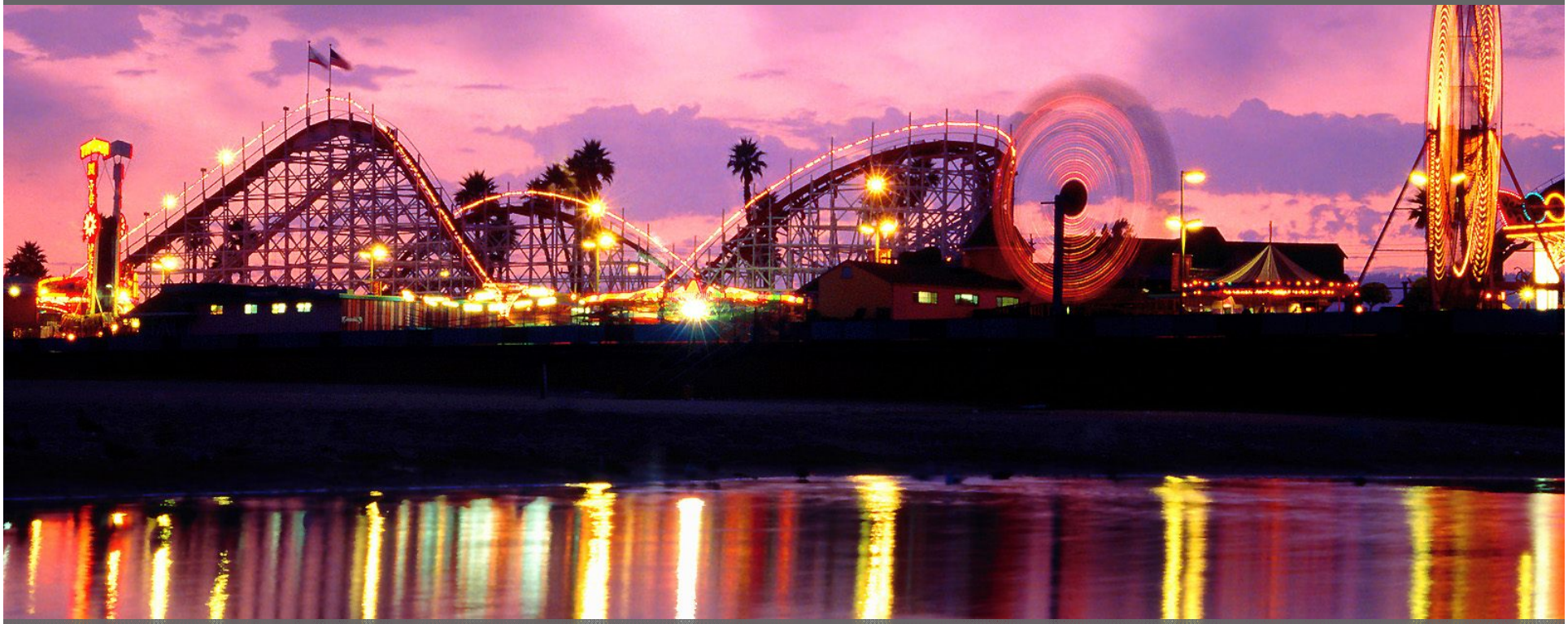
TTHM Removal Performance Comparison

2013 Fall CA/NV AWWA Section Conference

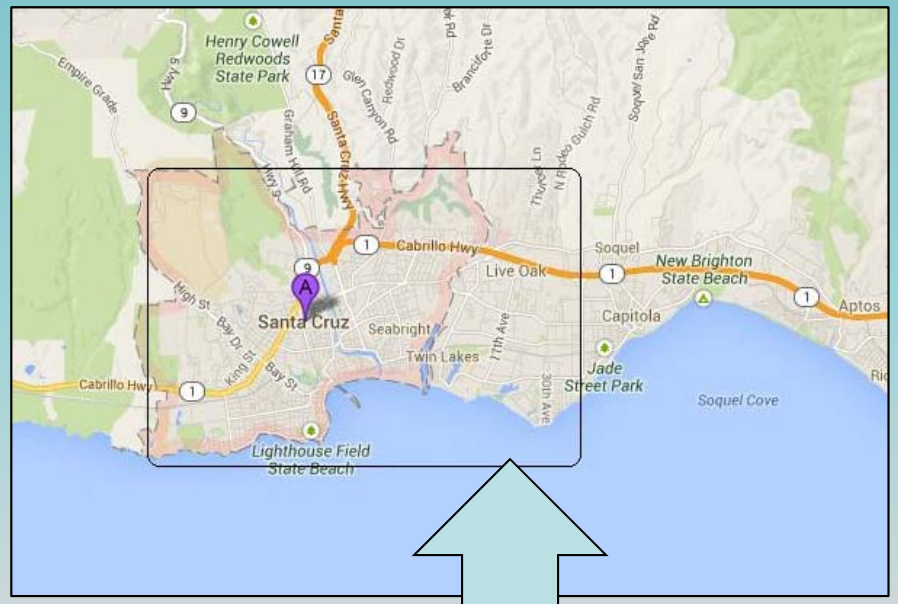


City of Santa Cruz Water Department

Background

City of Santa Cruz Service Area

Santa Cruz County

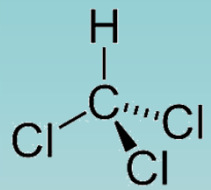


Approximate City of Santa Cruz Service Area

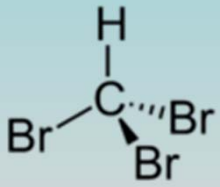
What are THM's?

Total Trihalomethanes (TTHM's) are disinfection by-products (DBP) which are Volatile Organic Carbon in the forms of :

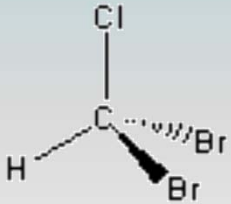
- $CHCl_3$ (Chloroform)



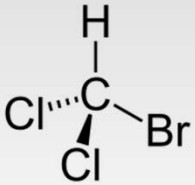
- $CHBr_3$ (Bromoform)



- $CHBr_2Cl$ (Chlorodibromomethane)



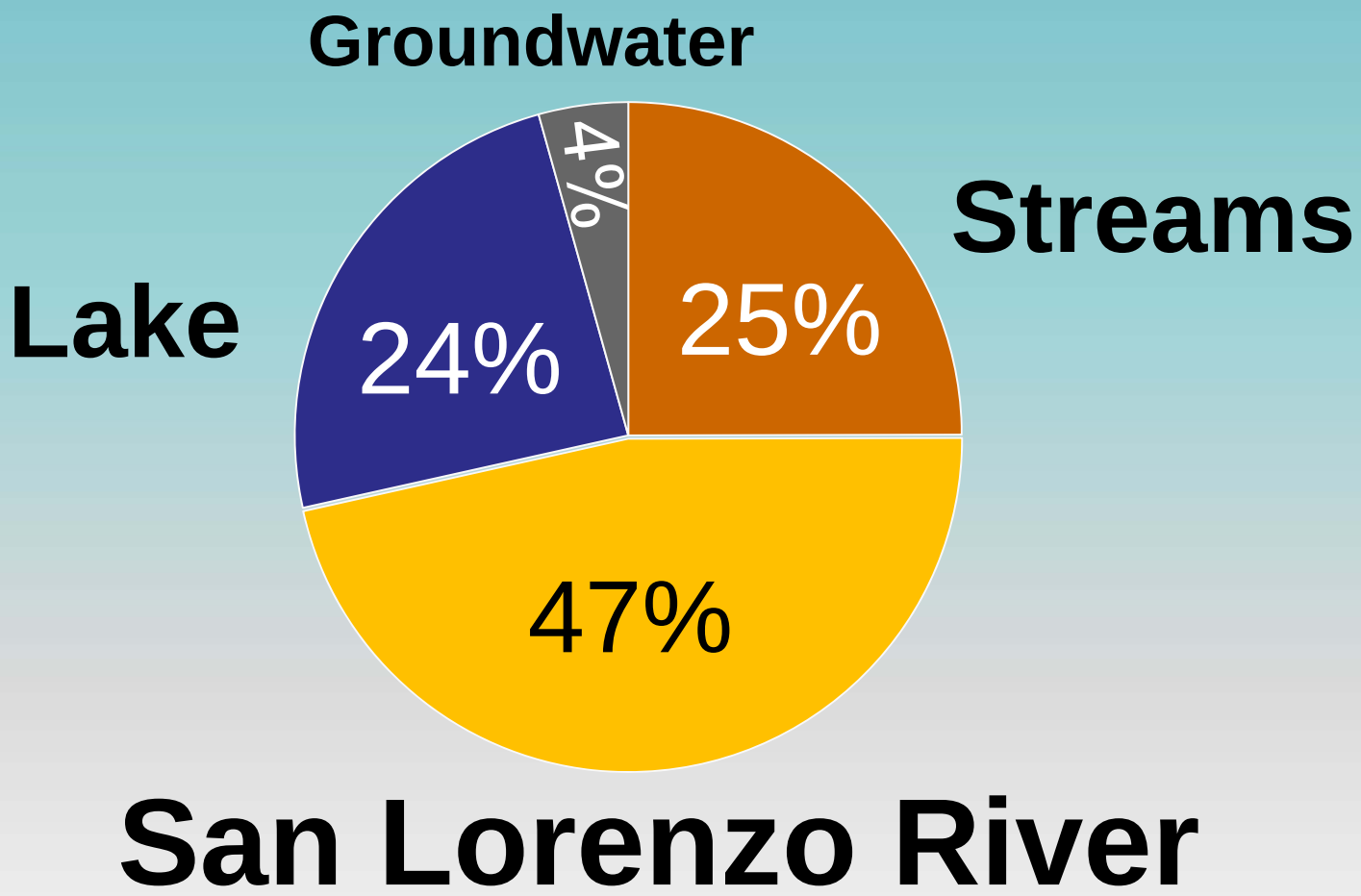
- $CHBrCl_2$ (Bromodichloromethane)



