) will be provided near the entrance to each building.
- Design and installation of the emergency shower/eye wash systems will meet the requirements of ANSI Z358.1-2004.
- The emergency shower will deliver 20 gpm of 80ºF tempered water, for 15 minutes at 30 psig.
- The emergency eye wash will deliver 0.4 gpm of 80ºF tempered water, for 15 minutes at 30 psig.

Cross Connection Control

- Cross connection control will be provided in accordance with the Plumbing Code.

Backflow Preventers

Reduced pressure zone backflow preventers will be installed for the following items, as a minimum:

- Main building potable water service
- As separation between PW and UW
- Fire protection water

Backflow preventers that are located outside will be placed within an insulated enclosure.

Fire Protection Design

The fire protection design of the standardized Fluoride Buildings will be based on the standards set forth below. H-4 High Health Hazard Occupancy rated buildings will require an automatic fire protection system.

Fire Protection Systems

- Hydrant locations - to be determined.
- Sprinkled locations and systems – Fluoride Storage and Feed rooms.
- Dry chemical extinguishing locations and systems - to be determined.
- Portable fire extinguishing locations - to be determined.

Design, layout, and installation of all required fire protection systems will be the responsibility of the fire protection contractor. Fire protection drawings will show fire sprinkler water supply into each building, the location of fire sprinkler risers, and fire department connections.

Performance specifications for automatic fire sprinkler systems will be provided and will list in detail the building to be protected, type of fire sprinkler systems, and design criteria for each building fire sprinkler system. Design criteria will include the building hazard occupancy rating, gpm/square foot density rating, and area of sprinkler operation. In addition, specifications will include all equipment and material required for each fire protection system.

All building fire protection design requirements will be coordinated with the authorities having jurisdiction prior to completion of building design.

Structural Design

The structural design of the Fluoride Buildings will be based on the standards set forth below, and the requirements of the other disciplines as determined throughout the coordination of the design.

Structures will have a steel joist roof system supported by concrete and/or concrete masonry unit wall systems. The roof joists shall be coated, primed and painted for steel protection against corrosion. Roof hatches will be provided to allow replacement of chemical storage tanks.

Design Calculations, Methods, and Assumptions

Calculations will be performed in accordance with the MWH Best Practices – Structural Calculation Procedures. A table of contents shall be included for each set of calculations greater than five sheets long. Half-size plots shall be included at the front of each set of calculations.

All structures will be designed in accordance with sound engineering principles based on the references listed below.

Concrete structures shall be designed using the phi factors from Chapter 9 of ACI 318.

Design References

2010 CBC	California Building Code
IBC-2012	International Building Code
ACI-31808	Building Code Requirements for Reinforced Concrete
ACI 530	Building Code Requirements for Masonry Structures
ACI 530.1	Specifications for Masonry Structures
ASCE 3	Composite Slabs

ASCE 7-05	Minimum Design Loads For Buildings and Other Structures
AISC 360-05	Manual of Steel Construction
AISI S100-07	AISI Specification for the Design of Cold-Formed Steel Structural Members
AA	Aluminum Association - Aluminum Design Manual
NDS	National Design Specification (NDS) for Wood Construction, Including Supplements
PS-20	American Softwood Lumber Standard
PS-1	Softwood Plywood - Construction and Industrial
AITC A 190.1	American National Standard for Wood Products - Structural Glued Laminated Timbers
MWH	Design Quality Procedures (DQP) Database
Moody	Moments and Reactions for Rectangular Plates - Engineering Monograph No. 27 - U.S. Bureau of Reclamation (USBR) - W.T. Moody - Reprinted 1986

Loading

The following load criteria will be used for design of the Fluoride Buildings, and any miscellaneous structures to which they may apply.

Live Loads

Roof:	20 psf for slopes with less than a 4-inch rise to 12-inch run
Stairs, Landings and walkway:	100 psf
Floor:	100 psf

Building Classification

All structures: III

Building Classification

Site class:	D**
Mapped spectral response acceleration at short periods (0.2 sec) – 5 percent damping (Ss):	1.50g**

Mapped spectral response acceleration at 1 second period - 5 percent damping (S1):	0.6g**
Importance factor (Ie):	1.25

** Seismic parameters are based on U.S. Geological Survey (USGS) seismic hazard map for the city of Forestville, California with an assumption that the site is classified as class D based on initial review of the map. Suitability of seismic parameter usage to all other sites will need to be verified by a geotechnical engineer at a later date.

Wind

Base wind speed – 3-second gust (V3s):	85 miles per hour (mph)
Exposure:	Exp C
Importance factor:	1.15

Geotechnical Information

The following geotechnical information (to be verified by the geotechnical engineer) is based on the most conservative allowable presumptive values permitted per the 2010 CBC. The following information will be used for design of the Fluoride Buildings, and any miscellaneous structures to which they may apply. The suitability of the geotechnical information for use will be verified at a later date by a Geotechnical Engineer.

MWH has recently received the geotechnical report used in the design of the River Road Corrosion Control Facility (Geotechnical Investigation, pH Adjustment/Corrosion Control Facility, 8001 River Road, Sonoma County, California, BACE Geotechnical, February 9, 1994). While a complete review of the report is outside the scope of the current work, MWH has been made aware that a geologic fault, classified as "potentially active" extends through the footprint of the proposed fluoridation building at the River Road site. During the next phase of the work, the building will need to be relocated on the site to avoid straddling the fault. Based on a preliminary review we believe the building can be constructed on the site if appropriate structural foundation features are incorporated. For current cost estimating purposes we have assumed a drilled pile foundation, similar to that used on the Corrosion Control Facility but with a 25-percent depth increase for contingency, will be used for the proposed fluoride building. A complete geotechnical evaluation and corresponding structural design will be completed in the next phase of the project.

Allowable Bearing Pressure

All loads (with wind and seismic):	2,000 psf
Dead plus live loads:	1,500 psf

Groundwater Elevation

100-year flood elevation:	River Road Facility = 78 ft (NAVD88), 81 ft +/- (NGVD29). Wohler Facility = TBD.

Other Parameters

Friction factor:	0.25
Moist weight:	120 pounds per cubic foot (pcf)
Buoyant weight:	60 pcf
Frost depth:	18 inches
Minimum footing width:	12 inches

Lateral Soil Pressure

	Above Groundwater (GW)	Below GW
Restrained (at rest):	90 pcf	120 pcf
Unrestrained (active):	45 pcf	85 pcf
Passive:	300 pcf	200 pcf

Safety Factors

The following safety factors will be used for design of the Fluoride Buildings, and any miscellaneous structures to which they may apply:

Buoyancy:	1.25
Overturning:	1.50
Sliding:	1.50

Structural Materials

The following structural material requirements will be used for design of the Fluoride Buildings, and any miscellaneous structures to which they may apply:

Concrete:	4,000 psi - Structural (all structural applications)
	3,000 psi - Sitework (curb, gutter, and civil applications)
	2,000 psi - Lean (unreinforced concrete (thrust blocks and encasements))
Reinforcing:	Grade 60 - all applications.

Steel:	Structural tubing - American Society for Testing and Materials (ASTM) A500, Grade B
	Structural pipe - ASTM A53, Grade B
	Wide flange shapes - ASTM A992
	Other standard shapes and plates - ASTM A36
Stainless Steel:	Type 304 - Architectural and common uses, and anaerobic conditions
	Type 316 - Submerged or corrosive areas
Aluminum:	6061-T6 - All applications.
Masonry:	ASTM C 90
	Light weight (less than 105 pcf)
	Special inspection required
	Solid grouted
	Grout - 2000 psi
	Mortar, Type S - 1,800 psi
	Size: 8-inches wide by 16-inches long x 8-inches High concrete masonry unit (CMU)
Gaskets:	Neoprene
Waterstops:	New construction - PVC MWH standard shapes

Weights of Materials

The following will be the assumed weights of materials for the design of the Fluoride Buildings, and any miscellaneous structures to which they may apply:

Concrete:	150 pcf
Steel:	490 pcf
Aluminum:	170 pcf
Fiberglass:	110 pcf

Special Inspections

Special inspections will be required during construction of the Fluoride Buildings, and any miscellaneous structures to which they may apply, including, structural welding, high strength bolting, concrete, bolts installed in concrete, reinforcing steel and prestressing, adhesive anchors/drilled anchors, and masonry.

Safety

Emergency Shower/Eyewash

An emergency eyewash and shower will be provided within the chemical storage and feed area inside the buildings as well as outside near the tank fill connection at each site, and will be located for quick access should an incident occur during routine chemical delivery activity or equipment maintenance.

Containment/Spill Control

The chemical at each site will be stored in double-wall tanks; therefore, a containment curb or wall is not required. The floor of the chemical storage and feed room will slope towards a sump.

A “spill kit” will be provided for each site consisting of the following items:

- Universal chemical absorbent (5-gallon bucket)
- Soda ash solution (5-gallon liquid container)
- Two generic spray bottles (containing soda ash solution)
- Litmus paper test strips
- Two tubes of acid neutralizing cream

It is assumed that Water Agency operator staff currently have the necessary clothing for handling hazardous materials; therefore, no additional protective wear will be provided.

Phase 2: Well Sites – Design Criteria and Facility Improvements

Civil Design

The civil design mainly consists of locating the new Fluoride Building, and locating injection, plant drain, and sample piping to and from the shed at each site. No substantial site work will be involved at any of the well sites other than preparation of each site for installation of the building, yard piping, contractor’s laydown area, and restoration of the site paving and/or landscaping surrounding the building foundation pad and over all newly constructed pipe trenches. It is assumed that the existing concrete truck unloading pads at the Wohler and River Road facilities will be used for delivering fluoride. New control/alarm panels and fixed piping to carry fluoride to the new buildings will be added.

General civil design criteria will be per the following:

• Site Paving:	3-1/2" minimum asphaltic concrete (AC) top layer with 9" minimum aggregate base (AB) layer in areas with prior AC pavement, otherwise 9" minimum AB layer
• All Buried Piping:	Traffic areas - minimum 36" cover Non-traffic areas - minimum 24" cover Non-traffic areas - concrete encase < 24" of cover
• Plant Drain Piping:	PVC ASTM D3034 SDR 35
• Sample and UW/PW Piping:	PVC, Schedule 80
• Chemical Piping:	Double contained Schedule 80 PVC

Location and Siting

The new CMU building enclosure will be provided at all well sites to house the chemical storage and metering equipment, and necessary appurtenances and controls. The enclosure will be located and oriented to be conducive to chemical deliveries and general operation procedures, and the particular site constraints at each well site.

The building will be suitably sized to house the storage tank and equipment, and allow enough room for an operator to stand inside the enclosure, warranting a 4 foot by 6 foot minimum footprint for each room within the enclosure. The basic electrical installation at each building will include lighting, a power receptacle, and an exhaust fan and louvers. Any control related equipment not required to be inside the building will be mounted in an integrated enclosure on the outside of the building to eliminate the risk of corrosive fumes from attacking the equipment.

Due to site constraints including small site acreage and limited security, it may not be possible to allocate a contractor's staging area for every site. This will be determined during final design.

Site Piping

New site piping from the building to the point of injection will be double-contained schedule 80 PVC pipe. The containment piping will be direct-buried, with a minimum cover described above.

It is assumed that the drainage from the fluoride analyzers will routed to the same locations as the existing chlorine analyzers. Typically, at sites which only have accessible storm drains or ditches, plant drain piping would connect to the existing drain system offsite, and dechlorination via replaceable activated carbon cartridge filters or dechlorination tablets would be required. At the sites with existing sewer piping, plant drain piping would be routed to the existing sewer system. This will need to be finalized upon review of the existing record drawing information and discussions with Water Agency.

Process Design

Dosing and Monitoring

H2SiF6 will be injected downstream from the main flow meter, but as far upstream as practical. Because of constraints related to short runs of exposed piping available for injection and sample point locations at the well sites, static mixers that are resistant to the corrosive effects of H2SiF6 may be used. As previously noted, the larger diameter pipes at the Wohler and River Road locations should allow for use of injection quills that project into the pipelines approximately one-third of the diameter and enable dilution of the chemical to avoid damage to the pipe walls. However, with the smaller diameter piping at the well sites it is assumed that a corrosion-resistant pipe spool will replace a section of existing pipe at each location.

Dosing calculations are based on water flow rates through the flow meter for each site **Table 9** shows the H2SiF6 requirements for each site.

All well sites will be equipped with continuous, online analyzers to measure fluoride concentrations downstream of the point of injection, and prior to water leaving the site. This equipment will provide the same benefits of accurate chemical feeding, recordkeeping, and protection from overfeeding of fluoride as for the Wohler and River Road Facilities. The fluoride concentration signals will be tied into each site's SCADA system for remote monitoring of status and alarms. The analyzer model to be used at all well sites will be the same as for the Wohler and River Road facilities.

The analyzers should receive the samples of treated water from a sample point as close as possible to the fluoride injection locations at each well site, yet the sample point also needs to be selected to ensure that proper mixing has occurred throughout the entire area of the pipeline/conduit.

Currently, existing sample piping is used for an existing chlorine analyzer at the well sites; this sample piping may also be used for the fluoride analyzer. Locations of the analyzers will be determined during final design after review of the record drawings for existing drain information.

Utility Water/Carrier Water

Existing nearby utility water connections and hoses should be adequate for maintenance needs. Utility water will be needed to flush piping systems and for possible wash-down requirements. If it is discovered that some sites do not have a connection, one will be added. Wash-down water will routed to piping from existing chlorination facilities.

No carrier water will be required at the well sites because injection piping runs are relatively short and the pump discharge to injection point time is short.

Equipment

Metering Pumps

Chemical metering pumps will be installed for the fluoride feed systems at each well site; the pumps must be manufactured of materials that are compatible with H2SiF6.

The metering pump type commonly used for smaller flows as typically used at well sites by many other water agencies is the solenoid drive type pump. Experience with this pump has proven it to be dependable and economical. The available capacities of this pump model are suitable for all well sites.

Each well site will require one metering pump. Metering pumps will be sized such that each pump will be capable of providing the full capacity required for its corresponding well site production. No standby pumps are required because the metering pumps are economical and are considered "disposable," and will be replaced upon diagnosis of any failure. Pump capacity requirements are shown in **Table 9**.

Pumps for the fluoride systems will be individually sized such that the maximum pump output is greater than, but as close as possible to the maximum chemical flow required, to reduce the risk of a pump overfeed.

Storage Tanks

As stated above for the Wohler and River Road Facilities, compatible materials for the chemical storage tanks include FRP and XLHDPE. A storage tank for each well site will be located inside the CMU building enclosure. Although FRP tanks can be repaired in the field, repairs would be difficult because the tank will be in such a small enclosure. The tanks also need to be double wall tanks, which are only available in XLHDPE; therefore, XLHDPE will be used. With a projected 10-year life of XLHDPE tanks, they will need to be replaced during the overall facility life. Therefore, roof hatches will be provided to allow the Water Agency to readily replace the tanks.

Tank storage capacity is based on daily maximum production rate for each well site, which is 7 days minimum, 14-days maximum capacity. Each tank will have an ultrasonic level indicator with local display readout to cover the entire volume range of the tank. For storage capacities of the tank at each well site, see **Table 9.** Capacities are based on the storage required and tank sizes available from manufacturers. Top-off chemical deliveries are typically made to the well sites on a weekly basis.

Process Piping

Process piping will be double-contained schedule 80 PVC at all well sites, except immediately after the pump and before the point of injection, where the carrier PVC will be routed within clear PVC pipe. All fasteners used within the building must be corrosion resistant to H2SiF6.

To prevent the building from having a corrosive atmosphere, any ventilation piping will penetrate the building wall or roof, and terminate outside.

Electrical and Instrumentation Design

The electrical and instrumentation design criteria will be industrial, heavy duty style and match existing sodium hypochlorite installations of Water Agency facilities for well site applications.

Power and Grounding

Power and grounding requirements will be the same as for the Wohler and River Road Facilities. 480-volt distribution panel boards do not apply to well sites.

Conduit and Cable Requirements

Conduit and cable requirements will be the same as for the Wohler and River Road Facilities.

Lighting and Receptacles

Lighting and receptacle requirements will be the same as for the Wohler and River Road Facilities.

Instrumentation and Special Systems

Instruments that will be provided for well sites are listed in **Table 16**.

Table 16 – Instrumentation Requirements for Well Sites

Process Measurement	Service	Instrument Type
Level - continuous	Fluoride tank	Ultrasonic
Level switches	Chemical containment pipe	Mercury free, level detection
Flow switches	Emergency Showers	Liquid flow, 316 SS
Fluoride residual	Finished potable water	Ion-specific fluoride sensor

PLC and SCADA Requirements

PLC and SCADA requirements will be the same as for the Wohler and River Road Facilities, except local speed setting for the fluoride metering pumps will be adjusted at the pumps, not on control panels.

Chemical Monitoring and Control

The fluoride metering pump at the well sites will be flow paced off well flow. The fluoride metering pump speed will be trimmed based on fluoride residual analyzer feedback. The fluoride metering pump can be started and operated locally at the pump or automatically from the plant's PLC. Local operation is with zero to 15 minute spring wound timer to visually inspect operation of pump and assist in priming. Pump stroke can only be set locally.

The fluoride metering pump will start based on commands from the PLC originating from the following permissives:

- Pump is "Ready" based on field Start/Stop hand switch in "Auto." "Ready" status is viewable at SCADA.
- Well pump is Running.
- PLC call to start is given.
- The Fluoride Metering Pump speed command will come from the PLC based on desired dosage and residual. Speed will be flow-paced controlled and trimmed based on feedback from the fluoride analyzer to achieve desired residual.
- The Fluoride Metering Pump will be shut off before the Well Pump.

The fluoride system at the well sites will include the following points connected to the PLC for monitoring and control:

- Metering Pumps – Auto status, Fault alarm, Metering Pump start command, Metering Pump speed command signal.
- Fluoride Tank – Tank level continuous signal.
- Fluoride Residual – Fluoride ppm continuous signal.
- Miscellaneous – Tank rate of change alarm (SCADA-derived), Fluoride Shed intrusion alarm.

Testing and Start-Up

Testing and start-up requirements will be the same as for the Wohler and River Road Facilities.

Architectural Design

The architectural design criteria will similar to the Wohler and River Road Facilities.

Code Compliance

The Fluoride Buildings will be designed according to the most recent versions of the California Building Code and the International Fire Code (IFC). Occupancy will be F-1 Moderate-Hazardous Occupancy when the total indoor storage of H2SiF6 is less than 500 gallons. The construction type will be Type IIN (non-combustible).

Building Materials

The proposed Fluoride Building walls will be cavity wall construction, comprising of 8 inch concrete masonry units. Exterior split face concrete masonry units and mortar will have a water resistance additive, and surface treatment to improve "weather-ability." Interior masonry surfaces will have masonry fillers, and will be painted with appropriate coating. Building design will be composed of structural concrete roofs. Minimum roof slope will be ½-inch per foot. Side-swinging doors and frames will be fiberglass.

HVAC, Plumbing, and Structural Design

The HVAC, plumbing, and structural design criteria will be the same as for the Wohler and River Road Facilities.

Safety

Emergency Shower/Eyewash

An emergency eyewash and shower unit currently exists at the well sites. Although new eyewash and shower units are not needed, various well sites may need the additional new units or the existing units relocated to suit modifications to the sites. The emergency eyewash/shower tap must be far enough downstream from injection points to ensure thorough mixing has taken place.

Containment/Spill Control

Since the tanks at the well sites will be double walled, no additional secondary containment is necessary. However, because of the remoteness of each well site, and the close proximities to residential housing, a "spill kit" will be provided for each site consisting of the following items:

- Universal chemical absorbent (5-gallon bucket)
- Soda ash solution (1-gallon liquid container)
- Generic spray bottle (containing soda ash solution)
- Litmus paper test strips
- Tube of acid neutralizing cream

It is assumed that Water Agency operational staff currently has the necessary clothing for handling hazardous materials; therefore, no additional protective wear will be provided.

FLUORIDATION FACILITIES OPINION OF PROBABLE COSTS

The following discussion presents the development of the capital cost estimates, O&M cost estimates, and a project cost summary for the proposed fluoridation facilities.