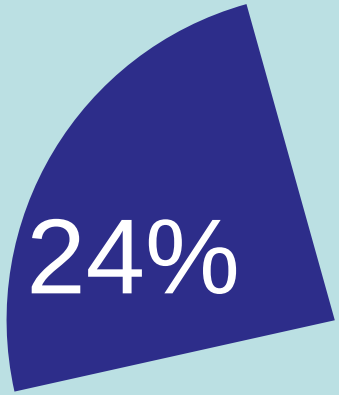
Why are THM's of Concern?

- According to the EPA, people who drink water containing total trihalomethanes in excess of the MCL over many years could experience liver, kidney, or central nervous system problems and increased risk of cancer
- The maximum contaminate level for THM's is 80 µg/L, for drinking water

City of Santa Cruz Water Sources



THM Source Formation Potentials

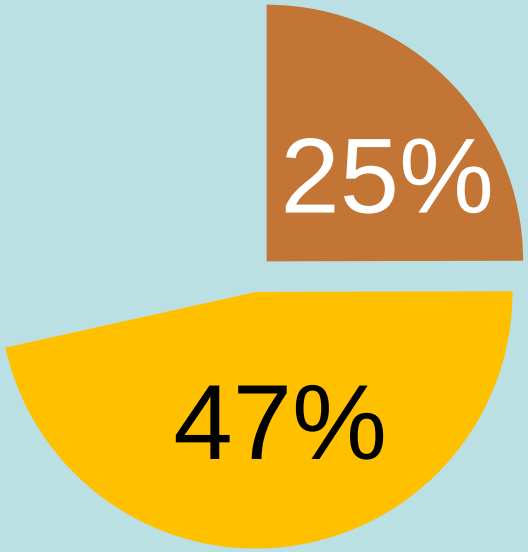


Lake

TTHM's
140 ppb

EPA

MCL
80 ppb



River/Stream

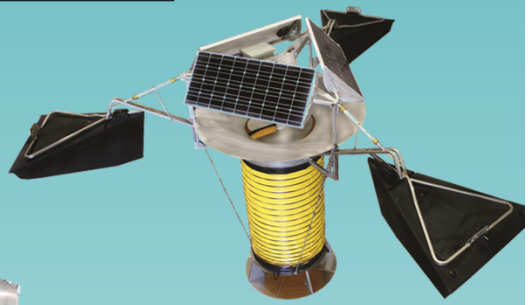
TTHM's
70 ppb

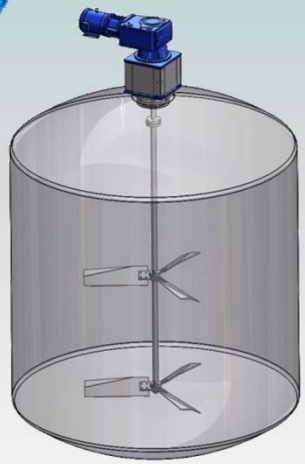
Addressing Future Challenges

- Rigorous EPA/CDPH regulations on Maximum Contamination Level (MCL) of DBP's
- More Stringent regulations by California Department of Fish and Wildlife
  - Decreased supply from stream and river sources
  - Increased reliance on lake source
- Expensive treatment plant upgrades
  - Distribution treatment options

TTHM Control

Commercially Available Technology





Build an own In-House unit?

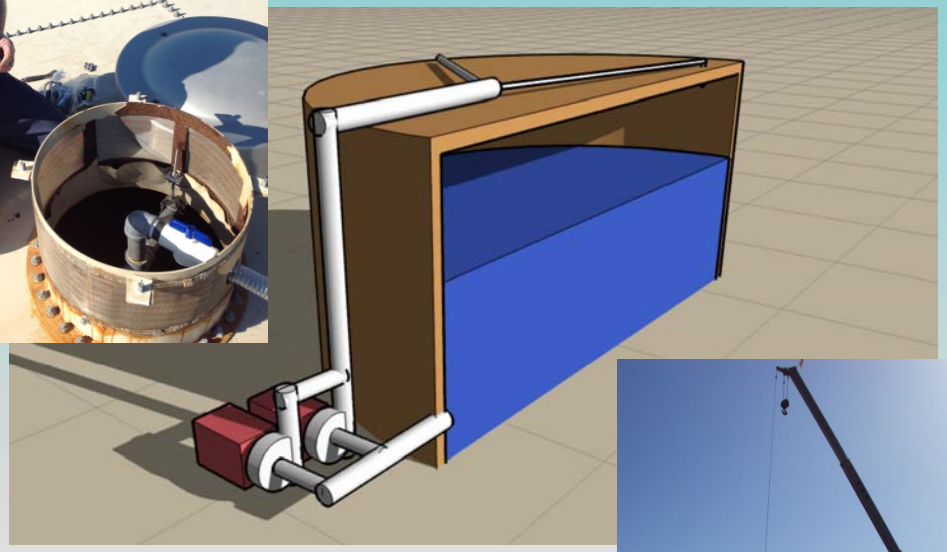
I. "Storage Tank Aeration Eliminates TTHM's"
- Walfoort, Messina, Miner
  - Suisun-Solano Water Authority
- Opflow May 2008

II. "Posttreatment to Reduce THM's"
- Ethan Brooke
- JAWWA 2011

"…spray Aeration appears to be a more efficient approach to THM stripping"

Challenges for an In-House unit

- **Material**
  - NSF approval
- **Personnel**
  - Fabrication
- **Design**
  - Criteria
- **Installation**
  - Constraints



Investigative Study

- Find the most effective unit that best meets our needs
- Compare the performance of commercially available products to an In-House unit
- Provide qualitative and quantitative data for meeting EPA/CDPH Stage 2 requirements

Performance Evaluation

Quantitative

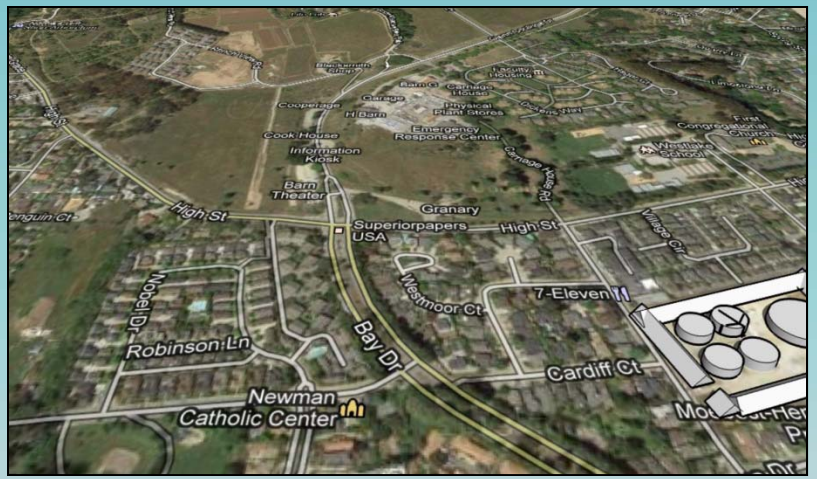
- TTHM Reduction
- Life Cycle Cost
- Stratification Reduction
- Chlorine Residual

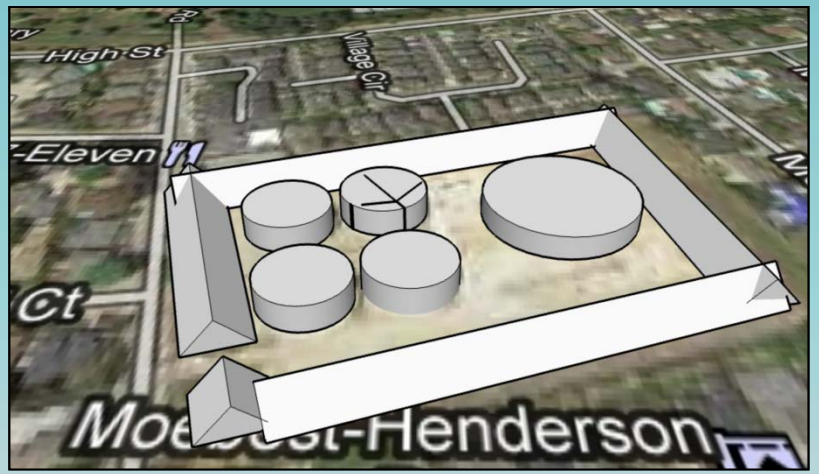
Qualitative

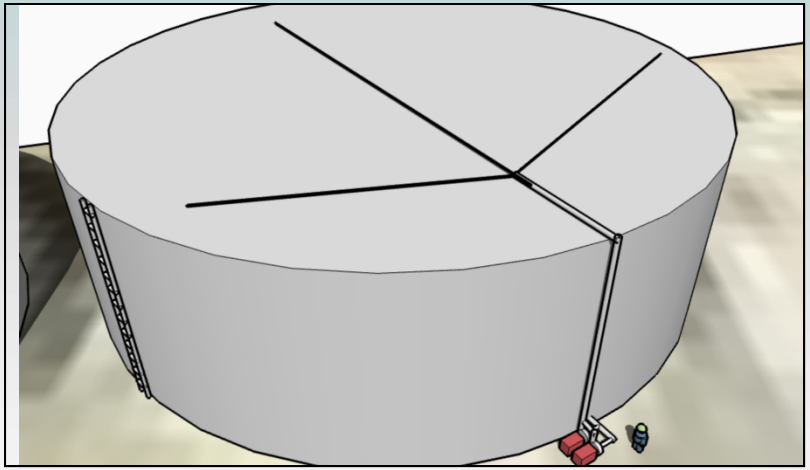
- Ease of Installation/Removal
- Maintenance Required
- Noise Threshold

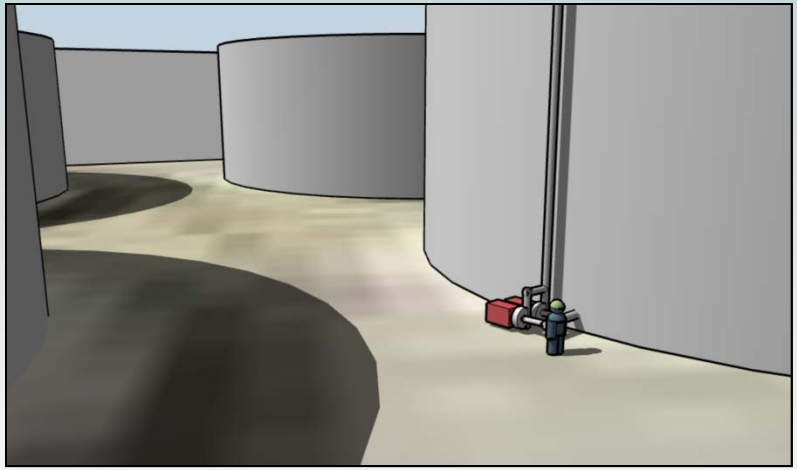
Testing Site:

Bay Street Reservoir









Testing Site

- (2) planned 6 MG pre-stressed reinforced concrete tanks
- (4) existing 1.5 MG temporary bolted steel tanks
- Common influent
- Isolated system of tanks

Results

In-house Results

Pros

- **Serviceability**
  - Accessibility
- **Installation**
- **ON/OFF Toggling**
- **Site Specific Considerations**
  - Pump/Pipe/Power
- **Modification Possibilities**
- **Weight of Unit**

Cons

- **Power Consumption**
- **Material Certification**
  - NSF/ANSI/FDA
- **Noise Pollution**
- **Aesthetics**
- **Warranty**
- **Design Flaws**

Commercially Available Product

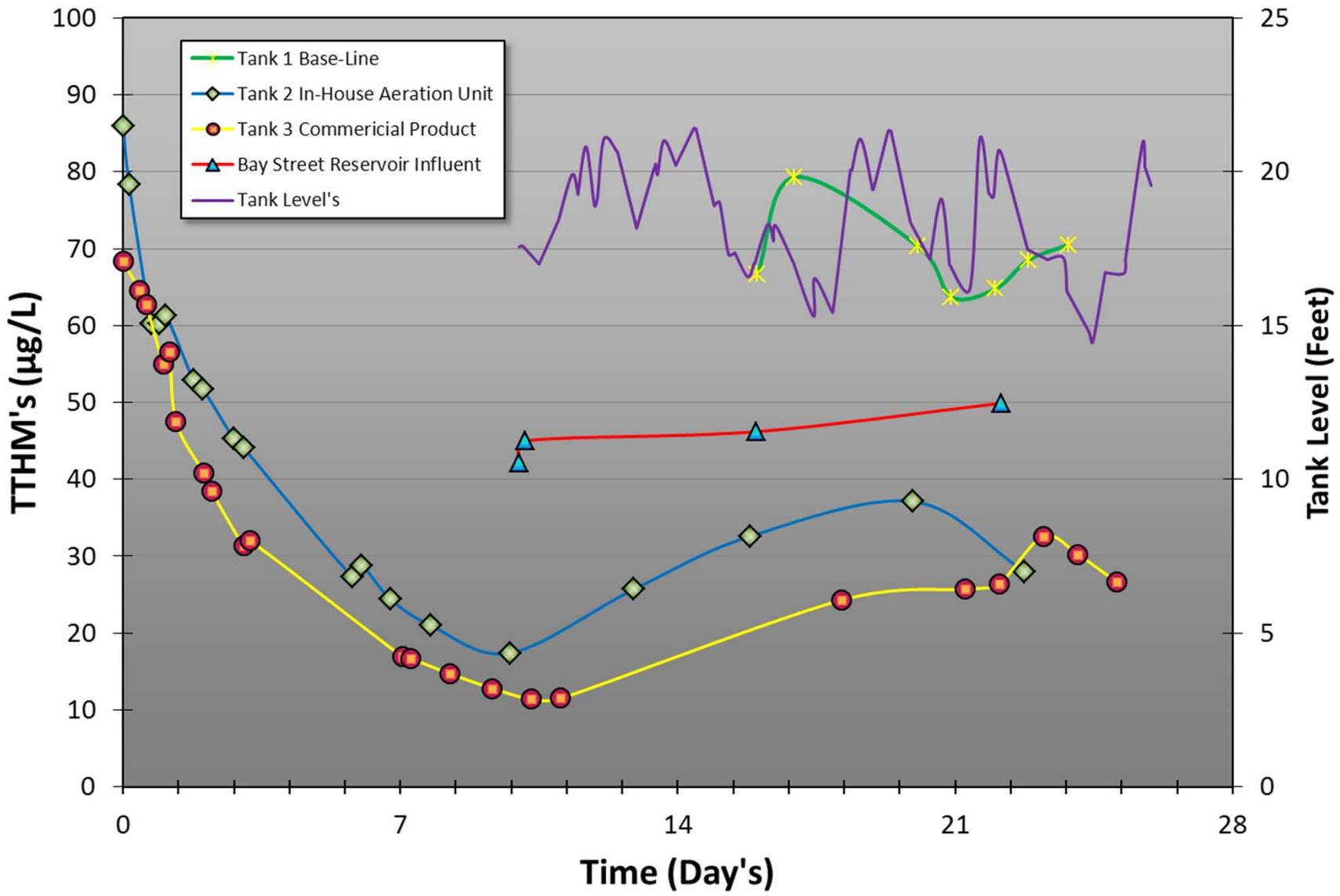
Pros

- **Power Consumption**
- **ON/OFF Toggling**
- **Material Certification**
  - NSF/ANSI/FDA
- **Aesthetics**
- **Warranty**
- **Design**
  - Research and Development

Cons

- **Serviceability**
  - Accessibility
- **Noise Pollution**
- **Installation**

Bay Street Reservoir - Investigative Study Results



Conclusion

- It is possible to build an In-House aerator and obtain THM reduction
- The pros and cons of building an In-House unit must be carefully analyzed prior to installation
- Negotiating a trial period with mixing/aeration vendors can present its own challenges
- At minimum, water department staff will learn more about the process of removing THM's

Thank You

- Questions?