Capital Cost Estimates

The capital cost estimates developed for proposed facilities were separated into the following components:

- General Site Development (typically includes include removals, clearing, grading, paving, fencing and storm water controls)
- Yard Piping (typically includes process area connection piping and vault structures)
- Fluoridation Buildings
    - Infrastructure (typically includes facility improvements and enclosure requirements)

  - Process (typically includes the specific process related equipment, piping and storage tanks)
- Electrical/I&C (typically includes the high and low voltage distribution/connections, SCADA and equipment automation scope)
- Constructability (covers the contractor’s temporary works costs (sheeting, shoring, SPPP) and duration equipment (cranes, etc.))
- Startup/Commission (covers the contractor’s costs to start-up/train and hand over the facility to the owner)
- Mobilization/General Conditions (covers the contractor’s field mobilization and oversight expenses)
- Markups (covers the contractor’s home office overheads, insurances, local taxes and job fee)
- Project Administration & Management (covers the owner’s soft costs inclusive of administration, legal, permitting, engineering and contingency)

The costs for these components were developed using the project design criteria, the facility layouts and P&IDs, costs obtained for similar projects, and the judgment of MWH’s cost estimating staff. Based on mixed market indices and the opinion of MWH cost estimated staff, the values reflect current market conditions and do not include escalation to a future construction date. It should be noted that this cost estimate assumes the preparation of an Initial Study/Mitigated Negative Declaration and includes preliminary permitting costs. It does not include costs for a Hazard and Hazardous Materials Corridor Study, United States Fish and Wildlife Service (USFWS) Burke’s Goldfield protocol survey, mitigation (i.e., CTS, vernal pool, seasonal wetland, special status plant species (Burke’s goldfields), and critical habitat mitigation; mitigation bank fees; and implementation of revegetation plan, and reporting cost), and permit fees. If it is determined that an EIR would be required, the cost would be expected to increase by an additional $200,000. Project capital costs are presented in **Tables 17 and 18**, while a more detailed cost breakdown is included in **Appendix C**. **Tables 17 and 18** reflect the anticipated phasing of construction of fluoridation facilities into Phase 1 (Wohler and River Road facilities) and Phase 2 (well sites), respectively. The capital costs were developed to an Association for the Advancement of Cost Engineering (AACE) International Class 3 Cost Estimate standard: “Class 3 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. Typically, engineering is 30% to 60% complete. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Virtually all Class 3 estimates use stochastic estimating methods such as cost curves, capacity factors, and other parametric and modeling techniques. Expected accuracy ranges are from -10% to -20% on the low side and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 20 hours or less to perhaps more than 300 hours may be spent preparing the estimate depending on the project and estimating methodology” (AACE International Recommended Practices and Standards).

Table 17 – Phase 1 – Wohler and River Road - Opinion of Fluoridation Facilities Capital Costs(1)(2)

Facility	Cost Range - Low	Opinion of Probable Construction Cost	Cost Range - High
Wohler Facility	$1,200,000	$1,770,000	$2,000,000
River Road Facility	$1,400,000	$2,070,000	$2,300,000
Opinion of Phase 1 Capital Cost	**$2,600,000**	**$3,840,000**	**$4,300,000**

(1)AACE Class 3 estimate. Cost basis May 2013.
(2)Costs include markups and project administration & management. Refer to **Appendix C** for additional details.

The capital costs in Table 17 can be compared to the Fluoridation Treatment Capital Cost Estimates provided to the California Department of Public Health by the Cities of Santa Rosa and Petaluma and the North Marin Water District. Those estimates were $5,363,000, $2,452,000, and $437,468 respectively. It should be noted that the current estimate and the Cities' estimates may not have been developed to the same scope and level of accuracy or the level of fluoridation throughout the cities.

Table 18 – Phase 2 – Well Sites - Opinion of Fluoridation Facilities Capital Costs(1)(2)

Facility	Cost Range - Low	Opinion of Probable Construction Cost	Cost Range - High
Occidental Road Well	$140,000	$220,000	$230,000
Sebastopol Road Well	$140,000	$220,000	$230,000
Todd Road Well	$140,000	$220,000	$230,000
Opinion of Phase 2 Capital Cost	**$420,000**	**$660,000**	**$690,000**
Grand Total Opinion of Phase 1& 2 Capital Cost	**$3,020,000**	**$4,500,000**	**$4,990,000**

(1)AACE Class 3 estimate. Cost basis May 2013.
(2)Costs include markups and project administration & management. Refer to **Appendix C** for additional details.

O&M Cost Development

The estimates for annual O&M of the fluoridation system include the following cost categories:

- Labor Costs
- Energy Costs
- Chemical Costs
- Replacement Costs

The Water Agency's estimated annual water production was used in the development of O&M costs for the Wohler and River Road Facilities. The projected 2025 water year volume (refer to **Table 1**) was estimated as an approximate midpoint of the 30 year lifecycle cost period and used in calculations of the above cost categories. The total projected 2025 volume was apportioned to the Wohler and River Road Facilities based on the ratio of their relative production rates (refer to **Table 2**). Similarly, the estimated annual production for the Santa Rosa Plain wells noted previously in the section Review of Existing Facilities (2,300 acre-feet or 749.4 MG for all years through 2035) was apportioned to the three wells based on the ratio of their relative production rates (1.5 MGD for Todd Road Well and 2 MGD for both Occidental Road and Sebastopol Road Wells).

Labor costs include scheduled monitoring and inspection (visual checks, readings, sampling, testing, recordkeeping, and reporting), routine maintenance costs (equipment calibration and adjustments), and unscheduled maintenance costs (alarm response). Labor rates for water treatment staff are based on the current rate of $131 per hour (inclusive of benefits). Costs already borne by existing maintenance operations are not included as part of the estimates.

Energy costs include electrical power consumption (ventilation, lighting, and equipment loads). Electrical energy costs are based on a planning rate of $0.12 kilowatt hour (kW-hr).

Chemical costs include chemical delivery and consumption costs. The fluorosilicic acid chemical cost for the Wohler and River Road Facilities is based on costs provided by Sierra Chemical at $4.04 per gallon plus a $1,098 individual trip charge for bulk deliveries from a 4000-gallon cargo tanker truck. The fluorosilicic acid chemical cost for the well sites is based on costs provided by Sierra Chemical at $7.62 per gallon plus a $300 total trip charge for all three wells for each site visit for deliveries from a 330-gallon truck mounted tote. Fluorosilicic acid consumption quantities are reduced where the residual amount of existing naturally occurring fluoride is known.

Chemical costs also include the increased caustic soda use required for neutralization of the low-pH fluorosilicic acid. The caustic soda chemical cost is based on current cost information provided by the Water Agency at $0.28/lb. ($3.56 per gallon).

Replacement costs include the costs of occasional major maintenance and equipment replacement. Replacement costs also include costs to replenish personal protective gear, spill kits, and test kit consumables. A present value cost analysis of replacement costs (3% escalation rate, 6% discount rate) was performed for a 30-year period and an equivalent annual value (i=3%, 30 years) of the present value was calculated. The replacement cost analysis was based on the following assumptions:

Fluoride System Component Replacement

- 1-Year Intervals – Limited replacement of PVC valves and fittings, injector quills, and other chemical appurtenances
- 1-Year Intervals – Replenish personal protective gear, spill kit, and test kit consumables

Equipment Refurbishment (rebuilds and overhauls)

- 5-Year Intervals – Motor Driven Metering Pumps

Equipment Replacement

- 10-Year Intervals – Solenoid Pumps
- 15-Year Intervals – Motor Driven Metering Pumps, Building Exhaust Fans
- 10-Year Intervals – High-Density Polyethylene (HDPE) Storage Tanks

Tables 19 and 20 present the O&M costs associated with labor, energy, chemicals, and replacement costs for fluoridation treatment at each site for Phase 1 and Phase 2, respectively. The total annual labor cost of $190,069, for the two Phases combined, translates to approximately 0.7 full time employees (FTE).

The annual O&M cost estimates provided herein are conceptual only, and are based upon the data available at the time of the estimate. The estimates have been prepared to serve as a guide and aid for project evaluation. Moreover, the actual costs will vary from these estimates. Funding and feasibility requirements must be carefully reviewed before making detailed financial decisions to ensure adequate project evaluation and appropriate funding.

Table 19 – Phase 1 – Wohler and River Road - Opinion of Fluoridation Facilities O&M Costs[1]

Facility Name	Annual Water Production[2] (MG)	Labor Costs	Energy Costs	Chemical Costs[1]	Replacement Costs (annualized 30 yr life cost)	Total Annual Costs
Phase 1 - Wohler and River Road Facilities						
Wohler Facility	9,881	$50,814	$265	$138,127	$3,531	**$193,000**
River Road Facility	14,773	$50,814	$265	$211,336	$3,531	**$266,000**
Total:	***24,654***					
Total Annual Phase 1 Costs		**$101,628**	**$531**	**$349,463**	**$7,062**	**$459,000**

[1] Chemical cost for the Wohler and River Road Facilities include the cost of caustic soda to neutralize added fluorosilicic acid.

[2] Water Agency estimated annual water production based on the projected 2025 water year volume, taken as an approximate midpoint of the 30 year cost period used in this report. (Refer to **Table 1**)

Table 20 – Phase 2 – Well Sites and Project Grand Total - Opinion of Fluoridation Facilities O&M Costs

Facility Name	Annual Water Production[1] (MG)	Labor Costs	Energy Costs	Chemical Costs	Replacement Costs (annualized 30 yr life cost)	Total Annual Costs
Phase 2 - Well Sites						
Occidental Road Well	272.5	$29,481	$232	$9,928	$683	$40,000
Sebastopol Road Well	272.5	$29,481	$232	$11,819	$683	$42,000
Todd Road Well	204.4	$29,481	$232	$9,172	$683	$40,000
Total:	***749.4***					
Total Annual Phase 1 Costs		**$88,442**	**$697**	**$30,919**	**$2,048**	**$122,000**
Grand Total Annual Phase 1 & 2 Costs		**$190,069**	**$1,228**	**$380,382**	**$9,110**	**$581,000**

(1) Water Agency estimated annual water production based on the projected 2025 water year volume, taken as an approximate midpoint of the 30 year cost period used in this report. (Refer to **Table 1**)

Project Cost Summary

An equivalent present value of the annual O&M costs for the project's 30-year design life cycle was calculated (i=3%, 30 years). Capital costs were added to present value of O&M costs to calculate total project present value cost. The Phase 1 costs are summarized in **Table 21** while the Phase 2 costs are summarized in **Table 22**.

Table 21 – Phase 1 – Wohler and River Road Facilities - Conceptual Project Cost Estimate Summary[1]

Description	Total Annual O&M Cost	Equivalent Present Value of Annual O&M (30 yrs, i=3%)	Capital Cost	Total Present Value of Project O&M and Capital Costs (30-yr Life Cycle)
Wohler Facility	$193,000	$3,783,000	$1,770,000	$6,317,000
River Road Facility	$266,000	$5,213,000	$2,070,000	$8,420,000
Total Phase 1	**$459,000**	**$8,996,000**	**$3,840,000**	**$12,836,000**

(1)Capital Cost is AACE Class 3 Estimate, cost basis May 2013, and includes markups and project administration & management. O&M costs assume labor rate of $80/hr and power cost of $0.12/kW-hr.

Table 22 – Phase 2 – Well Sites and Project Grand Total - Conceptual Project Cost Estimate Summary[1]

Description	Total Annual O&M Cost	Equivalent Present Value of Annual O&M (30 yrs, i=3%)	Capital Cost	Total Present Value of Project O&M and Capital Costs (30-yr Life Cycle)
Total Phase 2 - Well Sites	**$122,000**	**$2,391,000**	**$660,000**	**$3,051,000**
Grand Total Phase 1 & 2	**$581,000**	**$11,387,000**	**$4,500,000**	**$15,887,000**

(1)Capital Cost is AACE Class 3 Estimate, cost basis May 2013, and includes markups and project administration & management. O&M costs assume labor rate of $80/hr and power cost of $0.12/kW-hr.

These cost estimates are submitted with the understanding that MWH has no control over the costs of labor, materials, competitive bidding environments, unidentified field conditions, financial and/or commodity market conditions, or any other factors likely to affect the opinion of probable construction cost (OPCC) of this project, all of which are and will unavoidably remain in a state of change, especially in light of high market volatility attributable to Acts of God and other market forces or events beyond the control of the parties. As such, this OPCC deliverable is based on normal market conditions, defined by stable resource supply/demand relationships, and does not account for extreme inflationary or deflationary market cycles. Also, this OPCC is based on current conditions as of the date of this report, and the reliability of this OPCC will degrade over time. MWH cannot and does not make any warranty, promise, guarantee or representation, either express or implied that proposals, bids, project construction costs, or cost of O&M functions will not vary significantly from MWH's good faith Class 3 OPCC.

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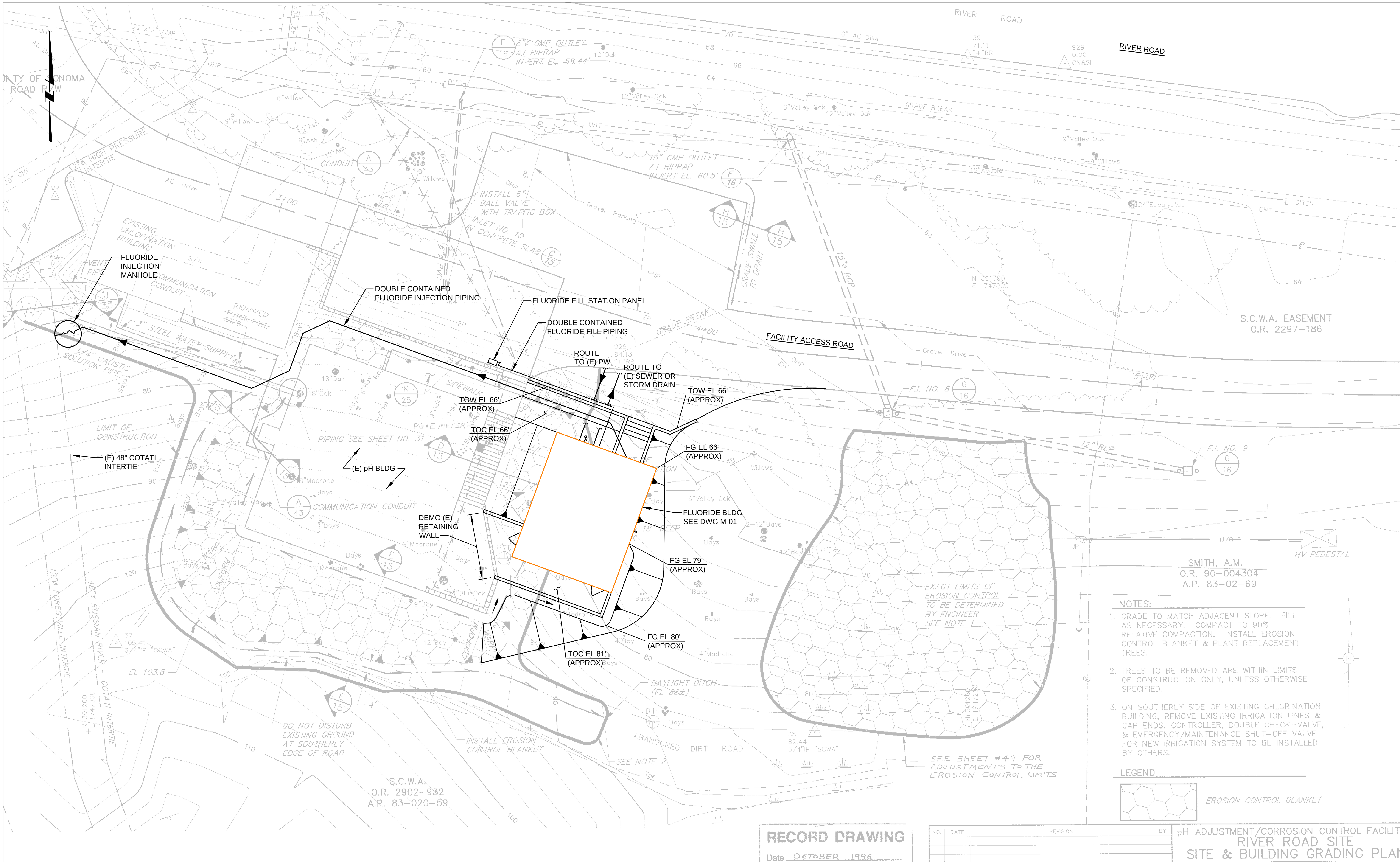
Appendix A – Drawings



SCALE			FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT	FIGURE
1" = 20' APPROX	MWH	SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	RIVER ROAD FACILITY SITE PLAN	C-01

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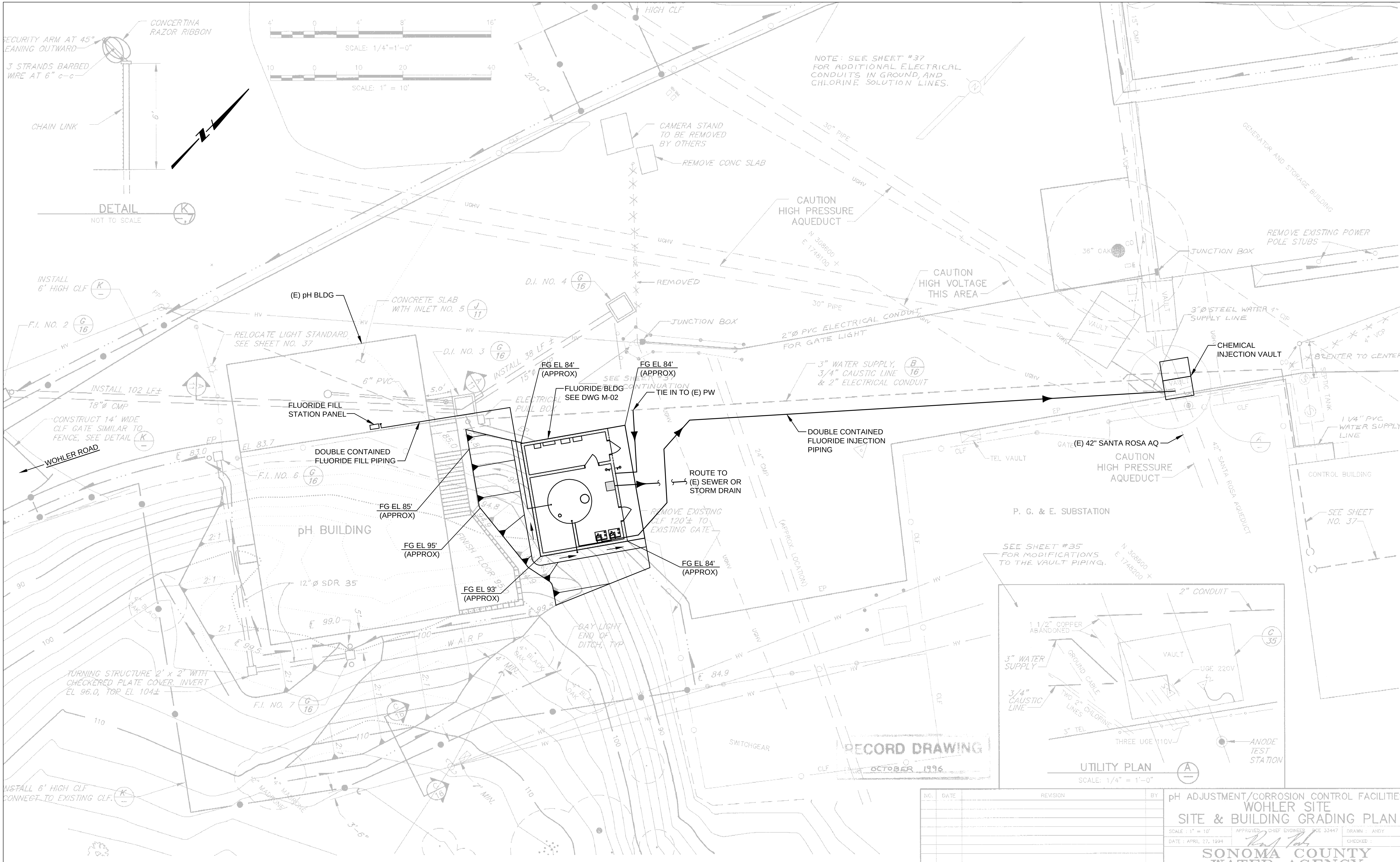

SCALE				FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT	FIGURE
1" = 20' APPROX	MWH		SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	WOHLER FACILITY SITE PLAN	C-02

SCALE	MWH	SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT	FIGURE
1" = 10' APPROX			OCCIDENTAL ROAD WELL SITE PLAN	C-03

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SCALE	MWH	SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT	FIGURE
1" = 10' APPROX			SEBASTOPOL ROAD WELL SITE PLAN	C-04