- Contact
  - Terry McKinney
    - City of Santa Cruz Water Department
    - Production Superintendent
    - tmckinney@cityofsantacruz.com

CITY OF
SANTA CRUZ

WATER ADMINISTRATION
212 Locust Street, Suite A, Santa Cruz, CA 95060 • Ph: 831-420-5210

July 1, 2014

State of California Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento CA 95812-2000

Attn: Barbara Evoy, Deputy Director for Water Rights

Subject: Order Approving Petition for Temporary Urgency Change (TUCP), License 9847 (Application 17913) City of Santa Cruz

Dear Ms. Evoy,

The State Water Board approved the City's TUCP on February 14, 2014. The Order allows a temporary, 180 day reduction in the downstream bypass/release from Newell Creek Reservoir from 1.0 cubic feet per second (cfs) to 0.2 cfs. The impact of the TUCP over the first four months has been to save 64 million gallons of storage in the reservoir. The TUCP is proving to be a significant benefit to the City's ability to manage the very real water shortage emergency we are facing.

Among the conditions of approval in the order are (1) reduce water demand by 20% of normal water use by instituting water rationing and promoting conservation; (2) monitor the effects of the amended release or bypass amount on fisheries resources and take all necessary steps to avoid harm to fish in Newell Creek; (3) submit a written report to the Deputy Director for Water Rights that summarizes all activities conducted to ensure compliance with the requirements of this Order, and the amount of water use reduction achieved. This report has been prepared to summarize our progress on these requirements.

Effect of Drought Response on Water Use

The City adopted and implemented a program by May 1, 2014, to meet with water reduction goals described in Stages 3 through 5 of the City Water Shortage Contingency Plan. On February 24, 2014, the City declared a Water Shortage Emergency in accordance with the Water Shortage Contingency Plan, which mandates 20% reduction in water use beginning May 1, 2014. Prior to that the City had been under continuous use reductions of 5% to 20%, since May 2013.

Reduction in use achieved for May 2014 was 18.3%, and as of June 20, 2014, 24%. While demand hardening due to our long standing pre-existing conservation programs makes new reductions in water use more difficult, the community is rising to the challenge.

The following sections detail just some of the many actions taken by the City to achieve the required use reduction.

1) is used to calculate these parameters and determine if the amount of carryover storage in Loch Lomond at the end of the year will be sufficient to meet essential health and safety needs in case the dry weather pattern continues into the following year, and ultimately, if even more aggressive use restrictions will be necessary. It also provides the data used to track use, as seen in the 2014 Water Production Targets (Attachments 2 and 2A). Attachment 3 is from the City website and states the goals for this year's program and Attachment 3A provides status of reduction achieved.

Implementation of Stage 3 Rationing

The City Water Department developed an action plan anticipating the activities that would be needed to successfully achieve the necessary reduction in water use. Attachment 4 describes these actions along with expected results, responsible staff, and status.

The City's strategy for dealing with water shortages of all levels involves the following four interrelated components:

A. Allocation system to establish reduction goals for different customer groups. Attachments 5 and 6 are the residential and business customer allotments developed for 2014.

B. Demand reduction measures. This element includes the actions necessary to declare a water emergency and provide the Water Department the authority to put rationing into effect and to fund the required activities. Attachments 7 and 8 are the City Council report for drought implementation and the City Council water emergency resolution.

C. Publicity and communications. The Water Department is conducting an aggressive and extensive public outreach and information program, making numerous mail outs, bill stuffers, and website information available in both English and Spanish. During the two months before rationing went into effect contact was made with all customer classes. The Rationing Communications Summary (Attachment 9) summarizes this effort, a good deal of which will be ongoing for the duration of rationing. Attachments 10 to 13 are examples of some information items distributed to customers.

D. Operating actions. The Water Department and other City Departments that use water in their normal operations have implemented a significant number of modified and new procedures to curtail their use. Attachment 14 details these actions.

Fiscal Impact

The required budget adjustment (Attachment 15) transferred $280,000 within the existing FY 2014 Water Department budget, and allocates an additional $420,000 for Stage 3 water rationing. Additional allocations for next fiscal year estimated to be $450,000, will be incorporated into the FY 2015 budget. Along with these additional costs of approximately $1,025,000, the lost revenue from decreased sales is expected to be around $1.1 million. Taken together, they have a material impact on the financial situation of the City and its Water Department, and unfortunately will require a significant rate increase in the near future.

Newell Creek Monitoring Results and Discussion

Monitoring of Newell Creek downstream of the reservoir began in early February 2014 and will continue as long as the TUCP remains in effect. By March 1, 2014, The City submitted to you a plan for compliance with Condition 2 of the TUCP Order, a copy of which is attached as

Attachment 16. This monitoring (Attachment 17) indicates that the reduced bypass flow has not changed passage conditions in critical riffles nor created any areas of hydrologic discontinuity.

Conclusion

The City is in compliance with the Order. We appreciate the assistance of the SWRCB to mitigate one of the impacts of the serious water shortage condition we are facing. As the dry season proceeds, we are seeing even lower flows in our local (and only) sources of municipal water supply. Absent material change to the prevailing hydrologic conditions, we anticipate needing to extend this order before its expiration on or about August 13, 2014. We will be in touch with you to coordinate that effort.

Please let us know if you have any questions or concerns. Again, we appreciate the opportunity to work in a collaborative manner to mitigate one of the impacts of this severe drought.

Sincerely,

for

Rosemary Menard
Water Director
City of Santa Cruz

Cc w/enc Martha Lennihan

CITY COUNCIL
AGENDA REPORT

DATE: 4/1/2014

AGENDA OF: 4/8/2014

DEPARTMENT: Water

SUBJECT: Budget for Implementation for Stage 3 Water Rationing – Budget Adjustment (WT)

Budget adjustment updated on 04/07/14.

RECOMMENDATION: Resolution amending the Water Department's FY 2014 Budget to authorize expenditures in the net amount of $419,656 to address the financial impact of implementing Stage 3 water rationing.

BACKGROUND: On February 25, 2014 the City Council adopted a resolution declaring a water shortage emergency and calling for at least a 25% reduction in normal water usage beginning May 1, 2014. The Water Department has been working diligently since then to identify and develop the various resources and systems needed to implement Stage 3 rationing effectively over the next seven months through October 2014.

The City has not had to implement such drastic water restrictions since 1990, but we are fortunate to have as a guide for this work the Water Shortage Contingency Plan approved by Council in 2009 which incorporates the lessons learned from those earlier restrictions.

DISCUSSION: We currently project needing additional resources in each of following sections of the Water Department to implement Stage 3 rationing. Note that all additional employees will be hired for no more than six months and costs include office or field equipment needed to support their work.

Costumer Service:
This section of the Water Department handles water account management and billing and will be the front line of communication with account holders about reduced water budgets and adjusted allocations. Anticipated resources needed are:

- Informational mailings to account holders regarding water rationing;
- Four (4) additional office employees to respond to increased customer communications and requests for adjusted allocations; and
- Two (2) additional field employees to respond, in the community, to customer requests about their service account and meter operations, and to help customer identify possible leaks.

Conservation:
The Conservation section will be the center of outreach into the community about rationing and ways to conserve to meet reduced water budgets. Anticipated resources needed are:

- Two (2) additional outreach employees to develop outreach materials, make presentations, staff information booths and events, and conduct customer water audits;
- Two (2) field employees to respond to water waste complaints, patrol to enforce water conservation ordinances, educate customers on drought restrictions, and issue violations when customers do not respond to education;
- Printed education and demonstration materials; and
- Conservation devices for free distribution.

Administration:
Anticipated resources needed in Water Administration are:

- One (1) additional coordinator position is needed to assist in the development and subsequent management of the violation appeals process modeled after the processed used for parking citation appeals;
- One (1) administrative employees to provide support to the violation appeals process as well as increased public communications efforts; and
- Critical public communications efforts including print and broadcast advertising.

Production:
As a result of reduced water flows, we expect to be treating water with higher turbidity. This has a significant impact on our water treatment system, requiring equipment changes, increased chemicals, and additional maintenance to ensure effective operations, including:

- Relocating and adding aerators and other treatment equipment;
- Increased costs for chemicals, electricity, and wastewater services; and
- One (1) additional plant mechanic to address increased maintenance needs caused by drought water conditions.

Distribution/Meter Shop:
We anticipate more calls to locate check and repairs water meters as customer focus more on their water usage.

- Two (2) additional meter technicians to conduct increased water meter reads, repairs and resolve meter problems in a more timely manner; and
- Accelerating the purchase of two trucks ($48,000), originally scheduled to be purchased in FY 2015, to take advantage of competitive pricing and provide staff with trucks needed for drought-related meter work.

The estimated total cost of these additional resources is $1,033,011; with $699,656 of that total needed in the Water Department's FY 2014 budget and $333,355 in FY 2015. We must caution that the factors on which these estimates are based are not fixed, but will be affected by changing drought conditions, human responses to necessary change, and other varying factors, that may make it necessary to return to Council with further adjustments.