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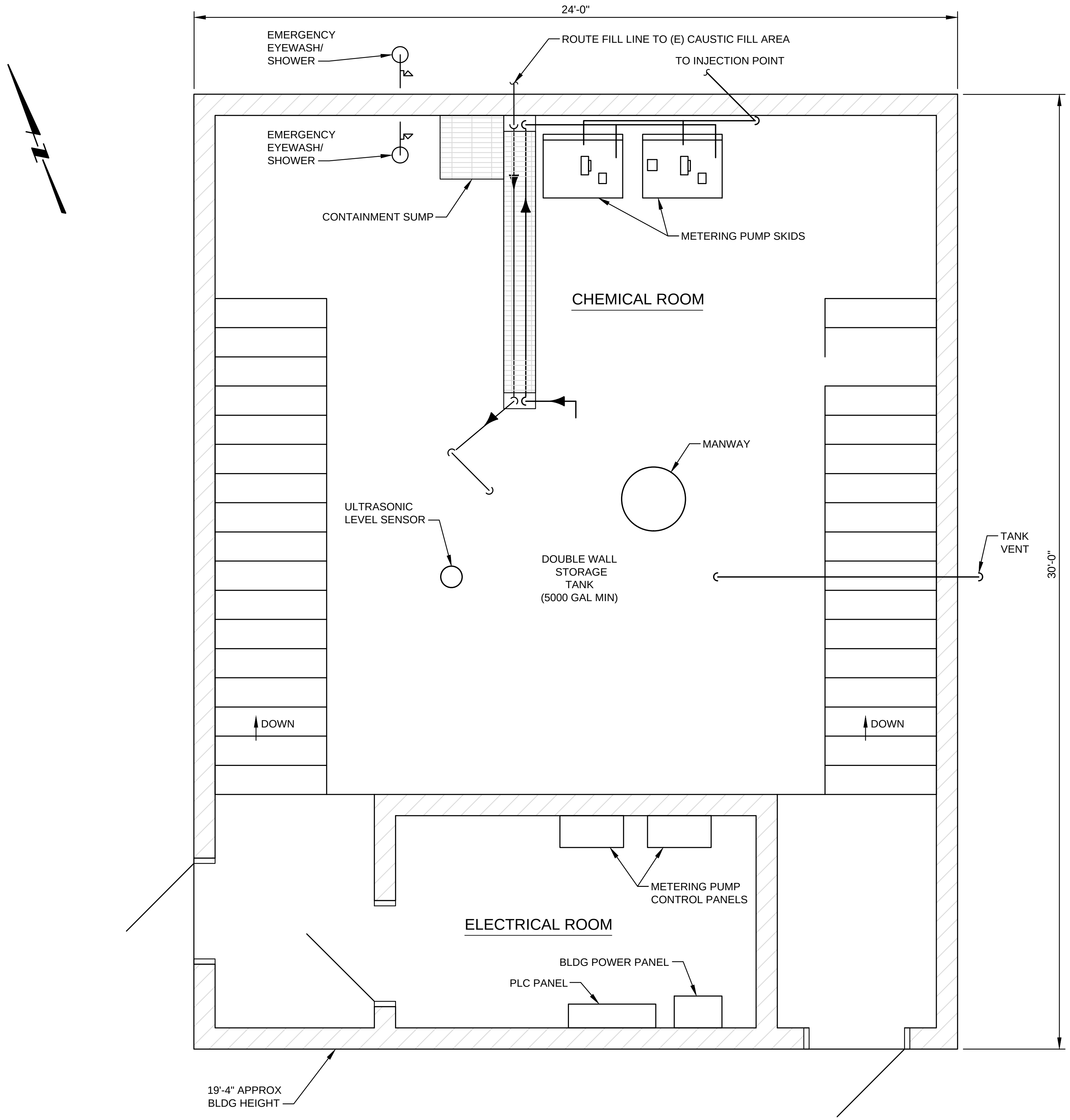
SCALE					FIGURE
1" = 10' APPROX	MWH		SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT TODD ROAD WELL SITE PLAN	C-05



RIVER ROAD FACILITY
FLUORIDATION BUILDING PLAN

SCALE: 1/4" = 1'-0"

MWH	SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT RIVER ROAD FACILITY FLUORIDATION BUILDING PLAN	FIGURE M-01

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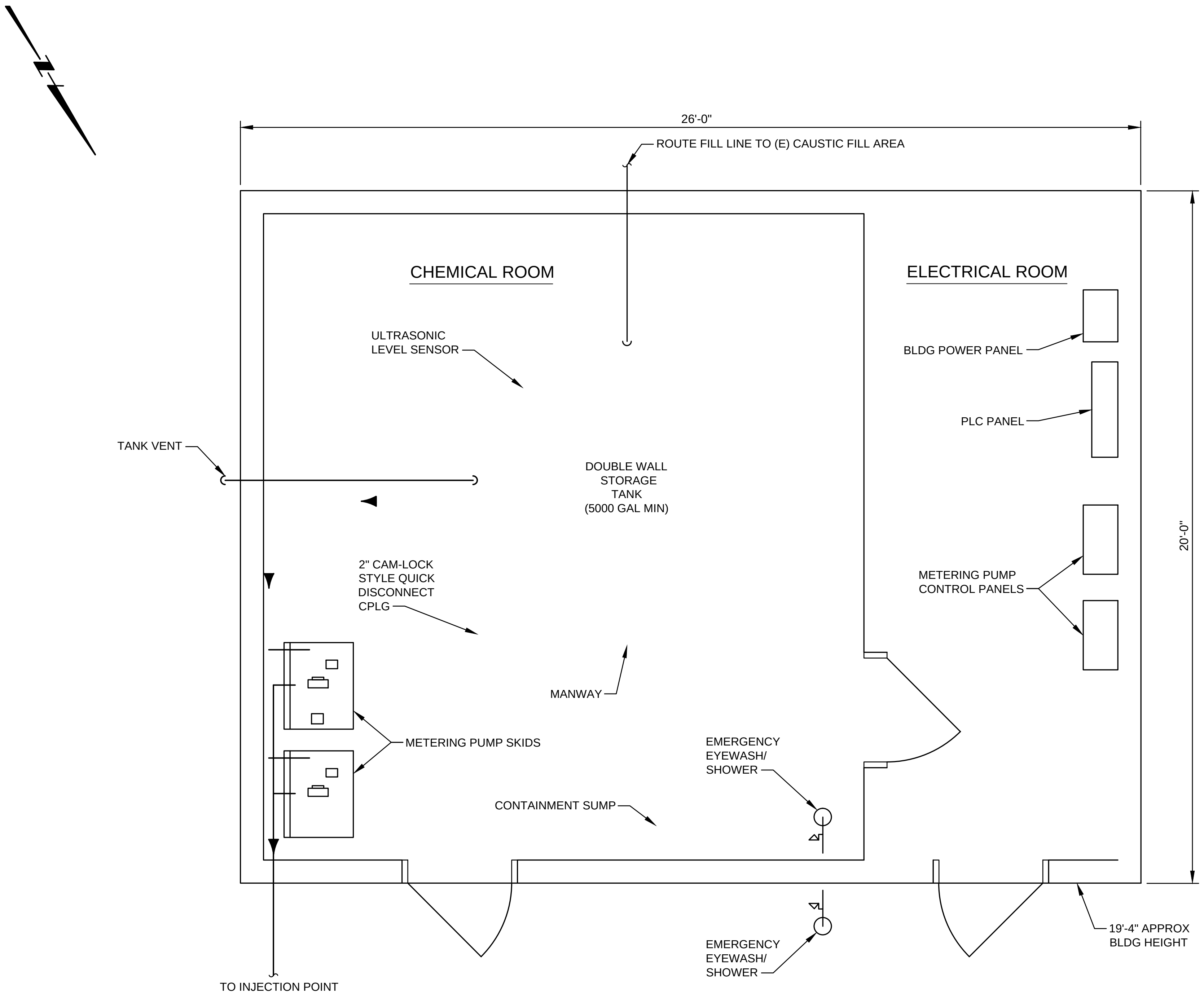

WOHLER FACILITY FLUORIDATION BUILDING PLAN

SCALE: 1/4" = 1'-0"

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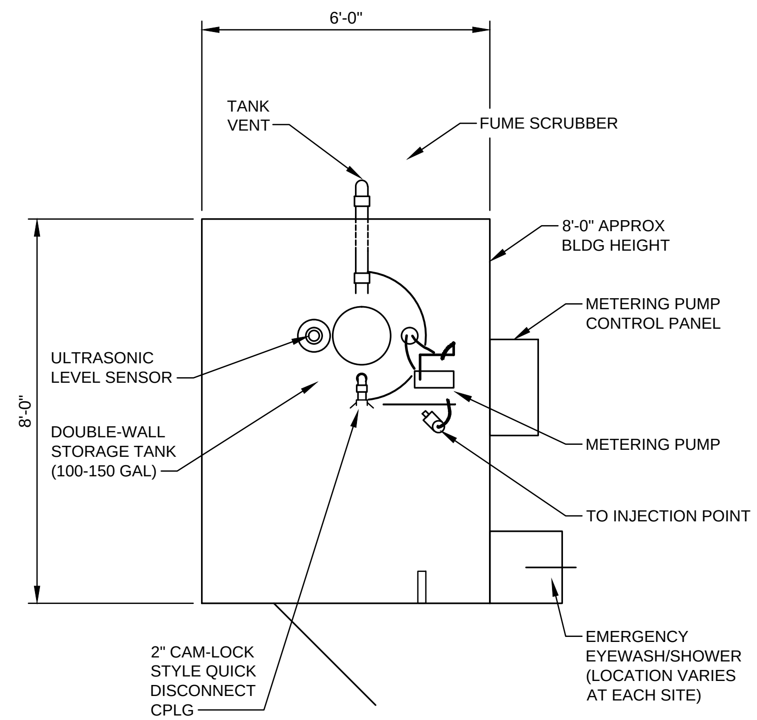
MWH	SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT WOHLER FACILITY FLUORIDATION BUILDING PLAN	FIGURE M-02



WELL SITES
TYPICAL FLUORIDATION BUILDING PLAN

SCALE: 1/4" = 1'-0"

MWH

SONOMA COUNTY
DEPARTMENT OF
HEALTH SERVICES

FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT

WELL SITES
TYPICAL FLUORIDATION BUILDING PLAN

FIGURE

M-03

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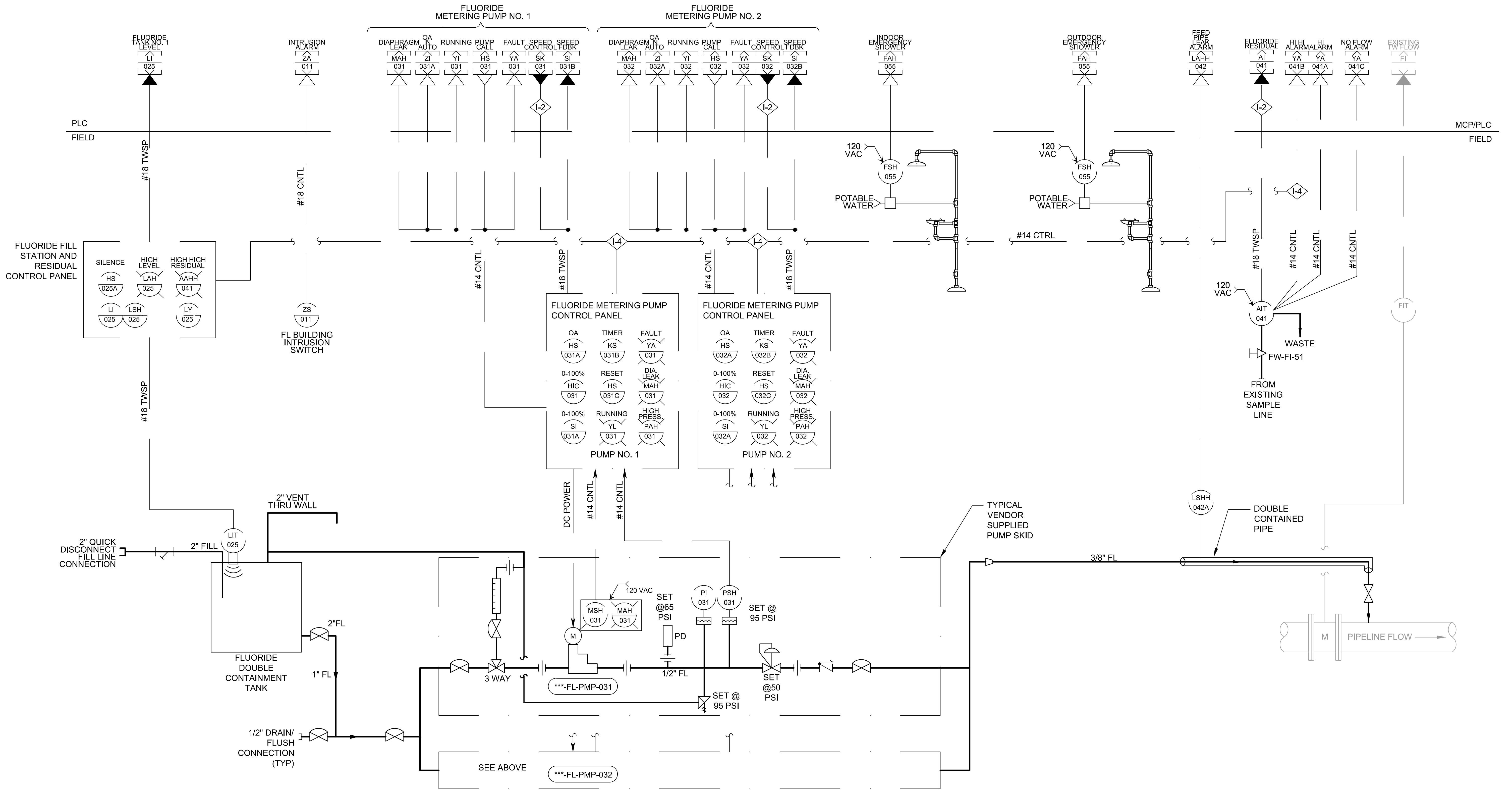

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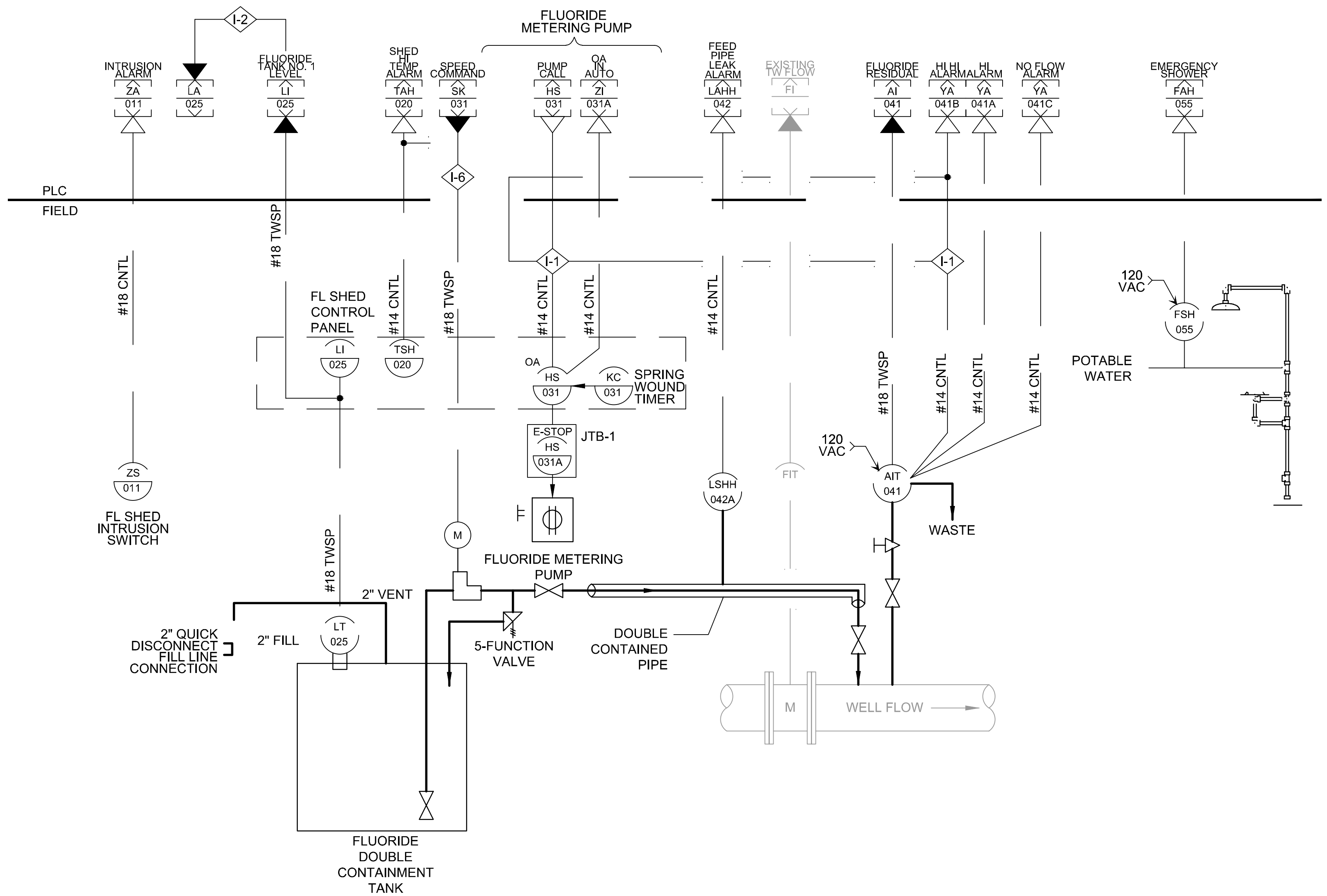
SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES

FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT

WOHLER AND RIVER ROAD FACILITIES
P&ID

FIGURE
I-01



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SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES

FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT

TYPICAL WELL SITE
P&ID

FIGURE
I-02

Appendix B – Design Criteria Technical Memorandum – July 2013

This Technical Memorandum was written in July 2013. The engineering and cost estimate report has been updated using 0.7 mg/L proposed community water fluoridation concentration standard.

T E C H N I C A L   M E M O R A N D U M

County of Sonoma Department of Health Services
Administration Division

Fluoridation Preliminary Engineering Design Report

Subject:	**Design Criteria Technical Memorandum**		
Prepared by:	Phil Salzman, MWH Edward Gosse, MWH	**Reference:**	10502520.030101
Reviewed by:	Mike Price, MWH Bill Taplin, MWH	**Date:**	**July 2013**

BACKGROUND

The County of Sonoma Department of Health Services (DHS) has determined that dental disease is a major source of preventable suffering and expenditures for Sonoma County residents of all ages, but particularly, the County's low income and minority residents. Consequently, the Community Health Assessment and the Sonoma County Smile Survey recommended water fluoridation as a primary means of preventing tooth decay and improving oral health.

Fluoridation of public water systems in California was first required in 1976. Current regulations state that systems serving more than 10,000 service connections must fluoridate unless the system does not receive sufficient funds from a source identified by the California Department of Public Health (CDPH) for capital and ongoing operations and maintenance costs.

As a water wholesaler, the Sonoma County Water Agency (Water Agency) is not specifically required to fluoridate water produced by its six radial collector wells and three groundwater wells. That responsibility lies with the retail entities. However, given that the Water Agency supplies water to more than 600,000 people in Sonoma and Marin Counties, fluoridation of water produced by the agency would have a wide reach and could be more cost effective than having individual retailers fluoridate, particularly in cases where the Water Agency provides all the water to individual retailers.

Given the need for improved dental health and the potential for reaching a large population of Sonoma County citizens, DHS has initiated this project to evaluate the technical and economic feasibility of fluoridating the Water Agency's water supply.

PURPOSE

The objective of this Technical Memorandum (TM) is to outline and establish the basis of design for the facilities required to fluoridate the Water Agency's water supply. This TM includes the results of an examination of existing water quality, flow and facility data provided by the Water Agency and a review of information and drawings for all existing treatment and well facilities to determine the fluoridation systems and operations that provide the optimum combination of safety, system performance, and life cycle costs. A review of existing fluoridation systems in the region and regulatory requirements was completed to assist in the development of appropriate design criteria.

Three chemicals, sodium fluoride (NaF), sodium fluorosilicate (NaSF), and fluorosilicic acid (HFA), the most common compounds used for the fluoridation of drinking water, are compared for applicability at the Water Agency production facilities. The most appropriate fluoride chemical to be used at each of the Water Agency's water supply facilities is recommended. In addition, alternative locations for addition of the fluoride are identified and the most appropriate locations selected. The possible need for remote fluoride addition at the well sites is also evaluated.

REVIEW OF EXISTING FACILITIES AND SELECTION OF FLUORIDE FEED LOCATIONS

This section includes a review of existing the Water Agency facilities and a discussion of the most appropriate location for fluoride feed facilities.

Review of Existing Facilities

The Water Agency currently operates six radial collector wells located along the banks of the Russian River (Refer to **Figure 1**). Wohler Collectors 1, 2 and 6 are located north of the Wohler Bridge while the Mirabel Collectors (3, 4 and 5) are located several thousand feet to the south. Although the discharges from the two collector facilities are interconnected with a 54-inch Wohler-Forestville Pipeline, typically, water from the Wohler Collectors is sent east via the 42-inch diameter Santa Rosa Aqueduct (Santa Rosa AQ), and water from the Mirabel Collectors is sent southeast through the 48-inch diameter Russian River - Cotati Intertie Pipeline (Cotati Intertie). The minimum, maximum, and average flows, in million gallons per day (MGD), for the two pipelines projected for the years 2015 and 2035 are shown in **Table 1**. The 2015 flows have been reported by Water Agency staff to be very close to current flow rates and will be assumed as current for this TM.

Table 1 – Water Agency Production Flow Rates*

Pipeline	Minimum Daily Flow Rate (MGD)	Maximum Daily Flow, 2015 (MGD)	Average Daily Flow Rate, 2015 (MGD)	Maximum Daily Flow, 2035 (MGD)	Average Daily Flow Rate, 2035 (MGD)
Santa Rosa Aqueduct	5.0	32.0	18.6	40.0	23.3
Cotati Intertie Pipeline	5.0	55.0	27.7	59.8	30.1

*Flow rates estimated from "2010 Urban Water Management Plan, Sonoma County Water Agency, June 2011 Draft" and correspondence with the Water Agency.