The Department will cover a portion of the current FY 14 year costs by re-programing $280,000 in existing budget allocations for net cost of $419,656 in the current year. Drought planning has

dominated much of the work in the Department during the last several months and work originally planned to be completed in FY 2014 was postponed allowing these budgeted amounts to be re-directed for drought related expenses. But additional allocation is still needed.

We also anticipate some revenue loss over the coming months as customers successfully conserve more water, and expect to use some of the current $2.4 million balance in the Water Rate Stabilization Fund to cover those lost revenues. We will return to Council at a later date to report on the specifics of that needed transfer.

Lastly, the Water Department would like to acknowledge the efforts of our other city department partners: Information Technology, Human Resources, Finance, and Public Works. Understanding the importance and timing of our efforts to implement a 25% reduction in water use, staff in these departments have shuffled their own priorities; worked long hours alongside Water Department staff; and have made a May 1st implementation date possible.

FISCAL IMPACT: The cost of implementing Stage 3 water rationing over the next seven months through October 2014 is currently projected to at $1,033,011; with $699,656 of that total needed in the Water Department's FY 2014 budget and $344,581 in FY 2015. In FY 2014, the $651,656 will be offset by reallocating existing resources for a net cost in FY 2014 of $419,656.

Council approval is requested of a budget adjustment that transfers $280,000 within the existing FY 2014 Water Department budget, and allocates an additional $419,656 for Stage 3 water rationing. Additional allocations for next fiscal year will be incorporated into the FY 2015 Recommended Budget.

Prepared by:	Submitted by:	Approved by:
Nicole Dennis	Rosemary Menard	Martín Bernal
Principal Management Analyst	Water Director	City Manager

ATTACHMENTS:
Budget Adjustment

City of Santa Cruz
BUDGET ADJUSTMENT REQUEST

○ Council Approval ..... Resolution No. _____
○ Successor Agency ..... Resolution No. _____
○ Administrative Approval

○ Current Fiscal Year
○ Prior Fiscal Year

TO: FINANCE DIRECTOR
FROM: Water Department's FY 2

DATE:

ACCOUNT	REVENUE EDEN ACCOUNT TITLE	
	TOTAL REVENUE	0

City of Santa Cruz
BUDGET ADJUSTMENT REQUEST

TO: FINANCE DIRECTOR

DATE:

FROM: Water Department's FY 2

ACCOUNT	EXPENDITURE EDEN ACCOUNT TITLE	
	see attached spreadsheet	
	TOTAL EXPENDITURE	0

NET: $ 0

Purpose:

Water Department's FY 2014 budget adjustments for implementation of Stage 3 Water Rationing

REQUESTED BY	DEPARTMENT HEAD APPROVAL	ACCOUNTING APPROVAL	FINANCE DIRECTOR APPROVAL	CITY MANAGER APPROVAL
Nicole B. Dennis Digitally signed by Nicole B. Dennis DN: cn=Nicole B. Dennis, o=City of Santa Cruz, ou=Water Department, email=ndennis@cityofsantacruz.com, c=US Date: 2014.04.02 07:22:24 -07'00' 04/02/14	Rosemary Menard Digitally signed by Rosemary Menard DN: cn=Rosemary Menard, o=City of Santa Cruz, ou=Water, email=rmenard@cityofsantacruz.com, c=US Date: 2014.04.01 15:40:42 -07'00' 04/01/14	Cheryl Fyfe Digitally signed by Cheryl Fyfe DN: cn=Cheryl Fyfe, o=City of Santa Cruz, ou=Finance, email=cfyfe@santacruz.com, c=US Date: 2014.04.02 10:23:47 -07'00' 04/02/14	Marcus Pimentel Digitally signed by Marcus Pimentel DN: cn=Marcus Pimentel, o=City of Santa Cruz, ou=Finance Department, email=mpimentel@cityofsantacruz.com, c=US Date: 2014.04.02 16:29:31 -07'00' 4/02/14	

Water Department
Drought Response CY 2014

Fund	Dept.	Division	New Drought Activity	Object	Description	Section Name	Total Expense	FY 2014 Budget Adjustment	FY 2015 Recommended Budget
711	70	90	7199	51122	Temporary	Administration	$ 69,720	34,860	34,860
711	70	90	7199	52199	Prof. & Tech Services	Administration	$ 42,500	42,500	-
711	70	90	7199	52261	Eqpmt, Bldg, Land Rentals	Administration	$ 1,260	1,260	-
711	70	90	7199	52960	Advertising	Administration	$ 22,850	8,000	14,850
711	70	90	7199	54203	Computer - non capital	Administration	$ 6,200	6,200	-
711	70	90	7199	54205	Telecommunications Equip	Administration	$ 400	400	-
711	70	90	7199	54990	Misc. supplies and services	Administration	$ 1,000	1,000	-
711	70	90	7199	57401	Office furniture equipment	Administration	$ 6,000	6,000	-
							$ 149,930	100,220	49,710
711	70	92	7199	51122	Temporary	Customer Svc	$ 115,750	57,875	57,875
711	70	92	7199	52199	Prof. & Tech Services	Customer Svc	$ 6,500	5,000	1,500
711	70	92	7199	52227	Fuel Charges	Customer Svc	$ 4,800	2,000	2,800
711	70	92	7199	52261	Eqpmt, Bldg, Land Rentals	Customer Svc	$ 2,500	1,000	1,500
711	70	92	7199	52972	Printing Outside	Customer Svc	$ 9,011	6,011	3,000
711	70	92	7199	53101	Postage	Customer Svc	$ 3,500	3,000	500
711	70	92	7199	53118	Uniforms	Customer Svc	$ 280	280	-
711	70	92	7199	54203	Computer - non capital	Customer Svc	$ 6,000	6,000	-
711	70	92	7199	54205	Telecommunications Equip	Customer Svc	$ 800	800	-
711	70	92	7199	57401	Office furniture equipment	Customer Svc	$ 12,000	12,000	-
							$ 161,141	93,966	67,175
711	70	93	7199	51122	Temporary	Conservation	$ 88,000	38,000	50,000
711	70	93	7199	52199	Prof. & Tech Services	Conservation	$ 50,000	50,000	
711	70	93	7199	52227	Fuel Charges	Conservation	$ 4,800	2,000	2,800
711	70	93	7199	52261	Eqpmt, Bldg, Land Rentals	Conservation	$ 1,000	1,000	-
711	70	93	7199	52972	Printing Outside	Conservation	$ 10,000	6,000	4,000
711	70	93	7199	53101	Postage	Conservation	$ 5,000	3,000	2,000
711	70	93	7199	53114	Program Operating supplies	Conservation	$ 85,000	25,410	59,590
711	70	93	7199	54203	Computer - non capital	Conservation	$ 3,600	3,600	-
711	70	93	7199	54205	Telecommunications Equip	Conservation	$ 600	600	-
711	70	93	7199	57401	Office furniture equipment	Conservation	$ 6,000	6,000	-
							$ 254,000	135,610	118,390
711	70	95	7199	51122	Temporary	Production	$ 31,320	15,660	15,660

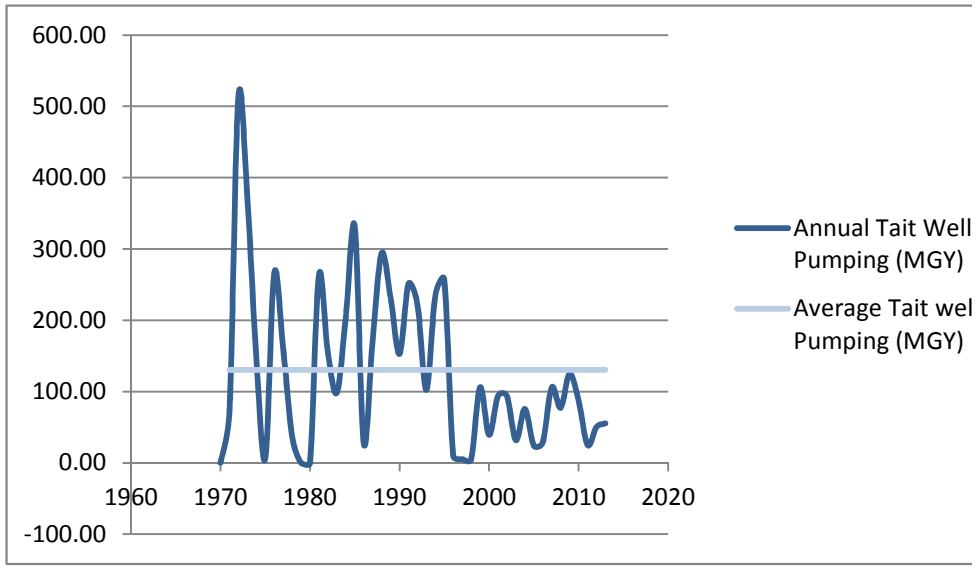
Water Department
Drought Response CY 2014