Average water quality values for raw water routed to the Santa Rosa AQ and Cotati Intertie are shown in Table 2.

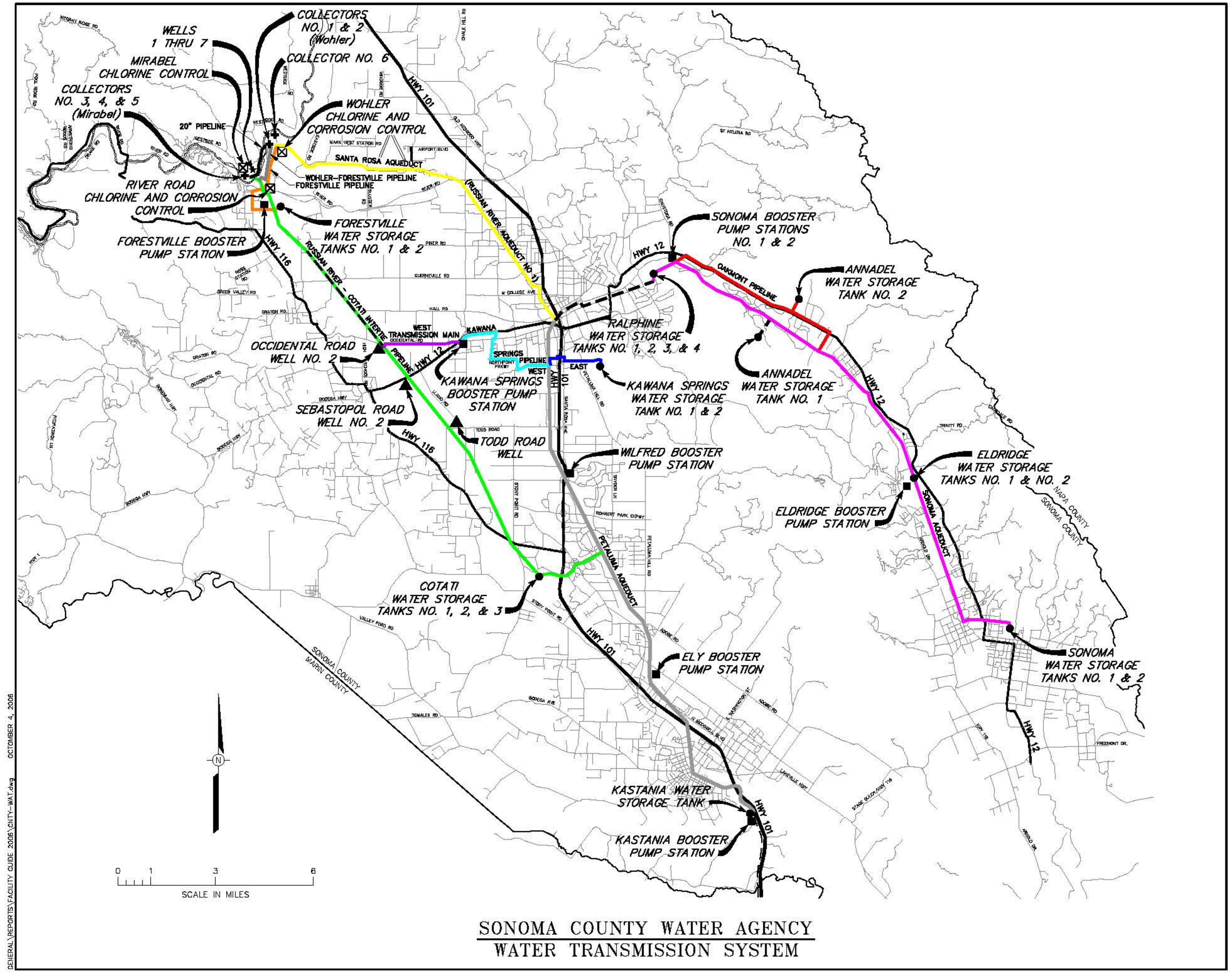


Figure 1 – Water Agency System Overview

Table 2 – 2012 Average Raw Water Quality Values*

Element	Santa Rosa AQ	Cotati Intertie
pH (unit)	7.2	7.5
Fluoride (mg/L)	0.17	0.15
Total Dissolved Solids (mg/L)	146.7	146.7
Alkalinity (mg/L as $CaCO_3$)	106.7	103.3
Calcium (mg/L)	23.7	24.3
Chloride (mg/L)	5.5	5.7
Sulfate (mg/L)	13.0	12.7
Temperature, Avg. (Celsius)	17	17

*Water quality values for Santa Rosa AQ are averages of results provided by the Water Agency for radial well collectors 1, 2, and 6. Values for Cotati Intertie are similarly averages for collectors 3, 4, and 5. Temperature values reflect an average of temperatures measured after treatment.

The Water Agency currently uses chlorine gas for disinfection and caustic soda for corrosion control of the treated water. For the Mirabel Collectors, chlorine gas is stored at the Mirabel Chlorination Facility, and chlorine is fed to each individual Ranney caisson. Back-up chlorination facilities for the Cotati Intertie are located at the River Road Chlorine and Corrosion Control Facility (River Road Facility). The River Road Facility also contains the caustic soda storage and feed facilities for the Cotati Intertie, located in a separate building. Both buildings are concrete masonry unit (CMU) block construction.

For the Wohler Collectors, chlorine gas and caustic soda are stored in separate buildings at the Wohler Chlorine and Corrosion Control Facility (Wohler Facility). Both buildings are CMU block construction. Chlorine is typically fed to each individual Ranney caisson, with a back-up feed point to the Santa Rosa AQ located in a vault on site. The primary and only feed for caustic soda is at the same vault.

Downstream of the River Road Facility (with respect to the Cotati Intertie) the Forestville Booster Pump Station (Forestville BPS) draws water from the Cotati Intertie via a 12-inch diameter connection. The building is CMU block construction. The Forestville BPS was identified as a potential fluoride feed location given its proximity to the Cotati Intertie. This will be discussed later in this section.

The Water Agency has three groundwater wells located in the Santa Rosa Plain; Occidental Road Well, Sebastopol Road Well, and Todd Road Well. These wells feed into the Cotati Intertie downstream of the Forestville BPS. The capacities of the Occidental Rd and Sebastopol Rd wells are estimated at approximately 2 MGD each and Todd Rd well has an estimated capacity of 1.5 MGD. This yields a total capacity of approximately 5.5 MGD. The production wells are not frequently used at the present time, but are planned for use to meet future system seasonal demands. A calcium hypochlorite tablet system is used to feed chlorine to the well pump discharge at each of the wells. The feed systems, as well as analyzers and ancillary equipment, are stored in small wood frame buildings with wood siding at each well site.

Selection of Fluoride Feed Locations

To fluoridate the Water Agency's entire water supply, fluoride feed is required in both the Cotati Intertie and the Santa Rosa AQ. Given the distance between the two sets of collectors, it was determined that providing one feed facility to fluoridate the Cotati Intertie and one feed facility to fluoridate the Santa Rosa AQ was the simplest and most reliable approach. The concept of providing a single feed facility and routing the fluoride to both pipelines was briefly considered but rejected due to the excessive chemical feed pipe lengths (each pipe would be more than a half-mile if the feed location were centrally located). Similarly, the concept of feeding directly to each of the collectors rather than the combined pipelines was rejected due to the increased system complexity and increased equipment requirements (six pumps and analyzers vs. two).

Fluoridation facility site selection was limited by the need to have the Cotati Intertie and the Santa Rosa AQ facilities both located either upstream or downstream of the 54-inch Wohler-Forestville Pipeline to assure proper system fluoridation. Several sites were considered for fluoride feed to the Cotati Intertie, with the River Road Facility selected as the preferred site. Although the existing buildings have no space to accommodate fluoridation equipment, the site has sufficient space to construct a fluoridation building, has existing power and controls infrastructure, and is in close proximity to the pipeline. The Mirabel Chlorination Facility was considered, but again the building had no extra space in which to locate fluoridation tanks and pumps. In addition, the Cotati Intertie is a significant distance from the facility, requiring a long feed pipe run with associated construction costs, maintenance difficulties, and feed rate control challenges. A site near Collector No. 5, which was close to the Cotati Intertie, was also rejected as it would have required that the grade be raised 10 to 15 feet to assure the feed facility would be above the 100-year flood elevation. The Forestville BPS site was also considered for fluoride feed to the Cotati Intertie, but again the existing building had no extra space for the required fluoridation equipment. The site was also too small to fit a separate fluoridation building.

The Wohler Facility was selected for fluoride feed to the Santa Rosa AQ. Similar to the River Road Facility the existing buildings do not have space to accommodate fluoridation equipment, but do have sufficient space on site to construct a fluoridation building. The site also has existing power and controls infrastructure and is in close proximity to the Santa Rosa AQ.

The existing wood buildings at the Water Agency's three wells are small and would not accommodate the additional fluoridation equipment. Corrosion of the existing buildings would also be a concern if the additional of fluoridation equipment is placed within them. The wells are several miles apart so there is no possibility of constructing a common fluoridation feed facility for all the wells. It is assumed that an individual fluoride feed system in a new separate building would be required at each well site. Since the Water Agency plans to operate the wells on a seasonal and as-needed basis, it is possible that the fluoride concentration in the Cotati Intertie flow might not be significantly diluted and individual well fluoridation not required. An evaluation of this possibility is presented later in this TM.

EVALUATION AND SELECTION OF FLUORIDATION CHEMICALS

An evaluation to determine the most appropriate chemical for fluoride feed to use at the project facilities was performed. The evaluation, presented below, includes discussions of regulatory fluoride levels, fluoridation chemical alternatives, fluoridation system descriptions, relative operational advantages and disadvantages of the chemical systems, and recommendations for the fluoridation system chemicals.

Regulatory Fluoride Levels

Regulatory requirements for fluoridation are defined under the California Code of Regulations (CCR) Title 22, Chapter 15, Article 4.1 Fluoridation. The optimum fluoride level is determined using the temperature-appropriate levels listed in Table 64433.2-A in Article 4.1. With an annual average of maximum daily temperatures of 70.4 degrees Fahrenheit (source USA.com), Sonoma County requires an optimum fluoride level of 0.9 mg/L with control range of 0.8 to 1.4 mg/L. The approximate fluoride dose added to water would be the difference between the optimum fluoride level and the naturally occurring fluoride level. For example, using **Table 2** results the dose for the Santa Rosa AQ would be 0.9 mg/L – 0.17 mg/L = 0.73 mg/L.

It should be noted that the U.S. Department of Health and Human Services (HHS) has recently proposed the revised recommendation of a single 0.7 mg/L fluoride level to replace the current temperature-based variable fluoride levels. The new proposed recommendation was published in the Federal Register on January 13, 2011and was schedule to accept comments from the public and stakeholders for a period of 20 days. HHS has not yet published final guidance on this issue so the CCR has not been changed and the temperature-based fluoride requirements remain in effect. The decrease in fluoride level would not significantly impact storage and feed facility requirements for the Water Agency but would reduce annual O&M costs through reduced chemical costs.

Fluoridation Chemical Alternatives

Three chemicals, sodium fluoride (chemical formula: NaF), sodium fluorosilicate (chemical formula: Na_2SiF_6), and fluorosilicic acid (chemical formula: H_2SiF_6), are the most common compounds used for the fluoridation of drinking water. A summary of the characteristics of these compounds is presented in **Table 3**.

Table 3 – Characteristics of Fluoridation Chemical Compounds

Item	Sodium Fluoride (NaF)	Sodium Fluorosilicate (Na_2SiF_6)	Fluorosilicic Acid (H_2SiF_6)
Form	Powder or crystal	Powder or very fine crystal	Liquid
Molecular weight	42.0	188.1	144.1
Active Chemical (percent)	90 – 98	98 – 99	22 - 30 (Typically 23 percent)
Available Fluoride (percent)	45.25	60.7	79.2
Pounds required per MG for 1.0 mg/L - F ion at indicated percent active chemical	18.8 (98 percent)	14.0 (98.5 percent)	45.7 of liquid (23 percent)
pH of saturated solution	7.6	3.5	1.2 (1 percent) solution)
Sodium ion (mg/L) contributed at 1 mg/L – F ion	1.17	0.40	0.00
Fluoride ion storage space- (cu ft/100 lb.)	22 – 34	23 – 30	54 - 73
Solubility at 25°C (g/100 g water)	4.05	0.762	Unlimited
Weight – (lb./cu. ft.)	65 – 90	55 – 72	10.0 lb./gal.* (23 percent)
Shipping containers	50 or 100-lb. bags, 125 - 400 lb. fiber drums, bulk	50 or 100-lb. bags, 125 - 400 lb. fiber drums, bulk	55-gal drums, bulk

Source: AWWA No. M4, Water Fluoridation Principles and Practices
* Equals 1.82 lb of F ion/gal of solution

Sodium fluoride is a dry chemical (powder or crystal), and is typically dissolved via a saturator, and then metered into the water supply as a liquid. Sodium fluoride has a stable (independent of temperature) solubility of approximately 4 percent as fluoride, which simplifies and stabilizes the process of metering the feed solution from the saturator into the process water. A saturated solution of sodium fluoride has a pH of approximately 7.6 and will not significantly impact the pH of the treated water. Sodium fluoride dust is harmful to human health and, consequently, safety equipment including goggles, gloves, aprons, dust masks, and respirators, as well as good ventilation system are recommended when handling this chemical.

Sodium fluorosilicate is available as a powder or as fine crystals and requires a dry feeder to meter the applied dose and mixing/dissolving chamber to feed a dilute fluoride solution into the water supply. Sodium fluorosilicate has a theoretical solubility that varies from roughly 0.5 to 0.7 percent as feed water temperature varies between approximately 50 and 70 degrees Fahrenheit. However, a practical solubility of 0.25 percent has been reported and is used in this evaluation. Sodium fluorosilicate requires the use of a mixer for proper dissolution before feeding into the process water. Similar to sodium fluoride, sodium fluorosilicate dust is harmful to human health and requires appropriate safety equipment and a robust dust collection and ventilation system.

Fluorosilicic acid is delivered in liquid form at approximately 23 percent solution strength and requires a metering pump feed system, similar to those used for other liquid chemical systems, such as caustic soda, to feed a concentrated fluoride solution into the process water. Fluorosilicic acid is a highly corrosive liquid that requires proper safety gear and continuous ventilation. Fluorosilicic acid also requires the use of acid-resistant materials for storage, pumping, and piping of the chemical. The off-gas from tank storage is corrosive to glass and metals and must be vented to the outside atmosphere if stored indoors.

Both sodium fluorosilicate and fluorosilicic acid will depress the pH of the treated water. For example, using a basic water quality model (Rothberg, Tamburini, and Windsor (RTW) Model, Version 4) and water data for the Santa Rosa AQ presented in **Table 2**, if fluorosilicic acid is added at a dose of 0.90 mg/L, the final pH would decrease by approximately 0.30 pH units. Increasing the dose of caustic soda by an additional 1.5 mg/L above the current dose rate (approximate 12% increase) would be required to achieve the target treated water pH, typically 8.5. The pH depression caused by sodium fluorosilicate would be roughly half that of fluorosilicic acid. Selection of the preferred fluoridation chemical at both the collectors and the well sites must address possible pH and corrosion-control impacts, as well as other design issues.

In the greater San Francisco - Sacramento area, fluorosilicic acid is the most common fluoridation chemical used. The City of Fairfield uses fluorosilicic acid at their Waterman and North Bay regional WTPs, and it is also used by the Marin Municipal Water District at their two WTPs and the Ignacio Pump Station. East Bay Municipal Utility District uses fluorosilicic at its six WTPs, and the San Francisco Public Utilities Commission uses fluorosilicic acid at its two WTPs and the Tesla Treatment Facility which feeds chemicals to the Hetch Hetchy supply. Both the City of Roseville and the City of Sacramento use fluorosilicic acid at their surface water treatment plants. The City of Roseville currently uses sodium fluoride at their well sites but is evaluating a switch to fluorosilicic acid based on operational problems with the sodium fluoride saturators. The City of Sacramento currently uses sodium fluoride at their well sites but has experienced operational problems due to the availability of only relatively poor quality chemical. Both the Sacramento Suburban Water District (South Service Area) and California American Water Company use fluorosilicic acid at their well sites. Sacramento County Water Agency is currently completing the addition of fluorosilicic acid feed systems to all of their groundwater wells and treatment facilities. Sacramento County Water Agency uses sodium fluorosilicate at their Vineyard Surface WTP.

Fluoridation System Descriptions

Depending upon the chemical selected to fluoridate the Water Agency's collector water and well water, one of three types of chemical systems will be required. Sodium fluoride requires a fluoride saturator system, sodium fluorosilicate requires a mechanical dry feed system, and fluorosilicic acid requires a liquid feed system. A brief description of the key elements of each of the three systems is presented below, followed by a summary of relative operational advantages and disadvantages of each chemical system.

Sodium Fluoride – Fluoride Saturator System

Sodium fluoride is typically fed into the process water using a saturator system (Refer to **Figure 2).** The key elements of a saturator system are an up-flow saturator tank, a water softener, and a metering pump. Typically, 50-pound bags of dry crystalline sodium fluoride are dumped into a 50- to 110-gallon-capacity polyethylene saturator tank to form a chemical bed. Softened water is allowed to flow at a slow rate up through the chemical bed, generating a saturated sodium fluoride solution. Since the solubility of sodium fluoride is effectively independent of feed water temperature, the system produces a consistent sodium fluoride solution concentration. A diaphragm metering pump is then used to meter the saturated sodium fluoride solution into the treated water pipeline.

As the dry sodium fluoride is slowly dissolved, operators add additional bags of the chemical to the saturator tank. The tank is typically semi-translucent and graduated in 5-gallon increments to facilitate monitoring of liquid and solid chemical phases. Appropriate operator safety gear is required for the refilling operation.

Feed water is typically softened to prevent precipitation of insoluble calcium fluoride (CaF_2). A water softener is not typically necessary if feed water has a hardness level below 50 mg/L. Since the radial collector well water is typically in the range of 100 to 150 mg/L and the three Santa Rosa Plain groundwater wells is in the range of 45 to 65 mg/L, water softening has been assumed.

Saturator installations are limited to smaller systems (less than approximately 3 MGD) due to practical size limitations of the saturators. The saturator system, and therefore sodium fluoride, will not be considered for use at the Wohler or River Road Facilities, which both have capacities greater than 30 MGD, but will be considered for the well sites.

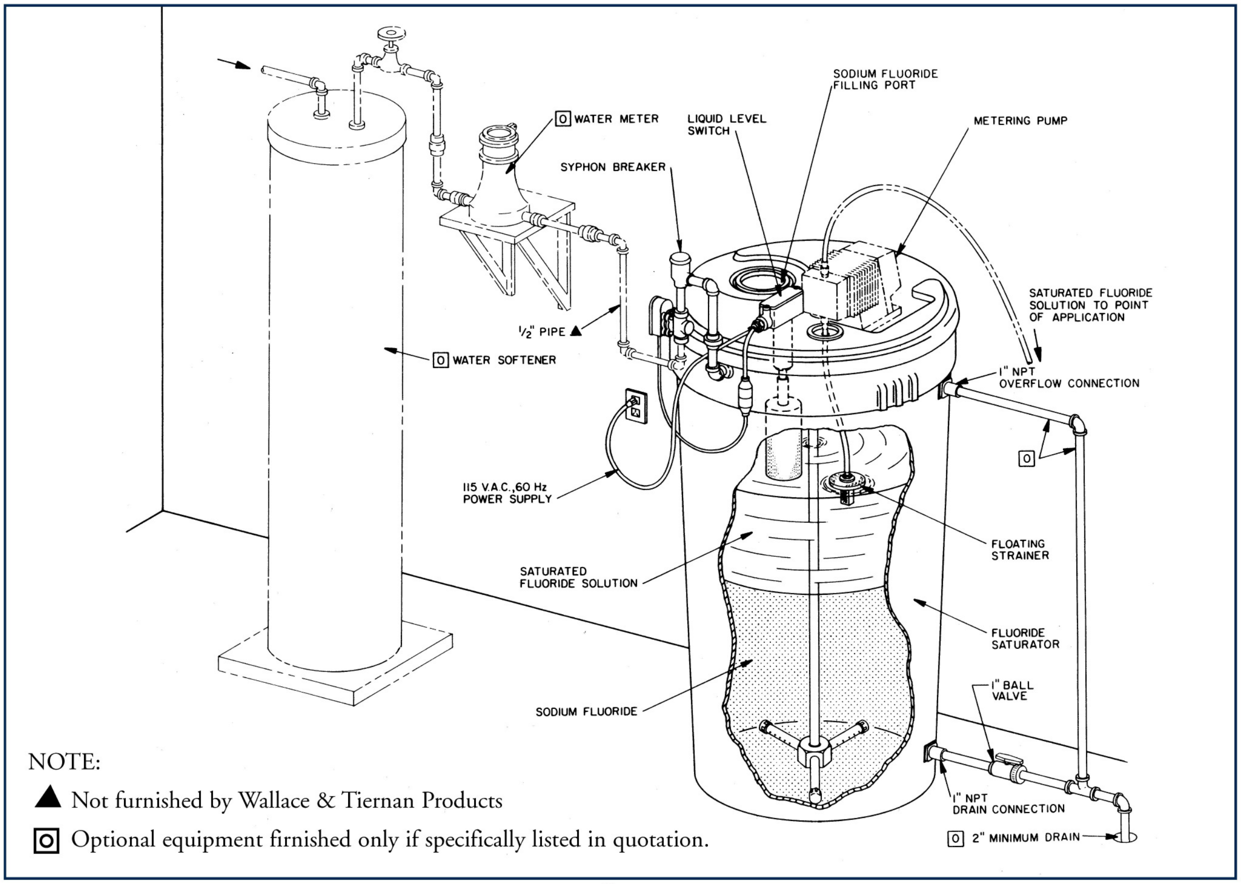


Figure 2 – Typical Fluoride Saturator

Sodium Fluorosilicate – Mechanical Dry Feed System

Sodium fluorosilicate is typically fed using a mechanical dry feed system (Refer to **Figure 3**). The key elements of a mechanical dry feed system are a bag-loading system with hopper, dust collection system, volumetric dry chemical feeder, and dissolving tank with mixer. Typically, 50-pound bags of crystalline sodium fluorosilicate are placed onto a bag loader and dumped into a dry chemical hopper. A dust collection system is typically provided to minimize operator contact with the hazardous sodium fluorosilicate dust. A volumetric feeder continuously conveys a precise dose of sodium fluorosilicate to a large dissolving tank with mixers to generate an approximate 0.25-percent solution. The dilute sodium fluorosilicate solution is then pumped or conveyed by gravity to an appropriate injection point in the treated water system.

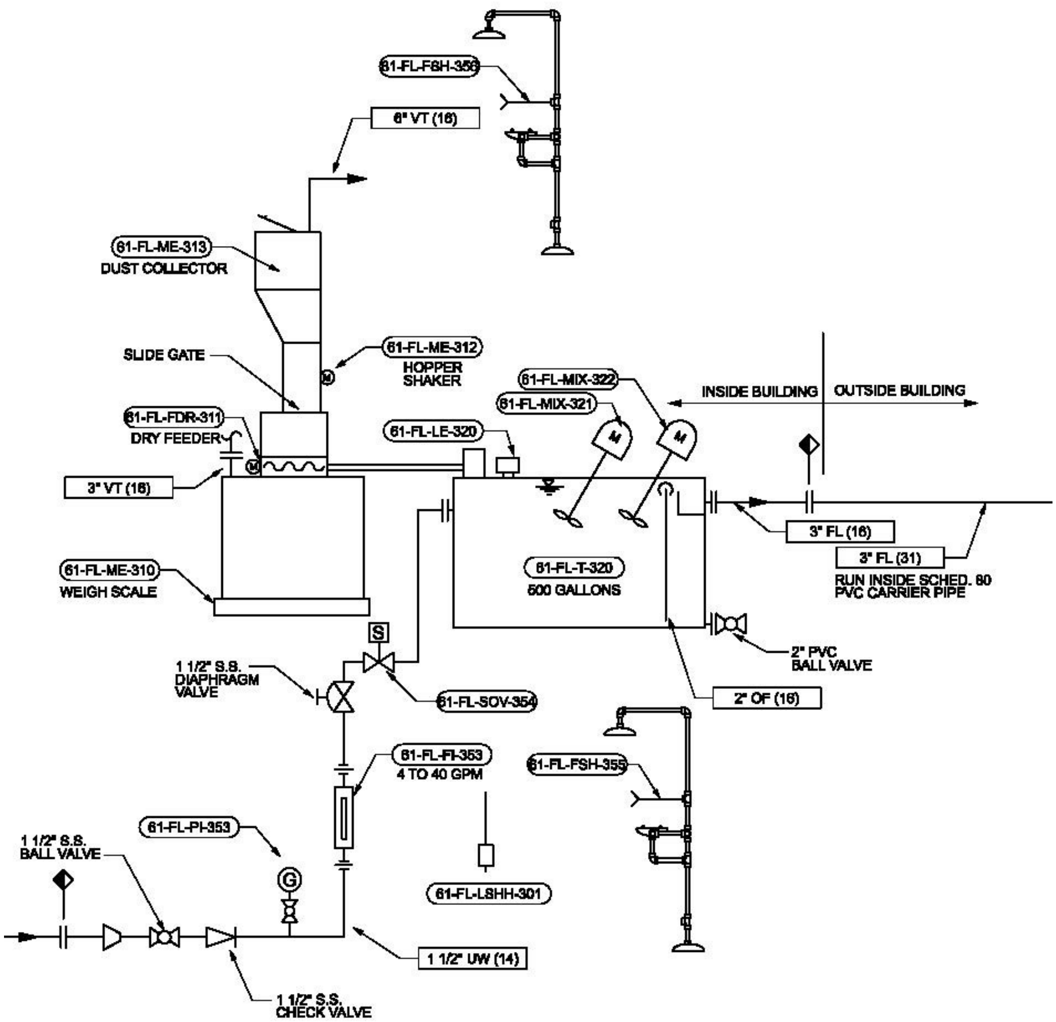


Figure 3 – Typical Sodium Fluorosilicate System

Operators add additional bags of sodium fluorosilicate to the chemical feed hopper as the product is removed by the volumetric feeder. Appropriate operator safety gear is required for the refilling operation. The chemical feed hopper is typically equipped with a loss-of-weight recorder to monitor chemical supply and to send an alarm at low-hopper chemical weight.

Dry feeder operations are generally more complex, more maintenance intensive, and more costly compared to a saturator system or a liquid fluorosilicic acid system. Dry feeders require more operator intervention to supply chemical to the feeder, to ensure the feeder has not caked or clogged, and to check the dissolving chamber to make sure that the chemical is completely dissolved before discharge and that no buildup of undissolved chemical has occurred. Because of the operator time required, as well as relative equipment costs, sodium fluorosilicate would not typically be recommended for smaller remote locations. Therefore, it will not be considered for use at the well sites, but will be considered for the Wohler and River Road Facilities.

Fluorosilicic Acid – Liquid Feed System

Fluoride addition using fluorosilicic acid requires only a liquid feed system similar to those used for other water treatment liquid chemicals such as alum or caustic soda (Refer to **Figure 4**). The key elements of a liquid feed system at a larger installation, such as would be required for the Wohler and River Road Facilities, are the bulk storage tank and the metering pumps. At smaller installations, such as the well sites, a single storage/feed tank providing a 7- to 14-day supply is typically used. Because fluorosilicic acid may be suitable for both larger sites and smaller remote well sites, this chemical will be considered for use at both the Wohler and River Road Facilities and at the well sites.

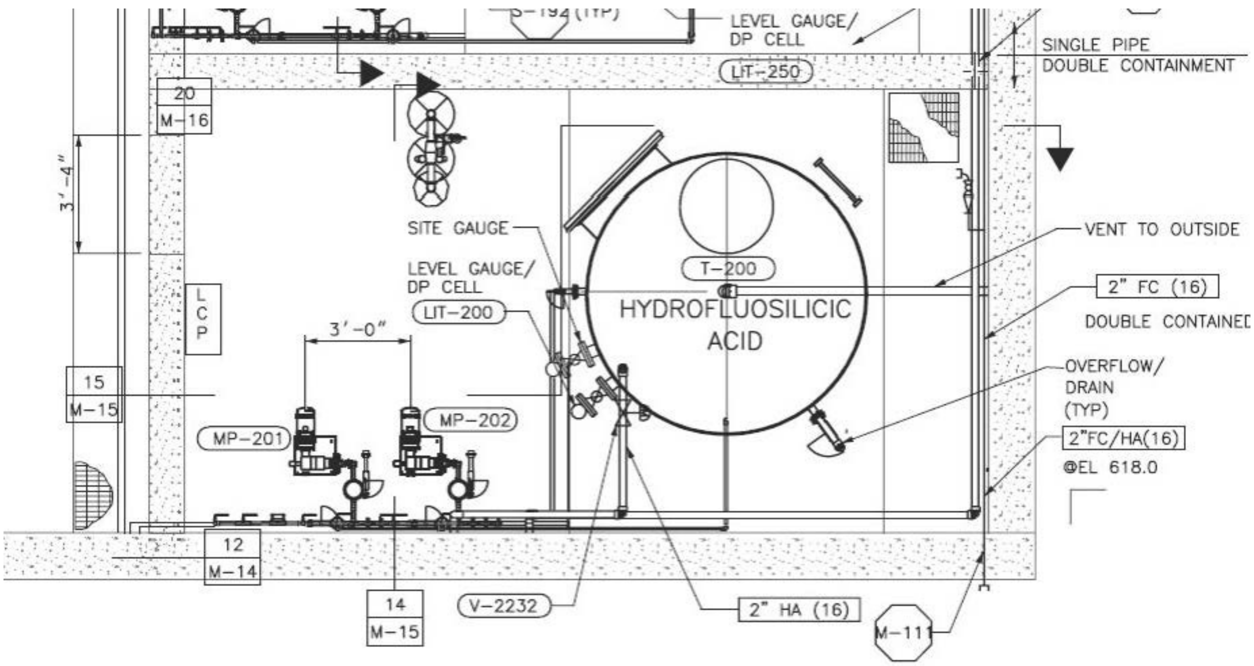


Figure 4 – Typical Fluorosilicic Acid System at Water Treatment Plant

At larger installations, such as the Wohler and River Road Facilities, a bulk fluorosilicic acid storage tank with approximately 30 days of storage and with sufficient additional storage to allow full tanker deliveries would typically be used. At very large installations or installations where all bulk tanks are grouped remotely, a day tank may be included in the system. An indoor day tank would be typically sized at a maximum of 500 gallons to avoid threshold fire sprinkler requirements. From the bulk tank or day tank, metering pumps are used to inject the fluorosilicic acid into the treated water pipeline, either with or without carrier water. Depending on the system, carrier water may improve mixing and reduce the risks associated with pumping concentrated acid.

At well sites, the storage/feed tank is generally filled either by a contracted chemical supplier, typically with a treatment operator present, or by treatment operators. The use of a contracted chemical supplier requires close staff coordination with the supplier, but has the benefit of reducing staff exposure to the acid. The use of treatment operators for deliveries would typically include either transfer from the bulk storage tank to a 275-gallon chemical tote or direct purchase of fluorosilicic acid in 55-gallon drums. The tote or drum would then be transferred to a delivery vehicle and transported to the well site where the acid would be transferred to the storage/feed tank.

Relative Operational Advantages and Disadvantages of the Chemical Systems

As noted in the preceding paragraphs, only sodium fluorosilicate and fluorosilicic acid will be considered for the Wohler and River Road Facilities, while only sodium fluoride and fluorosilicic acid will be considered for well sites. In both cases the selection is between a chemical in dry form versus a chemical in liquid form. In general, the liquid fluorosilicic acid system is less complex and requires less operator intervention than the dry chemical systems. However, as previously noted, fluorosilicic acid is a highly corrosive chemical that requires extra care and restrictive feed system materials selection. A summary of the relative operational advantages and disadvantages of the chemical systems is included in **Tables 4 and 5** for the respective applications at the Wohler and River Road Facilities and at the well sites.

Table 4 – Wohler and River Road Facilities - Operational Advantages and Disadvantages of Fluoride Feed System Chemicals

Compound	Advantages	Disadvantages
Sodium Fluorosilicate (Na_2SiF_6) (Powder/Crystal)	Chemical has acute health impact from occupational exposure than fluorosilicic acid Fewer pounds of chemical shipped and reduced storage area due to greater concentration of fluoride ion per pound.	More mechanically complex system Chemical must be kept in dry indoor storage area Need to properly dispose of chemical containers Requires dust control system - dust is toxic, handling requires respirator and full chemical suit Requires more routine chemical handling by staff Requires more routine maintenance by staff Solubility is temperature dependent Decreases pH, requiring additional caustic soda usage (roughly half the pH reduction caused by fluorosilicic acid)
Fluorosilicic Acid (H_2SiF_6) (Liquid)	Less routine chemical handling for staff Less routine maintenance for staff Consistent solubility and chemical strength Chemical widely available and used by other local water	Highly corrosive/hazardous agent Larger storage volume required due to lower fluoride ion concentration in liquid form Decreases pH, requiring additional caustic soda usage Requires double-containment system and ventilation

Table 5 – Well Sites - Operational Advantages and Disadvantages of Fluoride Feed Systems Chemicals

Compound	Advantages	Disadvantages
Sodium Fluoride (NaF) (Powder/Crystal)	Chemical has less acute health impact from occupational exposure than fluorosilicic acid No impact on pH Fewer pounds of chemical shipped and reduced storage area due to greater concentration of fluoride ion per pound.	Requires more routine chemical handling by staff Dust is toxic, handling requires respirator and full chemical suit Chemical must be kept in dry indoor storage area Need to properly dispose of chemical containers
Fluorosilicic Acid (H_2SiF_6) (Liquid)	Less routine chemical handling for staff Chemical widely available and used by other local water purveyors including City of Fairfield and Marin County	Highly corrosive/hazardous agent Larger storage volume required due to lower fluoride ion concentration in liquid form Decreases pH, which may impact process water corrosion potential Requires double-containment system and ventilation

Recommendations for Fluoridation System Chemicals

The evaluation of the alternative fluoridation chemical systems for use at the Wohler and River Road Facilities was performed separately from the well site evaluation. The recommended chemical systems for the Wohler and River Road facilities and the well sites will be further developed later in the preliminary engineering report where detailed designs and project cost estimates will be presented.

Wohler and River Road Facilities Fluoridation Systems Evaluation and Recommendation

The fluoridation facilities at the Wohler and River Road sites will be sized to accommodate future (2035) flow rates. The minimum, average, and maximum flow rates through the Santa Rosa AQ to be fluoridated at the Wohler Facility would be 5.0, 23.3, and 40 MGD respectively. For the River Road Facility fluoridating the Cotati Intertie Pipeline, minimum, average, and maximum flow rates would be 5.0, 30.1, and 59.8 MGD, respectively. Both facilities have sufficient space to accommodate a new building with new fluoridation facilities and chemical truck access. It is assumed that fluoride would be fed into the system near the existing chlorine injection point for both sites.

Only fluorosilicic acid and sodium fluorosilicate are considered for use at the Wohler and River Road Facilities. Sodium fluoride will not be considered because the saturator systems in which it is most effective are not easily scalable to water flow rates above approximately 3 MGD. The following evaluation compares the facility requirements, and relative merits of the fluorosilicic acid and sodium fluorosilicate systems.

The use of fluorosilicic acid at either the Wohler facility or River Road facility would require a bulk chemical storage tank and a fluoridation building with metering pump. Two criteria were used to size the storage tank: the greater of 30 days minimum storage at design dose and average future flow rate and the volume required by a 4000-gallon delivery truck plus an additional 1000-gallon storage buffer. A single 5000-gallon bulk storage tank was selected. This would accommodate full truckload deliveries and would provide 64 and 42 days storage at the Wohler and River Road sites, respectively. It is further assumed that an approximate 20- by 26-foot concrete masonry unit (CMU) building would be required for the fluoride facilities. The fluoride building would contain the bulk storage tank, chemical metering pumps, and electrical and instrumentation equipment. Fluoride chemical piping as well as electrical and instrumentation wiring would be trenched among the storage tanks, metering pumps, system injection point, and other existing facilities as required. Carrier water is not recommended for the system since there is ample mixing opportunity in the two transmission pipelines and it would add unnecessary complexity and maintenance to the system. A day tank is not recommended at either facility since it adds complexity to the system and offers no benefit relative to fire sprinkler requirements as the main storage tanks will be indoors and will trigger the sprinkler requirement.

A sodium fluorosilicate system at either the Wohler facility or River Road facility would require a dry chemical storage area as well as a chemical feed area. It is assumed that a 2-story building arrangement would be used to facilitate the process of filling hoppers with 50-pound bags of chemical. An approximate 25- by 25-foot CMU building would be required to provide a 30-day supply of sodium fluorosilicate, stored on pallets, as well as the required feed facilities. Four to five pallets would be required to store the 7,100 to 11,000 pounds of chemical required per month at the future average flow rate of each of the 2 facilities. It is assumed that the feed facilities would include one train which includes a bag-loading system and chemical hopper with weight scale, a volumetric dry feeder, a dissolving tank with mixer, and a pump to direct the chemical solution to the injection point.

As part of the evaluation of fluoridation chemicals, a comparison of the relative life cycle costs (capital and O&M costs) of fluorosilicic acid and sodium fluorosilicate systems was performed using the preliminary design information developed in this TM and costs from similar projects. Parametric cost estimating methods, in which costs from similar facilities are scaled to reflect probable costs of planned facilities, were used in the effort. The cost estimates accounted for initial capital costs and O&M costs, and assess the relative costs on a present worth basis assuming an annual inflation rate of 3 percent over a 20-year planning period. The results are shown in **Table 6**. An all-inclusive labor cost of $131.00/hr. was used in the analysis as well as the following chemical costs:

- Fluorosilicic Acid – Bulk Delivery to WTP - $ 4.19 per gallon ($2.30/lb. fluoride ion).
- Fluorosilicic Acid – Mini-Bulk Delivery to well sites – $ 7.62 per gallon plus service fee (approximately $4.62/lb. fluoride ion).
- Sodium Fluoride – 50-lb. bags - $1.20/lb. ($2.71/lb. fluoride ion).
- Sodium Fluorosilicate – 50-lb. bags - $1.58/lb. ($2.64/lb. fluoride ion).
- Caustic Soda – Bulk Delivery to WTP – $0.28/lb.

Table 6
COUNTY OF SONOMA DEPARTMENT OF HEALTH SERVICES - ADMINISTRATION DIVISION
FLUORIDATION DESIGN CRITERIA TM

Wohler and River Road Water Treatment Sites - Relative Chemical Cost Comparison of Fluoride Chemical Forms

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	ITEM COST	CATEGORY COST
FLUOROSILICIC ACID STORAGE AND FEED FACILITIES RELATIVE PROJECT COST						
1	Feed Building and Site Work (CMU 20x26)	1	EA	$310,000	$310,000	
2	Bulk Storage Tank (5,000 gal, Poly)	1	EA	$50,000	$50,000	
3	Metering Pumps (2 @ 15 gph, hydraulic diaphragm, complete)	1	LS	$30,000	$30,000	
4	Piping, Miscellaneous Equipment, and Appurtenances	1	LS	$30,000	$30,000	
5	Electrical, Controls, and Wiring	1	LS	$70,000	$70,000	
Subtotal Fluorosilicic Acid Storage and Feed Facilities Relative Construction Cost					**$490,000**	
	Contingency			30%	**$147,000**	
Total Fluorosilicic Acid Storage and Feed Facilities Relative Construction Cost					**$637,000**	
Grand Total Fluorosilicic Acid Storage and Feed Facilities Relative Construction Cost for 2 Facilities						**$1,274,000**
Annual Chemical Cost (16,900 MG @ 0.9 mg/L dose @ $4.19/gal, and caustic 1.5mg/L dose @ $0.28/lb)[1]					**$397,000**	
Present Worth of Annual Chemical Cost (i=3% n=20yrs)						**$5,911,000**
Annual Non-Chemical Labor O&M Cost (both sites)					**$5,000**	
Present Worth of Annual Non-Chemical Labor O&M Cost (i=3% n=20yrs)						**$70,000**
Total Fluorosilicic Acid Storage and Feed Facilities Relative Project Cost						**$7,255,000**
SODIUM FLUOROSILICATE STORAGE AND FEED FACILITIES						
1	Storage and Feed Building (CMU, 2 storey, 25x25)	1	EA	$170,000	$170,000	
2	Bag Loading System and Hopper with Scale	1	EA	$100,000	$100,000	
3	Volumetric Dry Feeder	1	EA	$20,000	$20,000	
4	Dissolving Tank with Mixers	1	EA	$30,000	$30,000	
5	Injection Pumps (10 gpm at max flow & dose)	2	EA	$10,000	$20,000	
6	Piping, Miscellaneous Equipment, and Appurtenances	1	LS	$100,000	$100,000	
7	Electrical, Controls, and Wiring	1	LS	$90,000	$90,000	
Subtotal Sodium Fluorosilicate Storage and Feed Facilities Relative Construction Cost					**$530,000**	
	Contingency			30%	**$159,000**	
Total Sodium Fluorosilicate Storage and Feed Facilities Relative Construction Cost					**$689,000**	
Grand Total Sodium Fluorosilicate Storage and Feed Facilities Relative Construction Cost for 2 Facilities						**$1,378,000**
Annual Chemical Cost (16,900 MG @ 0.9 mg/L dose, $1.58/lb, and caustic 0.75mg/L dose at $0.28/lb)[1]					**$387,000**	
Present Worth of Annual Chemical Cost (i=3% n=20yrs)						**$5,765,000**
Annual Non-Chemical Labor O&M Cost (both sites)					**$304,000**	
Present Worth of Annual Non-Chemical Labor O&M Cost (i=3% n=20yrs)						**$4,525,000**
Total Sodium Fluorosilicate Storage and Feed Facilities Relative Project Cost						**$11,668,000**