Fund	Dept.	Division	New Drought Activity	Object	Description	Section Name	Total Expense	FY 2014 Budget Adjustment	FY 2015 Recommended Budget
711	70	95	7199	52201	Water, sewer and refuse	Production	$ 19,000	19,000	
711	70	95	7199	52227	Fuel Charges	Production	$ 4,800	2,000	2,800
711	70	95	7199	53103	Chemicals	Production	$ 80,000	35,000	45,000
711	70	95	7199	53118	Uniforms	Production	$ 350	350	-
711	70	95	7199	53311	Electricity	Production	$ 16,000	7,000	9,000
711	70	95	7199	57990	Other capital outlay	Production	$ 218,330	218,330	-
							$ 369,800	297,340	72,460
711	70	96	7199	53103	Chemicals	Lab	$ 5,000	2,000	3,000
							$ 5,000	2,000	3,000
711	70	97	7199	51122	Temporary	Distr./Meter Shop	$ 39,640	19,820	19,820
711	70	97	7199	52227	Fuel Charges	Distr./Meter Shop	$ 4,800	2,000	2,800
711	70	97	7199	53118	Uniforms	Distr./Meter Shop	$ 700	700	-
711	70	97	7118	57402	Vehicle Equipment	Distr./Meter Shop	$ 48,000	48,000	
							$ 93,140	70,520	22,620
						Total	$ 1,033,011	699,656	333,355
711	70	90	7101	57203	Building Remodeling	Administration	$ (120,000)	(120,000)	-
711	70	90	7101	57401	Office furniture equipment	Administration	$ (30,000)	(30,000)	-
711	70	93	7104	52199	Prof. & Tech Services	Conservation	$ (120,000)	(120,000)	-
711	70	96	7107	52199	Prof. & Tech Services	Lab	$ (10,000)	(10,000)	-
							$ (280,000)	(280,000)	-
						Grand Total	$ 753,011	419,656	333,355

Tait Wells

4. copy of Historic Water Production

Year	Annual T	Average Tait wells Pumping (MGY)
1970	0.00	
1971	70.36	130.59
1972	512.84	130.59
1973	372.63	130.59
1974	148.35	130.59
1975	5.92	130.59
1976	265.93	130.59
1977	160.98	130.59
1978	36.98	130.59
1979	0.00	130.59
1980	0.00	130.59
1981	264.02	130.59
1982	154.57	130.59
1983	98.48	130.59
1984	204.42	130.59
1985	331.51	130.59
1986	27.55	130.59
1987	172.50	130.59
1988	294.09	130.59
1989	232.29	130.59
1990	152.76	130.59
1991	251.12	130.59
1992	223.08	130.59
1993	102.35	130.59
1994	235.53	130.59
1995	256.84	130.59
1996	9.93	130.59
1997	5.30	130.59
1998	4.85	130.59
1999	106.06	130.59
2000	39.38	130.59
2001	93.98	130.59
2002	93.74	130.59
2003	31.79	130.59
2004	75.63	130.59
2005	24.05	130.59



Tait Wells

4. copy of Historic Water Production

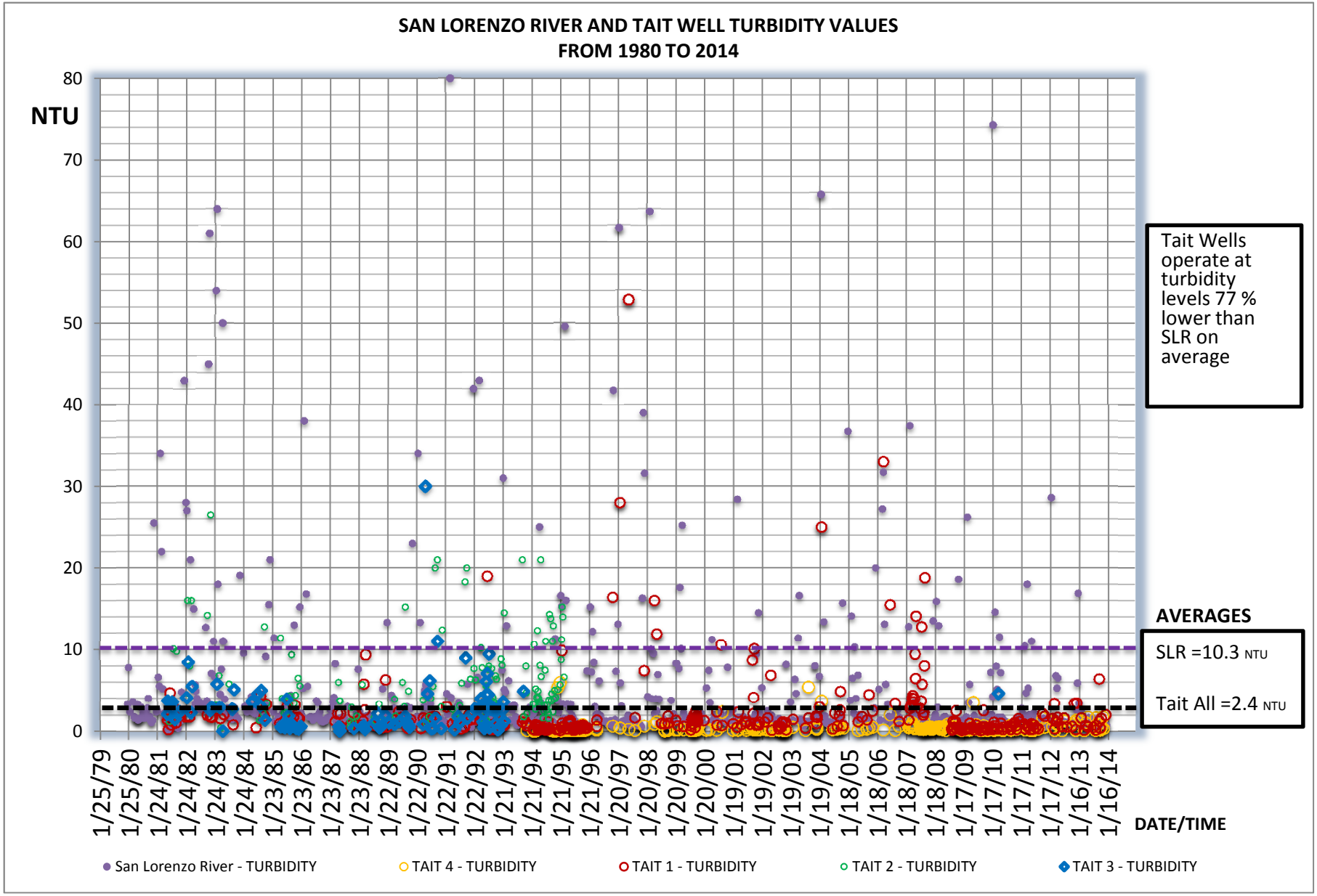
2006	28.74	130.59		
2007	105.81	130.59		
2008	77.34	130.59		
2009	124.77	130.59		
2010	87.72	130.59		
2011	25.18	130.59		
2012	50.21	130.59		
2013	55.55	130.59		
MAX:	512.84	1573.90	AFY	1.41 MGd
	130.59	400.77	AFY	0.36

Tait Wells

4. copy of Historic Water Production

ls

lls


SAN LORENZO RIVER AND TAIT WELL TURBIDITY VALUES
FROM 1980 TO 2014
NTU
80
70
60
50
40
30
20
10
0
1/25/79
1/25/80
1/24/81
1/24/82
1/24/83
1/24/84
1/23/85
1/23/86
1/23/87
1/23/88
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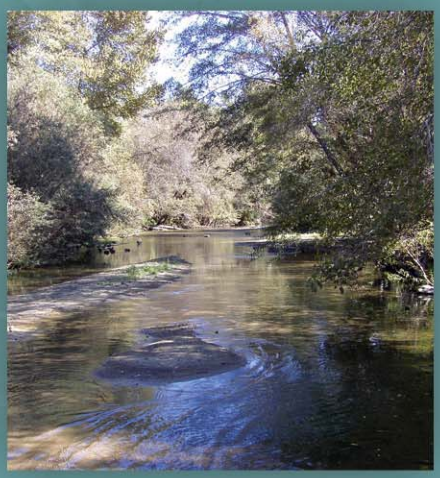
1/17/12
1/16/13
1/16/14
DATE/TIME
Tait Wells operate at turbidity levels 77 % lower than SLR on average
AVERAGES
SLR =10.3 NTU
Tait All =2.4 NTU
San Lorenzo River - TURBIDITY
TAIT 4 - TURBIDITY
TAIT 1 - TURBIDITY
TAIT 2 - TURBIDITY
TAIT 3 - TURBIDITY