1 - Annual flow based on combined average daily flow for Santa Rosa AQ and Cotati Intertie

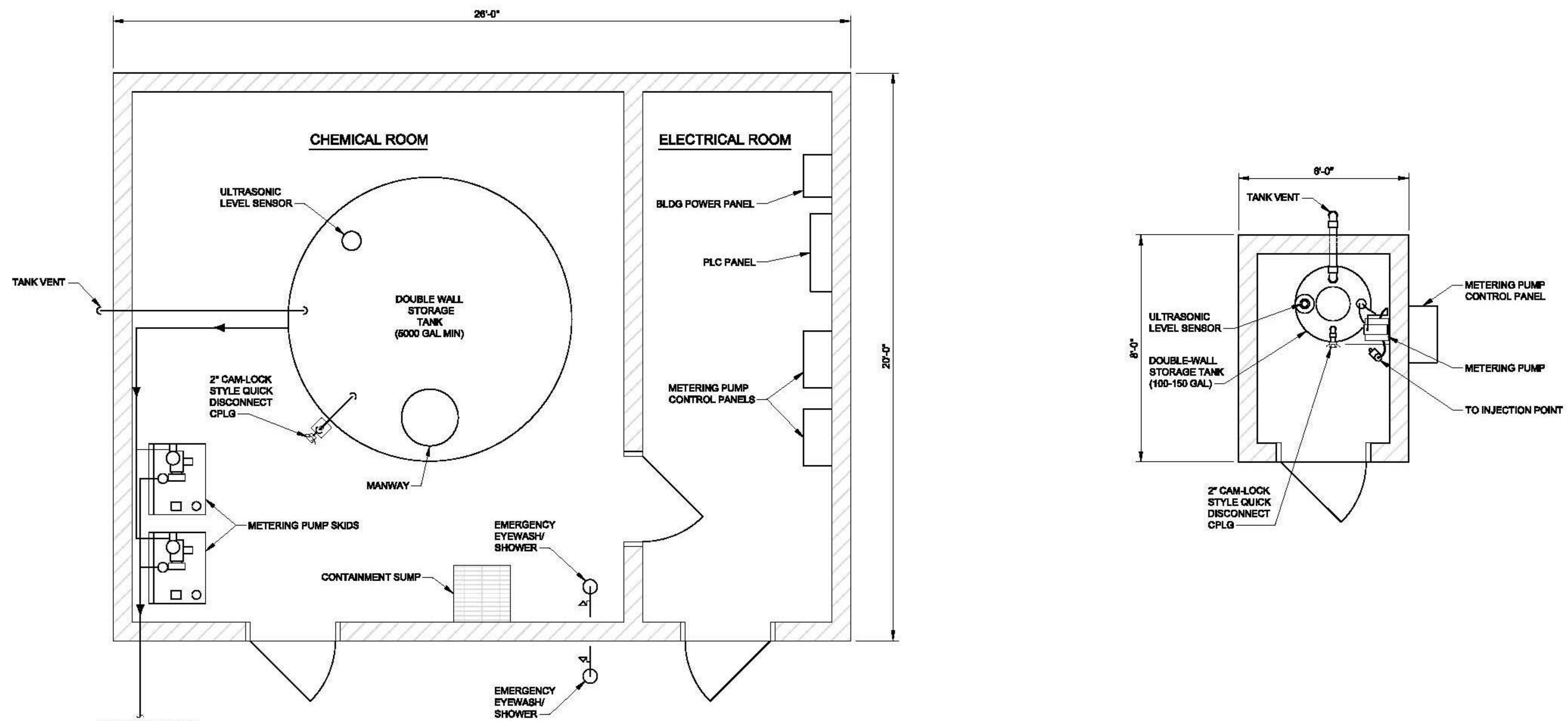
The results showed the present worth cost of the sodium fluorosilicate system to be over 60-percent higher than the fluorosilicic acid system. Although the annual costs for the sodium fluorosilicate and fluorosilicic acid chemicals were close, the non-chemical labor O&M costs for the sodium fluorosilicate system were significantly higher. Additional labor hours would be needed for the sodium fluorosilicate system to perform the routine pallet moving and daily bag dumping duties (which would require additional time for putting on and taking off chemical protective clothing and a respirator), as well as increased maintenance labor for the more complex mechanical equipment. It should be noted that these costs were very preliminary and were developed parametrically, but the results highlight the additional manpower requirements for sodium fluorosilicate system operation and maintenance.

Dry feed chemical systems are generally less popular than liquid chemical systems with WTP staff due to greater complexity, increased maintenance requirements, and higher probability of system breakdown. In an interview with a Sacramento County Water Agency operations staff member at the Vineyard Surface WTP, which uses sodium fluorosilicate for fluoridation, experience has shown that bag loading activities are frequent and time consuming, which takes away the availability of operations staff from performing other required activities. Equipment maintenance is much more involved than their previous experience with systems using fluorosilicic acid, which is what operations staff prefers. Based on the operational challenges and greater overall cost associated with the sodium fluorosilicate system, the liquid fluorosilicic acid is recommended for use at the Wohler and River Road Facilities. Refer to **Figure 5** for a preliminary typical fluoride building layout.

Well Site Fluoridation System Evaluation and Recommendation

The Santa Rosa Plain well sites range in capacity from approximately 1.5 to 2 MGD each, for a total capacity of approximately 5.5 MGD (3,820 gpm) for the three wells. It is understood that annual well production varies and may be zero in some years, but for cost purposes is was assumed that the three wells would operate for four months per year. Individual well site constraints were not considered in this evaluation since the space requirements for the alternative fluoridation systems are not significantly different and therefore the choice between alternative chemicals would not be affected.

Only fluorosilicic acid and sodium fluoride will be considered for use at the well sites. Sodium fluorosilicate will not be considered because it involves relatively complicated mechanical equipment and the associated high initial cost makes it both impractical and not cost competitive at the three remote well sites. The following evaluation compares the facility requirements, relative capital and O&M costs, and relative merits of the fluorosilicic acid and sodium fluoride systems.



TYPICAL FLUORIDATION BUILDING LAYOUT FOR WOHLER AND RIVER ROAD FACILITIES
SCALE: 1/4" = 1'-0"

TYPICAL FLUORIDATION BUILDING LAYOUT FOR WELL SITES
SCALE: 1/4" = 1'-0"

MWH	SONOMA COUNTY DEPARTMENT OF HEALTH SERVICES	FLUORIDATION PRELIMINARY ENGINEERING DESIGN REPORT WOHLER AND RIVER ROAD FACILITIES AND WELL SITES TYPICAL LAYOUTS	FIGURE 5

The use of fluorosilicic acid at the well sites would require a chemical storage/feed tank, a chemical metering pump, and a small building to house this equipment for each well site. The wells would each require a 100- to 150-gallon, double-contained tank to provide approximately 14 days of storage at a 0.9-mg/L dose and the 1.5 to 2.0 MGD well flow rate. It was assumed that an approximate 6- by 8-foot CMU building would be required to house the tank and metering pump, although a more economical prefabricated fiberglass building enclosure could be considered. Fluoride chemical piping, as well as electrical and instrumentation wiring, would be trenched among the metering pump, system injection point, and other existing facilities, as required. Fluorosilicic acid would be pumped "neat" to the injection point in double-contained piping. It is assumed that fluorosilicic acid would be delivered to a well site every 7 to 14 days by a chemical supply company.

A sodium fluoride saturator system at the well sites would require facilities very similar to the fluorosilicic acid system. The wells would require a 70-gallon saturator tank in place of the liquid fluorosilicic acid storage/feed tank, and would require a larger metering pump to inject the more dilute chemical solution (approximately 4-percent solution vs. fluorosilicic acid's 23-percent solution). The saturator system would also require a water softener to prevent precipitation of insoluble calcium fluoride (CaF_2) in the saturator tank. It is assumed that the water softener will be a cylinder tank that is replaced periodically by a water softener supply service. It is assumed that a 6- by 6-foot CMU building (or more economical similar-sized prefabricated fiberglass shed) will be suitable for the sodium fluoride saturator facilities. Fluoride chemical piping, as well as electrical and instrumentation wiring, would be trenched among the metering pump, system injection point, and other existing facilities, as required. Fluoride would be pumped as a 4-percent solution from the saturator to the injection point in double-contained piping. It is assumed that the Water Agency personnel would deliver sodium fluoride to each site one to two times per week, adding up to 200 pounds (up to four 50-pound bags) of sodium fluoride to each saturator tank. It is further assumed that sodium fluoride would be stored on pallets at an existing centralized location by the Water Agency.

A comparison of the relative capital and O&M costs of the fluorosilicic acid and sodium fluoride systems was performed in a similar fashion to those prepared for the Wohler and River Road Facilities. The results are shown in **Table 7**. The results indicated that the relative present worth costs of the two systems were close, with the sodium fluoride system approximately 4-percent lower than the fluorosilicic acid system. The chemical cost was higher for the fluorosilicic acid system, but the non-chemical cost (initial capital and O&M costs) was higher for the sodium fluoride system.

Table 7
COUNTY OF SONOMA DEPARTMENT OF HEALTH SERVICES - ADMINISTRATION DIVISION
FLUORIDATION DESIGN CRITERIA TM

Typical SCWA Well Site - Relative Cost Comparison of Fluoride Chemical Forms

ITEM NO.	DESCRIPTION	QUANTITY	UNITS	UNIT PRICE	ITEM COST	CATEGORY COST
	FLUOROSILICIC ACID STORAGE AND FEED FACILITIES RELATIVE PROJECT COST					
1	Feed Building and Site Work (6x8 CMU)	1	EA	$40,000	$40,000	
2	Chemical Tank (120 gal)	1	EA	$4,000	$4,000	
3	Metering Pump (0.5 gph, solenoid diaphragm, complete)	1	EA	$3,000	$3,000	
4	Piping, Miscellaneous Equipment, and Appurtenances	1	LS	$30,000	$30,000	
5	Electrical, Controls, and Wiring	1	LS	$40,000	$40,000	
	Subtotal Fluorosilicic Acid Storage and Feed Facilities Relative Construction Cost				**$117,000**	
	Contingency			30%	**$36,000**	
	Total Fluorosilicic Acid Storage and Feed Facilities Relative Construction Cost				**$153,000**	
	Grand Total Fluorosilicic Acid Storage and Feed Facilities Relative Construction Cost for 3 Well Sites					**$459,000**
	Annual Chemical Cost (5.5 MGD for 4 months annually = 720 MG @ 0.9 mg/L dose)[1]				**$25,000**	
	Present Worth of Annual Chemical Cost (i=3% n=20yrs)					**$372,000**
	Annual Non-Chemical Labor O&M Cost (4 month operation for all 3 wells)				**$6,000**	
	Present Worth of Annual Non-Chemical O&M Cost (i=3% n=20yrs)					**$94,000**
	Total Fluorosilicic Acid Storage and Feed Facilities Relative Project Cost					**$925,000**
	SODIUM FLUORIDE STORAGE AND FEED FACILITIES					
1	Feed Building and Site Work (6x8 CMU)	1	EA	$40,000	$40,000	
2	Saturator Tank (70 gal)	1	EA	$3,000	$3,000	
3	Metering Pump (34 gph, mechanical diaphragm, complete)	1	EA	$9,000	$9,000	
4	Piping, Miscellaneous Equipment, and Appurtenances	1	LS	$30,000	$30,000	
5	Electrical, Controls, and Wiring	1	LS	$40,000	$40,000	
	Subtotal Sodium Fluoride Storage and Feed Facilities Relative Construction Cost				**$122,000**	
	Contingency			30%	**$37,000**	
	Total Sodium Fluoride Storage and Feed Facilities Relative Construction Cost				**$159,000**	
	Grand Total Sodium Fluoride Storage and Feed Facilities Relative Construction Cost for 3 Well Sites					**$477,000**
	Annual Chemical Cost (5.5 MGD for 4 months annually = 720 MG @ 0.9 mg/L dose)[1]				**$15,000**	
	Present Worth of Annual Chemical Cost (i=3% n=20yrs)					**$218,000**
	Annual Non-Chemical Labor O&M Cost (4 month operation for all 3 wells)				**$13,000**	
	Present Worth of Annual Non-Chemical Labor O&M Cost (i=3% n=20yrs)					**$190,000**
	Total Sodium Fluoride Storage and Feed Facilities Relative Project Cost					**$885,000**

1 - Annual flow based on approximate combined flow for all 3 wells and assumed operation of 4 months per year.

Based on its proven track record and benefits for water treatment staff, MWH recommends that the Water Agency use the fluorosilicic acid liquid feed system to fluoridate treated water at the well sites. Refer to **Figure 5** for a preliminary typical well site fluoride building layout. The fluorosilicic acid system for the well sites is very simple and has been used successfully by other utilities for many years. In addition, problems with inconsistent feed chemical concentration and problems with "bridging" of the sodium fluoride crystals in saturator tanks have been reported. In an interview with a former City of Sacramento operations staff member (currently an operator with the Sacramento County Water Agency) who performed operations and maintenance activities for many of their wells equipped with sodium fluoride saturator systems, the piping within the saturators were prone to plugging, and solids carryover and crystallization into the discharge and injection piping often occurred, requiring unforeseen maintenance from operations staff. The problems were occurring in spite of water softening systems supplying the solution water to the saturators at all sites. More maintenance was required for the saturator systems than with systems using fluorosilicic acid at the City's two water treatment plants.

Additionally, the sodium fluoride system is more difficult for water treatment personnel, especially in the hot summer months, as they must wear chemical-protective suits and respirators to dump the bags of sodium fluoride at the unshaded well sites.

An alternative approach to fluoridation systems at the well sites is to consider no fluoridation treatment at the wells. If the wells are only operated during higher flow periods, such that they provide supplemental water only when the flow rates in the Cotati Intertie are high, the result of the blending would be only a slightly lower fluoride residual. For example, if the River Road facility is producing 48 MGD of water with a fluoride residual of 0.9 mg/L, while all three wells are on and producing non-fluoridated water at a combined flow of 5.5 MGD, the resulting combined fluoride level will be a minimum of 0.8 mg/L. This blended water with a slightly lower residual would still be in compliance with the CDPH required range of 0.8 to 1.4 mg/L for a target design dose of 0.9 mg/L. Similarly, with a non-fluoridated well flow of 2.0 MGD (one of the larger wells operating), the Cotati Intertie flow could be as low as 18 MGD and still maintain a blended fluoride level of 0.8 mg/L. If the non-fluoridated well system were operated manually, operations staff would need to monitor flow rates and confirm that if one or more wells are on, the required Cotati Intertie flow rates are met. The SCADA system could also be modified to monitor well pump status and Cotati Intertie flow rate and generate an alarm if the minimum flow rates are not met.

Alternatively, the River Road fluoridation facility could add fluoride at a slightly higher dose such that the blended water would have the target 0.9 mg/L fluoride level. The Forestville BPS turnout upstream of the wells would have slightly higher fluoride concentration but still within the CDPH range. For example, if the wells were contributing 6 MGD of non-fluoridated water and the Cotati Intertie flow were 16 MGD, the River Road facility metering pumps would ramp up to produce a fluoride dose of slightly over 1.2 mg/L to maintain the optimal blended fluoride level of 0.9 mg/L. SCADA communication and interlocks between the River Road fluoridation facility and each of the wells would be required in order to ensure the optimum fluoride dose is maintained and over-fluoridation could not occur.

Either of the above alternatives for eliminating fluoridation at the well sites would need to be discussed and negotiated with CDPH. Both alternatives would require CDPH acceptance of fluoride levels either higher or lower than the optimal level for portions of the system. The probability of acceptance would likely depend in part on how frequent and for what duration the non-optimal fluoride levels would persist. Further development of the two options is recommended for the next phase of design. The preliminary design report will include fluoridation facilities for the well sites since CDPH approval of non-fluoridation alternatives is not certain.

DESIGN CRITERIA

Design criteria for the fluoridation facilities were developed using water system goals and requirements, regulatory requirements, industry standards, and MWH's experience in the design of similar facilities. Separate design criteria were developed for the Wohler and River Road facilities and the well sites.

Wohler and River Road Facilities Design Criteria

The design criteria established for fluoridation facilities at the Wohler facility is summarized in **Table 8**, and at the River Road facility in **Table 9**.

Table 8 – Wohler Fluoridation Facility Design Criteria

Description	Criteria
Fluoride chemical	Fluorosilicic Acid
Maximum daily water production rate	40.0 MGD
Average daily water production rate	23.3 MGD
Minimum daily water production rate	5.0 MGD
Design fluoride level	0.9 mg/L
Additional caustic soda dose required for pH neutralization	1.5 mg/L
Fluoride storage requirements	One 5,000 gal tank.
Fluoride storage tank type	Double-contained polyethylene
Fluoridation building type	CMU block building, mechanically ventilated
Fluoridation building size	20 ft x 26 ft
Metering pump type	Hydraulically actuated diaphragm
Metering pump maximum flow range	Approx. 0.70 to 5.8 gallons per hour (gph)
Fluoride injection location	New vault near existing backup chlorine injection location
Fluoride residual measurement	Fluoride analyzer with sample piping tap at current pH analyzer tap

Table 9 – River Road Fluoridation Facility Design Criteria

Description	Criteria
Fluoride chemical	Fluorosilicic Acid
Maximum daily water production rate	59.8 MGD
Average daily water production rate	30.1 MGD
Minimum daily water production rate	5.0 MGD
Design fluoride dose	0.9 mg/L
Additional caustic soda dose required for pH neutralization	1.5 mg/L (maximum – dependent upon downstream well status and need to compensate for pH depression of wells due to addition of fluoride at downstream wells)
Fluoride storage requirements	One 5,000 gal tank.
Fluoride storage tank type	Double-contained polyethylene
Fluoridation building type	CMU block building, mechanically ventilated
Fluoridation building size	20 ft x 26 ft
Metering pump type	Hydraulically actuated diaphragm
Metering pump maximum flow range	Approx. 0.71 to 8.5 gallons per hour (gph)
Fluoride injection location	New manhole near existing chlorine injection location
Fluoride residual measurement	Fluoride analyzer with sample piping tap at current pH analyzer tap

Well Site Design Criteria

The design criteria established for fluoridation facilities at the well sites are summarized in **Table 10**.

Table 10 – Well Sites Design Criteria

Description	Criteria
Fluoride chemical form	Fluorosilicic Acid
Well flow rate	1.5 to 2.0 MGD depending on well site
Design fluoride dose	0.9 mg/L
Fluoride storage requirements	Minimum 10-day supply at max flow and design dose, target 14-day supply
Fluoride storage tank type	Double-contained polyethylene
Fluoride storage tank sizes	120 gallons
Fluoride building type	CMU block building (or alternate prefabricated fiberglass), mechanically ventilated
Fluoride building sizes (Inner Dimensions)	Maximum 6' by 8'
Metering pump type	Solenoid actuated diaphragm
Metering pump maximum flow range	0.22 to 0.34 gph (range varies depending on well site)
Fluoride injection location	Well discharge piping, exact location to be determined. Feed pipe to be double contained.
Fluoride mixing requirement	Fluoride fed neat. Wafer-type static mixer may be required depending on individual site conditions.
SCADA requirements	Existing SCADA to be expanded
Fluoride residual measurement	Fluoride analyzer to be provided at each well site

Appendix C – Fluoridation Facilities Capital Cost Detail

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Sonoma County Health Services
Fluoridation Preliminary Engineering Report
River Road Facility

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 2,070,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
A.		**Genl Site Development**				$28,600	
1	P	Sawcut Asphalt	50	lf	$7.00	$350	
2	P	Remove Asphalt	150	cys	$20	$3,000	
3	S	Demo (e) Retaining Wall at pH Bldg	1	ls	$2,000	$2,000	
4	S	Medium to Vegetative Heavy Clearing	1	ls	$3,000	$3,000	
5	S	Misc Earthworks/Grading at Access Road	1	dy	$3,500	$3,500	
6	S	Extend Paving at Access Road & Front Ret Wall	500	sf	$6.00	$3,000	(3.5" AC over 9")
7	S	Bulk Excavation at Hillside	500	cys	$15.00	$7,500	to waste/stkpl - on-site
8	S	Structural Backfill at Bldg Back Wall	250	cys	$15.00	$3,750	
9	S	Misc Grading at Hill Slope	1	ls	$2,500	$2,500	hand work, etc. grade to drain, compact
B.		**Yard Piping**				$34,250	
1	P	New Fluoride Injection Manhole - 12'	1	ea	$9,000	$9,000	
2	P	Injection Quill	1	ea	$2,000	$2,000	
3	P	Dbl Contained Piping (1" & 1/2" Schld 80 CPVC)	100	lf	$23	$2,250	
4	S	Injection Hot Tap Allowance	1	ls	$15,000	$15,000	
5	p	PW Tie-In Allowance	1	ls	$3,000	$3,000	
6	P	Sewer or SD Tie-in Allowance	1	ls	$3,000	$3,000	
C.		**Fluoride Building (2 story)**				$433,114	$382
1	P	***Civils***					
2	P	Shoring Allowance	-	sf	$30.00	$0	See Constructability
3	P	Slab/Fdn Structural Excavation	30	cys	$40.00	$1,200	ftg, slab excavation
4	S	Driller Mobe/Setup	1	ls	$10,000	$10,000	
5	S	Drilled 24" dia Piers	17	cys	$700.00	$11,729	say 9 each at 16' deep, incls rebar cage
6	P	Aggregate Base @ Slab Fdn 1'	27	cys	$52.00	$1,387	
7	P	Concrete Foundation SOG 1.5'	40	cys	$350	$14,000	
8	P	Concrete Retaining Wall & Ftg Near Street - 5'	9	cys	$650	$5,633	1' wide
9	P	Concrete Retaining Wall & Ftg Near Street - 3'	4	cys	$650	$2,456	<ditto>
10	P	Concrete Retaining Wall & Ftg at Back Bldg Wall - 11'	10	cys	$650	$6,356	"
11	P	Concrete Retaining Wall & Ftg Near Hill - 5'	9	cys	$650	$5,633	"
12	P	Concrete SW at Bldg Entrance	4	cys	$350	$1,361	
13	P	Concrete SW Near Street w/ Steps	4	cys	$650	$2,528	
14	P	Concrete Tank Equipment Pad	7	cys	$800	$5,807	
15	P	Concrete Valley Gutter at Back Hill	4	cys	$500	$2,222	
16	P	Reinforcing Steel	18,100	lb	$1.00	$18,100	at 200 #/cy
17	S	Structural Backfill	20	cys	$35.00	$683	
18	S	CMU Block at Retaining Wall	190	sf	$20.00	$3,800	
19	S	CMU Block Bldg Walls	1,340	sf	$20.00	$26,800	
20	S	CMU Interior Walls	210	sf	$17.00	$3,570	
21	S	Exterior Metal Doors	3	ea	$1,350	$4,050	
22	S	Interior Metal Doors	1	ea	$950.00	$950	
23	S	Roof Structural System w/ Metal Decking	720	sf	$32.50	$23,400	removable roof spec
24	S	Roof Shingle Overlay	720	sf	$15.00	$10,800	
25	S	Roof Specialties	720	sf	$5.00	$3,600	vents, flashing, etc.
26	S	HVAC Allowance	720	sf	$35.00	$25,200	fans, AHUs, louvers
27	P	Interior Containment Sump	1	ls	$3,500	$3,500	
28	S	Metal Stairs	30	riser	$325	$9,750	
29	S	Misc. Metals/Gratings/Pipe Support	1	ls	$15,000	$15,000	
30	P	Wall Spools/Piping Connects	1	ls	$10,000	$10,000	
31	S	Dampproofing/Process/Corrosion Coatings	1	ls	$20,000	$20,000	
32	S	Emergency Eye Shower	2	ea	$1,300	$2,600	
33	S	Bldg PW/UW/ORD Piping Allowance	1	ls	$5,000	$5,000	matls only
34	S	Fire Sprinkler Allowance	720	sf	$25	$18,000	
35	S	Landscaping Allowance	1	ls	$15,000	$15,000	front planter, back hillside
36	S	Erosion Controls at Hillside	1	ls	$15,000	$15,000	blankets, etc.
37	S	Overhead Ventilation System	1	ls	$5,000	$5,000	portable pull down
38	S	Exterior Room for Xrfm	100	sf	$100	$10,000	
39	S	***Process***					
40	P	5000 gal dbl Wall Polyethylene Chemical Tank	1	ea	$22,500	$22,500	matls only, quote (deld)
41	P	Hydraulic Diaphragm Metering Pump Skids	2	ea	$6,000	$12,000	<ditto>
42	P	Solenoid Pump	-	ea	$1,000	$0	"
43	P	Tank Connect/Vent/Chemical Feed Piping & Valves	1	ls	$5,000	$5,000	"
44	P	Mechanical Install Crew + Equip + Misc Matls	21	dys	$3,500	$73,500	4-5 man crew with matls & equipment
D.		**Electrical/I&C/Controls**				$154,250	
1	S	PLC Panel	1	ea	$5,000	$5,000	matls only
2	S	Bldg Power Panel	1	ea	$3,500	$3,500	<ditto>
3	S	Metering Pump Control Panels	2	ea	$5,000	$10,000	"
4	S	Bldg Lighting (Interior)	5	ea	$650	$3,250	"
5	S	Bldg Lighting (Exterior)	5	ea	$1,200	$6,000	"
6	S	Door Alarms	2	ea	$500	$1,000	"
7	S	Level Sensor	1	ea	$2,500	$2,500	"
8	S	HV/LV Distribution Conductors	1	lot	$7,500	$7,500	"
9	S	Power Tie-in	1	lot	$2,500	$2,500	"
10	S	Analyzers	2	ea	$7,500	$15,000	one for owner

Sonoma County Health Services
Fluoridation Preliminary Engineering Report
River Road Facility

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 2,070,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
11	S	VFDs for Metering Pumps	2	ea	$2,000	$4,000	"
12	S	Grounding Allowance	1	lot	$5,000	$5,000	"
13	S	HMI/PLC/SCADA Equipment/Install	1	lot	$15,000	$15,000	
14	S	PLC /SCADA Programming	60	hr	$150	$9,000	
15	S	UPS	1	ls	$15,000	$15,000	
16	S	Misc Electrical/Instrumentation Equip/Matls	1	ls	$5,000	$5,000	
17	S	Electrical Install Crew + Equip + Misc Matls	15	dys	$3,000	$45,000	3-4 man crew with matls & equipment
E.		**Constructability/Duration Equipment**				**$125,000**	
1	P	Build Crane Pads	-	ea	$5,000	$0	
2	P	Shoring/Temp Detwatering Allowance at Hill	1	ls	$20,000	$20,000	
3	P	Rent 50 Ton R/T Crane	3	mo	$15,000	$45,000	
4	P	Operate Crane (1)	600	hr	$100	$60,000	opr + FOG
F.		**Startup/Commission**				**$12,500**	
1	P	Startup Crew (Prime)	1	ls	$12,500	$12,500	Allowance, 5 days, punch list, training, etc.
2	S	Vendor Commissioning	1	ls	$0	$0	Allowance, costs also included in budget quotes
					Running Subtotal:	**$787,710**	
G.		**Mobilization/Field Oversight Expenses**				**$134,436**	
1	P	Contractor General Conditions (Prime)	6	mo	11%	$86,649	
2	S	Contractor General Conditions (Subcontractor)	6	mo	11%	$47,787	
3	P	Freight/Duties	1	ls	0%	$0	incl above
H.		**Estimating Allowance**				**$59,078**	
1	P	Unlisted Items Allowance	1	ls	7.5%	$59,078	known, but not priced
			Running Direct Cost Subtotal:			**$981,224**	
I.		**Markups**				**$211,473**	
1	S	Subcontractor Markups	1	ls	12.5%	**$54,304**	H/O Overheads, Job Fee & Risk (Included above), insur, bond
2	P	Prime Contractor OH&P on Subs	1	ls	5.0%	**$21,722**	ditto
3	P	Prime Contractor OH&P on Self-Perform	1	ls	10.0%	**$78,771**	ditto
4	P	Contractor Insurance Program	1	ls	2.5%	**$19,693**	Performance/Payments Bonds, Genl Liability, & Bldr's Risk
5	P	Local Sales Taxes	1	ls	8.0%	**$36,983**	CA Sales Tax on Matls = 40%
6	P	Escalation	1	ls	0.0%	**$0**	Excluded, current costs
				Running Price Subtotal:		**$1,190,000**	Total Estimated Constr Costs w/o contingency
			MU Factor:	1.213			
J.		**Project Administration & Management**				**$877,000**	
1	--	Permitting Plan	1	ls	$5,000	**$5,000**	
2	--	H&S and Haz Matls Business Plan	1	ls	$25,000	**$25,000**	Incls ISO certification
3	--	CEQA/ESA Process	1	ls	$180,000	**$180,000**	
4	--	Construction Oversight & Mgt	1	ls	15%	**$178,500**	
5	--	Engineering	1	ls	15%	**$178,500**	<ditto>
6	--	Misc Owner's Soft Costs (Oversight/Mgt)	1	ls	0%	**$0**	"
7	--	Scope Contingency/Market Conditions	1	ls	20%	**$310,000**	Design definition/estimating/market allowance
8	--	Interest During Construction	1	ls		**$0**	Financing costs excluded
9	--	Owner's Construction Contingency/Mgt Reserve	1	ls		**$0**	Excluded, owners allowance for changed field conditions
					Grand Total:	**$2,070,000**	Total Estimated Constr Costs w/ Contingency
				Cost Range:	**$1,400,000**	**$2,300,000**	Per AACE cost estimate guidelines

Assumptions
1) Specialized foundation treatment (micro-piles, etc.) is excluded.
2) Scope assumed to be consistent with CEQA approach.

Notes:
1) This OPCC is classified as a Class 3 cost estimate per AACE guidelines. Stated accuracy range = -20% to + 30%.
2) Pricing basis = 2nd Qtr 2013, escalation to midpoint of construction is excluded.
3) Pricing assumes competitive market conditions at time of tender (+3 bidders/trade).
4) Owner soft costs and project management expenses excluded.
5) Capital spare parts not included.

OPCC Disclaimer

The client hereby acknowledges that MWH has no control over the costs of labor, materials, competitive bidding environments, unidentified field conditions, financial and/or commodity market conditions, or any other factors likely to affect the OPCC of this project, all of which are and will unavoidably remain in a state of change, especially in light of high market volatility attributable to Acts of God and other market forces or events beyond the control of the parties. As such, Client recognizes that this OPCC deliverable is based on normal market conditions, defined by stable resource supply/demand relationships, and does not account for extreme inflationary or deflationary market cycles. Client further acknowledges that this OPCC is a "snapshot in time" and that the reliability of this OPCC will degrade over time. Client agrees that MWH cannot and does not make any warranty, promise, guarantee or representation, either express or implied that proposals, bids, project construction costs, or cost of O&M functions will not vary significantly from MWH's good faith Class 3 OPCC

AACE International CLASS 3 Cost Estimate - Class 3 estimates are generally prepared based on preliminary design layouts. Typically, engineering is 30% to 60% complete. They are typically used for budget approval. Virtually all Class 3 estimates use detailed cost estimating methods such as crew analysis and detailed historical pricing plus vendor quotes if available Expected accuracy ranges are from -10% to -20% on the low side and +10% to 30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 20 hours or less to perhaps more than 300 hours may be spent preparing the estimate depending on the project and estimating methodology (AACE International Recommended Practices and Standards).

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Sonoma County Health Services
Fluoridation Preliminary Engineering Report
Wohler Facility

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 1,770,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
A.		**Genl Site Development**				**$33,960**	
2	P	Sawcut Asphalt	30	lf	$7.00	$210	
3	P	Remove Asphalt	100	cys	$20	$2,000	
4	S	Misc Earthworks/Grading at Access Road	1	ls	$2,500	$2,500	
5	S	Extend Paving at Access Road & Front Ret Wall	500	sf	$6.00	$3,000	(3.5" AC over 9")
6	S	Bulk Excavation at Hillside	500	cys	$15.00	$7,500	to waste/stkpl - on-site
7	S	Structural Backfill at Bldg Back Wall	250	cys	$15.00	$3,750	
8	S	Misc Grading at Hill Slope	1	ls	$2,500	$2,500	hand work, etc. grade to drain, compact
9	S	Expanded Spill Pad/Containment Curb	500	sf	$25	$12,500	
B.		**Yard Piping**				**$33,200**	
1	P	Demo/Dispose (e) Chemical Injection Vault	1	ea	$1,000	$1,000	
2	P	New PC Chemical Injection Vault	1	ea	$6,500	$6,500	
3	P	Injection Quill	1	ea	$2,000	$2,000	
4	P	Dbl Contained Piping (1" & 1/2" Schld 80 CPVC)	120	lf	$23	$2,700	
5	S	Injection Hot Tap Allowance	1	ls	$15,000	$15,000	
6	p	PW Tie-In Allowance	1	ls	$3,000	$3,000	
7	P	Sewer or SD Tie-in Allowance	1	ls	$3,000	$3,000	
C.		**Fluoride Building (1 story)**				**$315,439**	$313
1	P	***Civils***					
2	P	Shoring Allowance	-	sf	$30.00	$0	see Genl Site Development
3	P	Slab/Fdn Structural Excavation	20	cys	$40.00	$800	ftg, slab excavation
4	P	Aggregate Base @ Slab Fdn 1'	23	cys	$52.00	$1,186	
5	P	Concrete Foundation SOG 1'	22	cys	$350	$7,778	
6	P	Concrete Retaining Wall & Ftg Near Street - 3'	4	cys	$650	$2,744	<ditto>
7	P	Concrete Tank Equipment Pad	7	cys	$800	$5,807	
8	P	Concrete Valley Gutter at Back Hill	6	cys	$500	$2,778	
9	P	Reinforcing Steel	7,900	lb	$1.00	$7,900	at 200 #/cy
10	S	Structural Backfill	13	cys	$35.00	$455	
11	S	CMU Block at Retaining Wall	130	sf	$20.00	$2,600	
12	S	CMU Block Bldg Walls	820	sf	$20.00	$16,400	
13	S	CMU Interior Walls	220	sf	$17.00	$3,740	
14	S	Exterior Metal Doors	2	ea	$1,350	$2,700	
15	S	Interior Metal Doors	1	ea	$950.00	$950	
16	S	Roof Structural System w/ Metal Decking	520	sf	$32.50	$16,900	removable roof spec
17	S	Roof Shingle Overlay	520	sf	$15.00	$7,800	
18	S	Roof Specialties	520	sf	$5.00	$2,600	vents, flashing, etc.
19	S	HVAC Allowance	520	sf	$35.00	$18,200	fans, AHUs, louvers
20	P	Interior Containment Sump	1	ls	$3,500	$3,500	
21	S	Metal Stairs	-	riser	$325	$0	
22	S	Misc. Metals/Gratings/Pipe Support	1	ls	$15,000	$15,000	
23	P	Wall Spools/Piping Connects	1	ls	$7,500	$7,500	
24	S	Dampproofing/Process/Corrosion Coatings	1	ls	$15,000	$15,000	
25	S	Emergency Eye Shower	2	ea	$1,300	$2,600	
26	S	Bldg PW/UW/ORD Piping Allowance	1	ls	$5,000	$5,000	matls only
27	S	Fire Sprinkler Allowance	520	sf	$25	$13,000	
28	S	Landscaping Allowance	1	ls	$12,000	$12,000	front planter, back hillside
29	S	Erosion Controls at Hillside	1	ls	$10,000	$10,000	blankets, etc.
30	S	Overhead Ventilation System	1	ls	$7,500	$7,500	portable pull down
31	S	Exterior Room for Xrfm	100	sf	$100	$10,000	
32	S	***Process***					
33	P	5000 gal dbl Wall Polyethylene Chemical Tank	1	ea	$22,500	$22,500	matls only, quote (deld)
34	P	Hydraulic Diaphragm Metering Pump Skids	2	ea	$6,000	$12,000	<ditto>
35	P	Solenoid Pump	-	ea	$1,000	$0	"
36	P	Tank Connect/Vent/Chemical Feed Piping & Valves	1	ls	$5,000	$5,000	"
37	P	Mechanical Install Crew + Equip + Misc Matls	21	dys	$3,500	$73,500	4-5 man crew with matls & equipment
D.		**Electrical/I&C/Controls**				**$149,250**	
1	S	PLC Panel	1	ea	$5,000	$5,000	matls only
2	S	Bldg Power Panel	1	ea	$3,500	$3,500	<ditto>
3	S	Metering Pump Control Panels	2	ea	$5,000	$10,000	"
4	S	Bldg Lighting (Interior)	5	ea	$650	$3,250	"
5	S	Bldg Lighting (Exterior)	5	ea	$1,200	$6,000	"
6	S	Door Alarms	2	ea	$500	$1,000	"
7	S	Level Sensor	1	ea	$2,500	$2,500	"
8	S	HV/LV Distribution Conductors	1	lot	$7,500	$7,500	"
9	S	Power Tie-in	1	lot	$2,500	$2,500	"
10	S	Analyzers	2	ea	$5,000	$10,000	one for owner
11	S	VFDs for Metering Pumps	2	ea	$2,000	$4,000	"
12	S	Grounding Allowance	1	lot	$5,000	$5,000	"
13	S	HMI/PLC/SCADA Equipment/Install	1	lot	$15,000	$15,000	
14	S	PLC /SCADA Programming	60	hr	$150	$9,000	
15	S	UPS	1	ls	$15,000	$15,000	
16	S	Misc Electrical/Instrumentation Equip/Matls	1	ls	$5,000	$5,000	
17	S	Electrical Install Crew + Equip + Misc Matls	15	dys	$3,000	$45,000	3-4 man crew with matls & equipment

MWH | **JL**
Sacramento | 6/13/2013

Sonoma County Health Services
Fluoridation Preliminary Engineering Report
Wohler Facility

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 1,770,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
E.		**Constructability/Duration Equipment**				**$115,000**	
1	P	Build Crane Pads	-	ea	$5,000	$0	
2	P	Shoring/Temp Detwatering Allowance at Hill	1	ls	$10,000	$10,000	
3	P	Rent 50 Ton R/T Crane	3	mo	$15,000	$45,000	
4	P	Operate Crane (1)	600	hr	$100	$60,000	Opr + FOG
F.		**Startup/Commission**				**$12,500**	
1	P	Startup Crew (Prime)	1	ls	$12,500	$12,500	Allowance, 5 days, punch list, training, etc.
2	S	Vendor Commissioning	1	ls	$0	$0	Allowance, costs also included in budget quotes
					Running Subtotal:	**$659,350**	
G.		**Mobilization/Field Oversight Expenses**				**$111,957**	
1	P	Contractor General Conditions (Prime)	6	mo	11%	$72,528	
2	S	Contractor General Conditions (Subcontractor)	6	mo	11%	$39,429	
3	P	Freight/Duties	1	ls	0%	$0	incl above
H.		**Estimating Allowance**				**$49,451**	
1	P	Unlisted Items Allowance	1	ls	7.5%	$49,451	known, but not priced
			Running Direct Cost Subtotal:			**$820,759**	
I.		**Markups**				**$176,055**	
1	S	Subcontractor Markups	1	ls	12.5%	**$44,806**	H/O Overheads, Job Fee & Risk (Included above), insur, bond
2	P	Prime Contractor OH&P on Subs	1	ls	5.0%	**$17,922**	ditto
3	P	Prime Contractor OH&P on Self-Perform	1	ls	10.0%	**$65,935**	ditto
4	P	Contractor Insurance Program	1	ls	2.5%	**$16,484**	Performance/Payments Bonds, Genl Liability, & Bldr's Risk
5	P	Local Sales Taxes	1	ls	8.0%	**$30,909**	CA Sales Tax on Matls = 40%
6	P	Escalation	1	ls	0.0%	**$0**	Excluded, current costs
					Running Price Subtotal:	**$1,000,000**	Total Estimated Constr Costs w/o contingency
			MU Factor:	1.218			
J.		**Project Administration & Management**				**$770,000**	
1	--	Permitting Plan	1	ls	$5,000	**$5,000**	
2	--	H&S and Haz Matls Business Plan	1	ls	$25,000	**$25,000**	Incls ISO certtification
3	--	CEQA/ESA Process	1	ls	$180,000	**$180,000**	
4	--	Construction Oversight & Mgt	1	ls	15%	**$150,000**	
5	--	Engineering	1	ls	15%	**$150,000**	<ditto>
6	--	Misc Owner's Soft Costs (Oversight/Mgt)	1	ls	0%	**$0**	"
7	--	Scope Contingency/Market Conditions	1	ls	20%	**$260,000**	Design definition/estimating/market allowance
8	--	Interest During Construction	1	ls		**$0**	Financing costs excluded
9	--	Owner's Construction Contingency/Mgt Reserve	1	ls		**$0**	Excluded, owners allowance for changed field conditions
					Grand Total:	**$1,770,000**	Total Estimated Constr Costs w/ Contingency
				Cost Range:	**$1,200,000**	**$2,000,000**	Per AACE cost estimate guidelines

Assumptions
1) Specialized foundation treatment (micro-piles, etc.) is excluded.
2) Scope assumed to be consistent with CEQA approach.

Notes:
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2) Pricing basis = 2nd Qtr 2013, escalation to midpoint of construction is excluded.
3) P=Prime, S=Subcontractor
4) Pricing assumes competitive market conditions at time of tender (+3 bidders/trade).
5) Owner soft costs and project management expenses excluded.
6) Capital spare parts not included.