ALTERNATIVE EVALUATION REPORT

Tait Street Diversion Sanding Study

May 2009

WOOD RODGERS

DEVELOPING INNOVATIVE DESIGN SOLUTIONS

3301 C Street, Bldg 100-B
Sacramento, CA 95816
Tel: 916.341.7760
Fax: 916.341.7767

TAIT STREET DIVERSION

SANDING STUDY

ALTERNATIVES EVALUATION REPORT

Prepared For:

Santa Cruz Water Department

May 2009

Prepared By:

WOOD RODGERS
ENGINEERING • PLANNING • MAPPING • SURVEYING
3301 C Street, Bldg. 100-B Tel: 916.341.7760
Sacramento, CA 95816 Fax: 916.341.7767

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Introduction

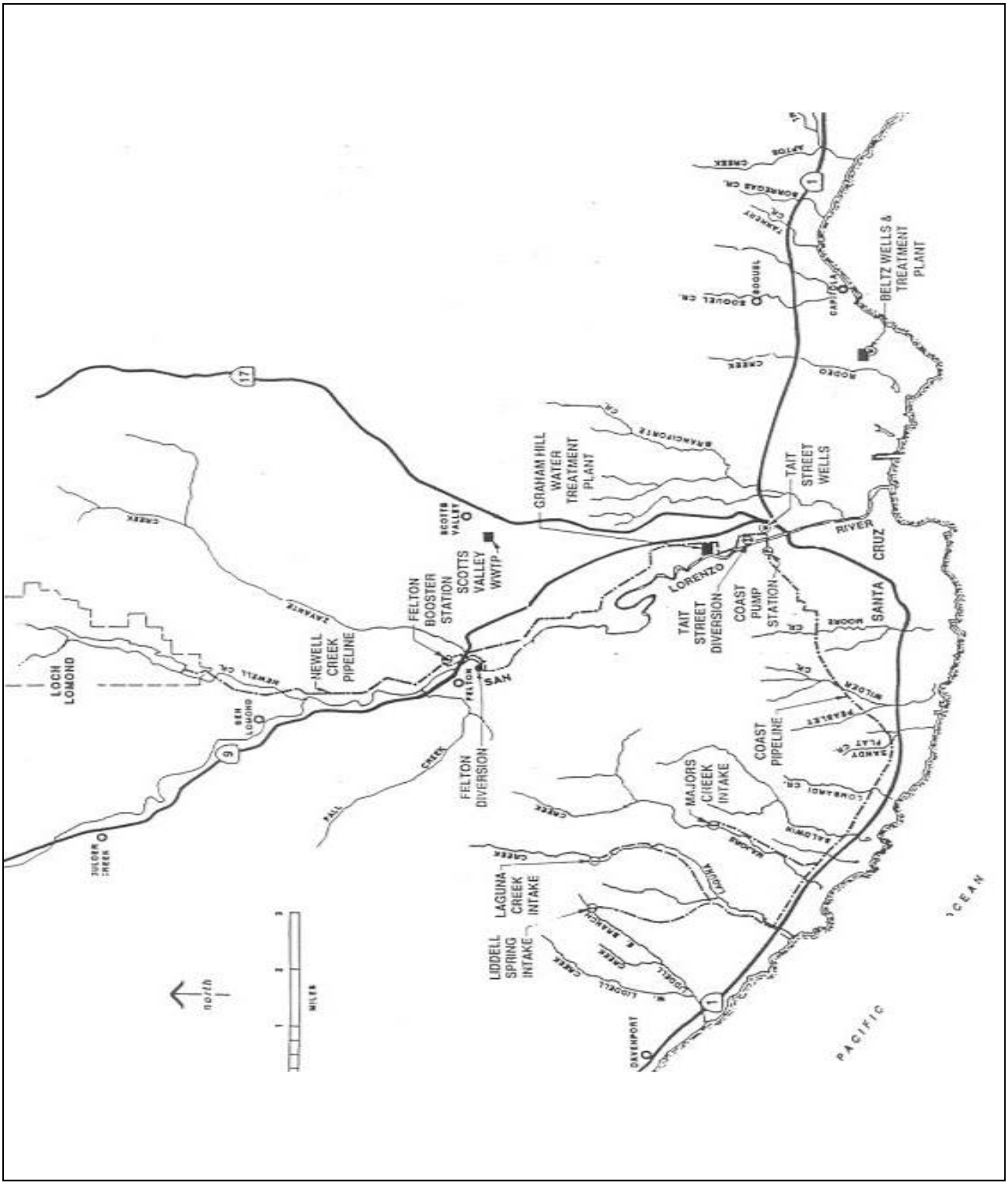
The original Tait Street Diversion was constructed in 1961 on the east bank of the San Lorenzo River, roughly two miles upstream of the point of confluence with the Pacific Ocean (Appendix A). Since that time it has become the Santa Cruz Water Department's (SCWD) single most valuable source for raw water production, accounting for roughly half of the City's overall water supply during any given year.

The facility originally consisted of a fish screened intake, pump station, and three wells operated conjunctively to divert and pump raw water from the San Lorenzo River to SCWD's Graham Hill Water Treatment Plant (WTP), approximately one mile to the north. Since its implementation, the Tait Street Diversion has suffered a series of misfortunes challenging its usefulness: flood related damage and reconstruction of the gravity diversion on the west side of the river in 1983, high levels of sedimentation burying the intake and limiting the rate of diversion, turbidity correlating to high river flows which limits the opportunity for diverting raw water, and mechanical failures due to pumping water laden with abrasives.

Raw water from the San Lorenzo River is a heavily depended upon resource given it is available virtually year round and, according to the City, requires less energy to utilize than its other sources. In terms of SCWD's system-wide supply sources, the Tait Diversion, North Coast System, Loch Lomond Reservoir on Newell Creek, and Beltz Groundwater Wells are operated collectively to sustain the City's domestic water demands. Given the City's water production sources and storage capabilities are in limited supply, it is important to optimize the Tait Street Diversion to the fullest extent.

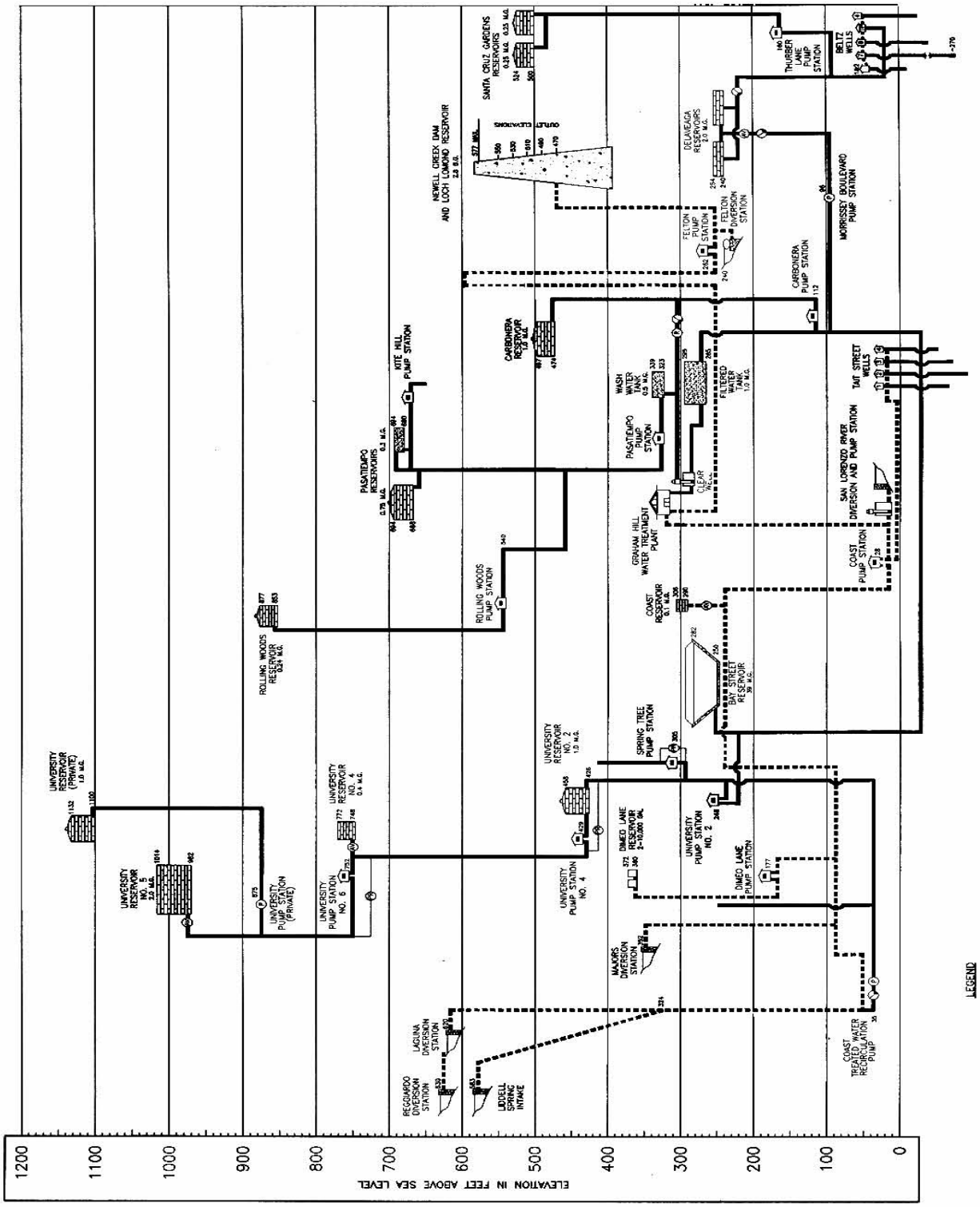
The subject point of diversion is fed by direct runoff and ground seepage from an approximate 115-square-mile watershed upstream (Appendix A). The City's water right license allotment was received under two licenses; the first license (No. 001553) granted in 1928 allotted the City 6.2 cfs, and the second license (No. 007200) granted in 1963 allotted the City 6.0 cfs. The 30-year period of record available from USGS hydrologic data (USGS Gage 11161000 San Lorenzo River at Santa Cruz, 1952-1960 and 1987-2006), indicates surface water in the river is available above 12.2 cfs for 75% of the time. According to the data, flows are less than 12.2 cfs mainly between July and December. Because the gauge is located downstream of the City's diversion, the influence of the diversion is not accounted for, and the percentage of time flow exceeds 12.2 cfs is actually greater than 75%. Regardless, the ability to continue to tap this resource is critical.