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Sonoma County Health Services
Fluoridation Preliminary Engineering Report
<u>Occidental Road Well</u>

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 220,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
A.		**Genl Site Development**				**$2,500**	
1	S	Earthworks for Slab	1	ls	$2,500	$2,500	
B.		**Yard Piping**				**$8,388**	
1	P	Injection Quill	1	ea	$2,000	$2,000	
2	P	Dbl Contained Piping (1" & 1/2" Schld 80 CPVC)	35	lf	$23	$788	
3	S	Cut-in Flanged Pipe Spool for Injector	1	ea	$5,600	$5,600	
C.		**Fluoride Building (1 story)**				**$35,620**	$25
1	P	***Civils***					
2	P	Aggregate Base @ Slab Fdn 1'	3	cys	$70.00	$200	
3	P	Concrete Foundation SOG 1'	2	cys	$450	$1,100	
4	P	Concrete Tank Equipment Pad	1	cys	$800	$800	
5	P	Reinforcing Steel	700	lb	$1.00	$700	at 200 #/cy
6	S	CMU Block Bldg Walls	250	sf	$20.00	$5,000	
7	S	Exterior Metal Doors	1	ea	$1,350	$1,350	
8	S	Roof Structural System w/ Metal Decking	48	sf	$25.00	$1,200	
9	S	Roof Shingle Overlay	-	sf	$15.00	$0	
10	S	Roof Specialties	48	sf	$5.00	$240	vents, flashing, etc.
11	S	HVAC Allowance	48	sf	$35.00	$1,680	fans, AHUs, louvers
12	P	Wall Spools/Piping Connects	1	ls	$1,000	$1,000	
13	S	Dampproofing/Process/Corrosion Coatings	1	ls	$2,000	$2,000	
14	S	Emergency Eye Shower (Heated)	2	ea	$1,300	$2,600	
15	S	***Process***					
16	P	100 gal Dbl Wall Polyethylene Chem Tank	1	ea	$750	$750	Matls only
17	P	Solenoid Pump	1	ea	$1,000	$1,000	"
18	P	Tank Connect/Vent/Chemical Feed Piping & Valves	1	ls	$3,500	$3,500	"
19	P	Mechanical Install Crew + Equip + Misc Matls	5	dys	$2,500	$12,500	2-3 man crew with matls & equipment
D.		**Electrical/I&C/Controls**				**$40,100**	
1	S	Bldg Power Panel	1	ea	$2,000	$2,000	<ditto>
2	S	Metering Pump Control Panels	1	ea	$3,000	$3,000	"
3	S	Bldg Lighting (Interior)	1	ea	$650	$650	"
4	S	Bldg Lighting (Exterior)	1	ea	$1,200	$1,200	"
5	S	Door Alarms	1	ea	$500	$500	"
6	S	Level Sensor	1	ea	$750	$750	"
7	S	HV/LV Distribution Conductors	1	lot	$2,000	$2,000	"
8	S	Power Tie-in	1	lot	$2,500	$2,500	"
9	S	Analyzer	1	ea	$5,000	$5,000	"
10	S	VFDs for Metering Pumps	1	ea	$2,000	$2,000	"
11	S	Grounding Allowance	1	lot	$1,500	$1,500	"
12	S	PLC /SCADA Programming	30	hr	$150	$4,500	
13	S	Misc Electrical/Instrumentation Equip/Matls	1	ls	$2,000	$2,000	
14	S	Electrical Install Crew + Equip + Misc Matls	5	dys	$2,500	$12,500	3-4 man crew with matls & equipment
E.		**Constructability/Duration Equipment**				**$0**	
1	P	Build Crane Pads	-	ea	$5,000	$0	
2	P	Shoring/Temp Detwatering Allowance at Hill	-	ls	$10,000	$0	
3	P	Rent 50 Ton R/T Crane	-	mo	$15,000	$0	
4	P	Operate Crane (1)	-	hr	$50	$0	
F.		**Startup/Commission**				**$5,000**	
1	P	Startup Crew (Prime)	1	ls	$5,000	$5,000	Allowance, 2 days, punch list, training, etc.
2	S	Vendor Commissioning	1	ls	$0	$0	Allowance, costs also included in budget quotes
					Running Subtotal:	**$91,610**	
G.		**Mobilization/Field Oversight Expenses**				**$13,849**	
1	P	Contractor General Conditions (Prime)	6	mo	9%	$8,245	
2	S	Contractor General Conditions (Subcontractor)	6	mo	9%	$5,604	
3	P	Freight/Duties	1	ls	5%	$0	incl above
H.		**Estimating Allowance**				**$9,161**	
1	P	Unlisted Items Allowance	1	ls	10%	$9,161	known, but not priced
			Running Direct Cost Subtotal:			**$114,620**	

MWH | JL
Sacramento | 7/13/2013

Sonoma County Health Services
Fluoridation Preliminary Engineering Report
Occidental Road Well

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 220,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
I.		**Markups**				$26,731	
1	S	Subcontractor Markups	1	ls	12.5%	$7,784	H/O Overheads, Job Fee & Risk (Included above), insur, bond
2	P	Prime Contractor OH&P on Subs	1	ls	5.0%	$3,114	ditto
3	P	Prime Contractor OH&P on Self-Perform	1	ls	10.0%	$9,161	ditto
4	P	Contractor Insurance Program	1	ls	2.5%	$2,290	Performance/Payments Bonds, Genl Liability, & Bldr's Risk
5	P	Local Sales Taxes	1	ls	8.0%	$4,383	CA Sales Tax on Matls = 40%
6	P	Escalation	1	ls	0.0%	$0	Excluded, current costs
					Running Price Subtotal:	$140,000	Total Estimated Constr Costs w/o contingency
			MU Factor:	1.221			
J.		**Project Administration & Management**				$82,000	
1	--	Permitting Plan	1	ls		$0	
2	--	CEQA Process	1	ls		$0	
3	--	Construction Oversight & Mgt	1	ls	15%	$21,000	
4	--	Engineering	1	ls	15%	$21,000	<ditto>
5	--	Misc Owner's Soft Costs (Oversight/Mgt)	1	ls	0%	$0	"
6	--	Scope Contingency/Market Conditions	1	ls	20%	$40,000	Design definition/estimating/market allowance
7	--	Interest During Construction	1	ls		$0	Financing costs excluded
8	--	Owner's Construction Contingency/Mgt Reserve	1	ls		$0	Excluded, owners allowance for changed field conditions
					Grand Total:	$220,000	Total Estimated Constr Costs w/ Contingency
				Cost Range:	$140,000	$230,000	Per AACE cost estimate guidelines

Assumptions
1) Specialized foundation treatment (micro-piles, etc.) is excluded.
2) Scope consistent with assumed CEQA approach.

Notes:
1) This OPCC is classified as a Class 3 cost estimate per AACE guidelines. Stated accuracy range = -20% to + 30%.
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6) Capital spare parts not included.

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Sonoma County Health Services
Fluoridation Preliminary Engineering Report
Sebastopol Road Well

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 220,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
A.		**Genl Site Development**				$2,500	
1	S	Earthworks for Slab	1	ls	$2,500	$2,500	
B.		**Yard Piping**				$8,388	
1	P	Injection Quill	1	ea	$2,000	$2,000	
2	P	Dbl Contained Piping (1" & 1/2" Schld 80 CPVC)	35	lf	$23	$788	
3	S	Cut-in Flanged Pipe Spool for Injector	1	ea	$5,600	$5,600	
C.		**Fluoride Building (1 story)**				$35,620	$25
1	P	***Civils***					
2	P	Aggregate Base @ Slab Fdn 1'	3	cys	$70.00	$200	
3	P	Concrete Foundation SOG 1'	2	cys	$450	$1,100	
4	P	Concrete Tank Equipment Pad	1	cys	$800	$800	
5	P	Reinforcing Steel	700	lb	$1.00	$700	at 200 #/cy
6	S	CMU Block Bldg Walls	250	sf	$20.00	$5,000	
7	S	Exterior Metal Doors	1	ea	$1,350	$1,350	
8	S	Roof Structural System w/ Metal Decking	48	sf	$25.00	$1,200	
9	S	Roof Shingle Overlay	-	sf	$15.00	$0	
10	S	Roof Specialties	48	sf	$5.00	$240	vents, flashing, etc.
11	S	HVAC Allowance	48	sf	$35.00	$1,680	fans, AHUs, louvers
12	P	Wall Spools/Piping Connects	1	ls	$1,000	$1,000	
13	S	Dampfroofing/Process/Corrosion Coatings	1	ls	$2,000	$2,000	
14	S	Emergency Eye Shower (Heated)	2	ea	$1,300	$2,600	
15	S	***Process***					
16	P	100 gal Dbl Wall Polyethylene Chem Tank	1	ea	$750	$750	Matls only
17	P	Solenoid Pump	1	ea	$1,000	$1,000	"
18	P	Tank Connect/Vent/Chemical Feed Piping & Valves	1	ls	$3,500	$3,500	"
19	P	Mechanical Install Crew + Equip + Misc Matls	5	dys	$2,500	$12,500	2-3 man crew with matls & equipment
D.		**Electrical/I&C/Controls**				$40,100	
1	S	Bldg Power Panel	1	ea	$2,000	$2,000	<ditto>
2	S	Metering Pump Control Panels	1	ea	$3,000	$3,000	"
3	S	Bldg Lighting (Interior)	1	ea	$650	$650	"
4	S	Bldg Lighting (Exterior)	1	ea	$1,200	$1,200	"
5	S	Door Alarms	1	ea	$500	$500	"
6	S	Level Sensor	1	ea	$750	$750	"
7	S	HV/LV Distribution Conductors	1	lot	$2,000	$2,000	"
8	S	Power Tie-in	1	lot	$2,500	$2,500	"
9	S	Analyzer	1	ea	$5,000	$5,000	"
10	S	VFDs for Metering Pumps	1	ea	$2,000	$2,000	"
11	S	Grounding Allowance	1	lot	$1,500	$1,500	"
12	S	PLC /SCADA Programming	30	hr	$150	$4,500	
13	S	Misc Electrical/Instrumentation Equip/Matls	1	ls	$2,000	$2,000	
14	S	Electrical Install Crew + Equip + Misc Matls	5	dys	$2,500	$12,500	3-4 man crew with matls & equipment
E.		**Constructability/Duration Equipment**				$0	
1	P	Build Crane Pads	-	ea	$5,000	$0	
2	P	Shoring/Temp Detwatering Allowance at Hill	-	ls	$10,000	$0	
3	P	Rent 50 Ton R/T Crane	-	mo	$15,000	$0	
4	P	Operate Crane (1)	-	hr	$50	$0	
F.		**Startup/Commission**				$5,000	
1	P	Startup Crew (Prime)	1	ls	$5,000	$5,000	Allowance, 2 days, punch list, training, etc.
2	S	Vendor Commissioning	1	ls	$0	$0	Allowance, costs also included in budget quotes
					Running Subtotal:	**$91,610**	
G.		**Mobilization/Field Oversight Expenses**				$13,849	
1	P	Contractor General Conditions (Prime)	6	mo	9%	$8,245	
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H.		**Estimating Allowance**				$9,161	
1	P	Unlisted Items Allowance	1	ls	10%	$9,161	known, but not priced
			Running Direct Cost Subtotal:			**$114,620**	

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7/13/2013

Sonoma County Health Services
Fluoridation Preliminary Engineering Report
Sebastopol Road Well

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 220,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
I.		**Markups**				$26,731	
1	S	Subcontractor Markups	1	ls	12.5%	$7,784	H/O Overheads, Job Fee & Risk (Included above), insur, bond
2	P	Prime Contractor OH&P on Subs	1	ls	5.0%	$3,114	ditto
3	P	Prime Contractor OH&P on Self-Perform	1	ls	10.0%	$9,161	ditto
4	P	Contractor Insurance Program	1	ls	2.5%	$2,290	Performance/Payments Bonds, Genl Liability, & Bldr's Risk
5	P	Local Sales Taxes	1	ls	8.0%	$4,383	CA Sales Tax on Matls = 40%
6	P	Escalation	1	ls	0.0%	$0	Excluded, current costs
					Running Price Subtotal:	$140,000	Total Estimated Constr Costs w/o contingency
			MU Factor:	1.221			
J.		**Project Administration & Management**				$82,000	
1	--	Permitting Plan	1	ls		$0	
2	--	CEQA Process	1	ls		$0	
3	--	Construction Oversight & Mgt	1	ls	15%	$21,000	
4	--	Engineering	1	ls	15%	$21,000	<ditto>
5	--	Misc Owner's Soft Costs (Oversight/Mgt)	1	ls	0%	$0	"
6	--	Scope Contingency/Market Conditions	1	ls	20%	$40,000	Design definition/estimating/market allowance
7	--	Interest During Construction	1	ls		$0	Financing costs excluded
8	--	Owner's Construction Contingency/Mgt Reserve	1	ls		$0	Excluded, owners allowance for changed field conditions
					Grand Total:	$220,000	Total Estimated Constr Costs w/ Contingency
				Cost Range:	$140,000	$230,000	Per AACE cost estimate guidelines

Assumptions

1) Specialized foundation treatment (micro-piles, etc.) is excluded.
2) Scope consistent with CEQA approach.

Notes:

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JL
7/13/2013

Sonoma County Health Services
Fluoridation Preliminary Engineering Report
Todd Road Well

Opinion of Probable Construction Costs

Currency: USD-United States-MAY 2013 Dollar

Grand Total Price: $ 220,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
A.		**Genl Site Development**				**$2,500**	
1	S	Earthworks for Slab	1	ls	$2,500	$2,500	
B.		**Yard Piping**				**$8,388**	
1	P	Injection Quill	1	ea	$2,000	$2,000	
2	P	Dbl Contained Piping (1" & 1/2" Schld 80 CPVC)	35	lf	$23	$788	
3	S	Cut-in Flanged Pipe Spool for Injector	1	ea	$5,600	$5,600	
C.		**Fluoride Building (1 story)**				**$35,620**	$25
1	P	***Civils***					
2	P	Aggregate Base @ Slab Fdn 1'	3	cys	$70.00	$200	
3	P	Concrete Foundation SOG 1'	2	cys	$450	$1,100	
4	P	Concrete Tank Equipment Pad	1	cys	$800	$800	
5	P	Reinforcing Steel	700	lb	$1.00	$700	at 200 #/cy
6	S	CMU Block Bldg Walls	250	sf	$20.00	$5,000	
7	S	Exterior Metal Doors	1	ea	$1,350	$1,350	
8	S	Roof Structural System w/ Metal Decking	48	sf	$25.00	$1,200	
9	S	Roof Shingle Overlay	-	sf	$15.00	$0	
10	S	Roof Specialties	48	sf	$5.00	$240	vents, flashing, etc.
11	S	HVAC Allowance	48	sf	$35.00	$1,680	fans, AHUs, louvers
12	P	Wall Spools/Piping Connects	1	ls	$1,000	$1,000	
13	S	Dampproofing/Process/Corrosion Coatings	1	ls	$2,000	$2,000	
14	S	Emergency Eye Shower (Heated)	2	ea	$1,300	$2,600	
15	S	***Process***					
16	P	100 gal Dbl Wall Polyethylene Chem Tank	1	ea	$750	$750	Matls only
17	P	Solenoid Pump	1	ea	$1,000	$1,000	"
18	P	Tank Connect/Vent/Chemical Feed Piping & Valves	1	ls	$3,500	$3,500	"
19	P	Mechanical Install Crew + Equip + Misc Matls	5	dys	$2,500	$12,500	2-3 man crew with matls & equipment
D.		**Electrical/I&C/Controls**				**$40,100**	
1	S	Bldg Power Panel	1	ea	$2,000	$2,000	<ditto>
2	S	Metering Pump Control Panels	1	ea	$3,000	$3,000	"
3	S	Bldg Lighting (Interior)	1	ea	$650	$650	"
4	S	Bldg Lighting (Exterior)	1	ea	$1,200	$1,200	"
5	S	Door Alarms	1	ea	$500	$500	"
6	S	Level Sensor	1	ea	$750	$750	"
7	S	HV/LV Distribution Conductors	1	lot	$2,000	$2,000	"
8	S	Power Tie-in	1	lot	$2,500	$2,500	"
9	S	Analyzer	1	ea	$5,000	$5,000	"
10	S	VFDs for Metering Pumps	1	ea	$2,000	$2,000	"
11	S	Grounding Allowance	1	lot	$1,500	$1,500	"
12	S	PLC /SCADA Programming	30	hr	$150	$4,500	
13	S	Misc Electrical/Instrumentation Equip/Matls	1	ls	$2,000	$2,000	
14	S	Electrical Install Crew + Equip + Misc Matls	5	dys	$2,500	$12,500	3-4 man crew with matls & equipment
E.		**Constructability/Duration Equipment**				**$0**	
1	P	Build Crane Pads	-	ea	$5,000	$0	
2	P	Shoring/Temp Detwatering Allowance at Hill	-	ls	$10,000	$0	
3	P	Rent 50 Ton R/T Crane	-	mo	$15,000	$0	
4	P	Operate Crane (1)	-	hr	$50	$0	
F.		**Startup/Commission**				**$5,000**	
1	P	Startup Crew (Prime)	1	ls	$5,000	$5,000	Allowance, 2 days, punch list, training, etc.
2	S	Vendor Commissioning	1	ls	$0	$0	Allowance, costs also included in budget quotes
					Running Subtotal:	**$91,610**	
G.		**Mobilization/Field Oversight Expenses**				**$13,849**	
1	P	Contractor General Conditions (Prime)	6	mo	9%	$8,245	
2	S	Contractor General Conditions (Subcontractor)	6	mo	9%	$5,604	
3	P	Freight/Duties	1	ls	5%	$0	incl above
H.		**Estimating Allowance**				**$9,161**	
1	P	Unlisted Items Allowance	1	ls	10%	$9,161	known, but not priced
					Running Direct Cost Subtotal:	**$114,620**	

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Sacramento

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Grand Total Price: $ 220,000

Item	GC	Description	Quantity	UOM	Unit Price (Cost)	Total Price	Comments
I.		**Markups**				**$26,731**	
1	S	Subcontractor Markups	1	ls	12.5%	**$7,784**	H/O Overheads, Job Fee & Risk (Included above), insur, bond
2	P	Prime Contractor OH&P on Subs	1	ls	5.0%	**$3,114**	ditto
3	P	Prime Contractor OH&P on Self-Perform	1	ls	10.0%	**$9,161**	ditto
4	P	Contractor Insurance Program	1	ls	2.5%	**$2,290**	Performance/Payments Bonds, Genl Liability, & Bldr's Risk
5	P	Local Sales Taxes	1	ls	8.0%	**$4,383**	CA Sales Tax on Matls = 40%
6	P	Escalation	1	ls	0.0%	**$0**	Excluded, current costs
					Running Price Subtotal:	**$140,000**	Total Estimated Constr Costs w/o contingency
			MU Factor:	1.221			
J.		**Project Administration & Management**				**$82,000**	
1	--	Permitting Plan	1	ls		**$0**	
2	--	CEQA Process	1	ls		**$0**	
3	--	Construction Oversight & Mgt	1	ls	15%	**$21,000**	
4	--	Engineering	1	ls	15%	**$21,000**	<ditto>
5	--	Misc Owner's Soft Costs (Oversight/Mgt)	1	ls	0%	**$0**	"
6	--	Scope Contingency/Market Conditions	1	ls	20%	**$40,000**	Design definition/estimating/market allowance
7	--	Interest During Construction	1	ls		**$0**	Financing costs excluded
8	--	Owner's Construction Contingency/Mgt Reserve	1	ls		**$0**	Excluded, owners allowance for changed field conditions
					Grand Total:	**$220,000**	Total Estimated Constr Costs w/ Contingency
				Cost Range:	**$140,000**	**$230,000**	Per AACE cost estimate guidelines

Assumptions
1) Specialized foundation treatment (micro-piles, etc.) is excluded.
2) CEQA consistent with assumed CEQA approach.

Notes:
1) This OPCC is classified as a Class 3 cost estimate per AACE guidelines. Stated accuracy range = -20% to + 30%.
2) Pricing basis = 2nd Qtr 2013, escalation to midpoint of construction is excluded.
3) P=Prime, S=Subcontractor
4) Pricing assumes competitive market conditions at time of tender (+3 bidders/trade).
5) Owner soft costs and project management expenses excluded.
6) Capital spare parts not included.

OPCC Disclaimer

The client hereby acknowledges that MWH has no control over the costs of labor, materials, competitive bidding environments, unidentified field conditions, financial and/or commodity market conditions, or any other factors likely to affect the OPCC of this project, all of which are and will unavoidably remain in a state of change, especially in light of high market volatility attributable to Acts of God and other market forces or events beyond the control of the parties. As such, Client recognizes that this OPCC deliverable is based on normal market conditions, defined by stable resource supply/demand relationships, and does not account for extreme inflationary or deflationary market cycles. Client further acknowledges that this OPCC is a "snapshot in time" and that the reliability of this OPCC will degrade over time. Client agrees that MWH cannot and does not make any warranty, promise, guarantee or representation, either express or implied that proposals, bids, project construction costs, or cost of O&M functions will not vary significantly from MWH's good faith Class 3 OPCC

AACE International CLASS 3 Cost Estimate - Class 3 estimates are generally prepared based on preliminary design layouts. Typically, engineering is 30% to 60% complete. They are typically used for budget approval. Virtually all Class 3 estimates use detailed cost estimating methods such as crew analysis and detailed historical pricing plus vendor quotes if available Expected accuracy ranges are from -10% to -20% on the low side and +10% to 30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 20 hours or less to perhaps more than 300 hours may be spent preparing the estimate depending on the project and estimating methodology (AACE International Recommended Practices and Standards).

Prepared by

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