The Tait Diversion plays a vital role in the City's overall water supply infrastructure. The location and geographic relationship of system components are illustrated in the following figures, Figures 1 and 2.



Reference: City of Santa Cruz 2000 Urban Water Management Plan

Figure 1.
City of Santa Cruz Water Supply System – Geographic Layout



Reference: City of Santa Cruz 2000 Urban Water Management Plan

Figure 2. Schematic Diagram of SCWD's Water System

Statement of Scope & Purpose

The Santa Cruz Water Department is interested in improving the reliability and operations of its Tait Street Diversion. As a fundamental starting point, it is necessary to identify deficiencies of the joint facilities and define criteria and performance objectives by which to rectify their shortcomings. Because the Tait Diversion is the dominant contributor toward SCWD's overall domestic water supply, the City is seeking a solution that capitalizes on its capabilities. As a result, the SCWD has enlisted the services of Wood Rodgers to formulate and develop corrective measures that are hydraulically reliable, operationally sound, environmentally viable, and afford regulatory certainty into the future.

The primary purpose of this study is to identify practical means and methods that accomplish the following:

- Prevent intake and transport of abrasives found damaging to pumping equipment and WTP operations and minimize the effects of sediment deposition impeding the City's diversion operations.
- Upgrade fish screens to meet regulatory agency criteria for juvenile steelhead, fry-size life stage.
- Consider the condition and function of the check dam and formulate solutions to maximize diversions.
- Not a primary goal but an attractive benefit would be to minimize turbidity in the diverted surface water if possible.

The intent of this study is to present design parameters, performance criteria, and practical approaches for achieving the above. In doing so, feasible improvements to the City's existing facilities can be developed based on sound engineering principles and field proven technologies. Once viable alternatives are identified, a systematic approach comparing strengths and weaknesses of each is applied based on a common suite of characteristics.

The method of comparison, weighting, and ranking is developed so comparisons can be made based on a total cumulative score approach. More importantly, the method is a means of understanding the strengths and weaknesses of the alternatives. The ranking procedure also provides a convenient method of testing the sensitivity of each criterion in the comparison.

By applying this approach, it is possible to identify the alternative or combination thereof that best achieves the outlined goals and objectives, while at the same time correlating cost with benefits. Through the process of comparing potential solutions, the City can determine which alternative best suits the Project's objectives and the City's needs.

As a supplement to the above, concept level drawings are provided in Appendix B to adequately demonstrate the scope of each alternative suggested. The drawings serve as the basis for quantity takeoffs and provide the foundation for developing cost estimates provided in Appendix C. As the concepts are not developed to a final stage and are based on a limited understanding of existing features and facilities, a contingency is included to conservatively account for the cost of potential unknowns and future design refinement. Due to market volatility in recent years, additional cost factors are included to err conservative in the projection of alternative budgets.

The tools described above and furnished within this study lay the groundwork for the City to advance a preferred alternative toward the final design stage. To promote objectivity, progressive

versions of this document have been distributed to City engineering and O&M staff for review and comment. Accordingly, the weighting and cumulative scoring of alternative characteristics has been subjected to the influence of these involved parties. Using this approach supports a heightened confidence level that the results are consistent with a comprehensive and equitable decision-making process. A consolidated list of paraphrased review comments and responses to those comments is made available for review in Appendix D.

In terms of content, this report covers the following key elements to accomplish the purpose of this study:

- Scope and purpose of evaluation
- Description of existing facilities
- Current operating procedures
- Alternative development including descriptions and performance criteria for each
- System by which to appraise and compare alternatives based on a method of characteristics
- Summary of comparisons and scoring matrix
- Concept level exhibits for each alternative
- Cost estimates for each alternative

Description of Existing Facilities

In its current form, the Tait Street Diversion (Project) consists of a pair of relatively shallow (<100 feet) wells on the east side of the river and a screened intake and pump station on the west side. The two components share a common 24-inch CCP raw water force main routed to the City's WTP approximately 300 vertical feet above point of diversion and roughly one mile to the north. The facilities are operated according to the City's water production rules and operating protocols such that water quality and cost dictate which and when each is used. The Project is further broken down by component below.

Fish Screened Intake Structure

On the west bank of the San Lorenzo River approximately 100 feet upstream of the City's Coast Pump Station, a replacement gravity intake was designed and constructed in 1982/1983 after flood damage impaired the former facility and an alternative evaluation was conducted. The evaluation, prepared by Dewante and Stowell in July of 1982, recommended a chute-type gravity intake normal to the west end of the existing check dam. The relocation to the outside radius of the river channel was promoted as the ideal site to avoid siltation problems.

The intake, as it exists today, consists of an 8-foot by 25-foot reinforced concrete "box" housing two tee-type cylindrical screens with a compressed air scour cleaning system. The intake includes a substantial trash rack at the upstream end to protect the screens from impact damage due to entrained debris and bed load. The intake also includes upstream bulkhead slots and downstream channels for a slide gate to isolate and access the structure, see Drawing B-1, provided in Appendix B.

The intake was designed to maintain self cleaning transport velocities through the structure and to prevent fish impingement/entrainment up to the City's maximum diversion allotment of 12.2 cfs. The intake structure is connected to the pump station wet well via a buried 24-inch welded steel pipeline that transitions to a 36-inch CMP gravity inlet line.

The two fish screens are connected to the pipeline at the intake structure via a manifold and hydraulically operated butterfly valve located immediately adjacent to the intake in a below grade vault. The fish screen cleaning operation is provided by a 25-Hp air compressor and two receiver tanks with a combined volume of 500 gallons located inside the Coast Pump Station control building. The receiver conveys compressed air to the distribution manifolds in the screen elements via 2-1/2" galvanized steel conduits.

San Lorenzo River Pump Station

The San Lorenzo River Pump Station was constructed as an augmentation to SCWD's Coast Pump Station following the aforementioned flood damage. The original San Lorenzo River Pump Station was essentially relocated to the opposite side of the river channel utilizing an available wet well already constructed as part of the original Coast Pump Station improvements. The existing San Lorenzo River Pump Station wet well is therefore immediately adjacent to the Coast Pump Station and is housed within its compound. When the equipment was relocated, the wet well was reconfigured to receive gravity flow from the intake and pumped water from the Tait Wells located on the opposing side of the river channel.

In summary, the San Lorenzo River Pump Station consists of an 11-foot by 25-foot by 25-foot deep conventionally reinforced concrete sump, three multi-stage vertical turbine pumps, two with 250-Hp top set motors and one with a 150-Hp motor. The pumping systems include discharge circuits and valving, 20-inch discharge piping, a flow measurement station with acoustic flowmeter and below grade vault, a 10-inch pressure relief/return line (augmented by above grade electrically actuated bypass line), a hydropneumatic surge tank to arrest hydraulic transients, two submersible centrifugal desanding pumps, and electrical switchgear and motor control sections.

The pump station is configured to pump either 12.2 cfs from the river intake or a combination of diverted raw water and groundwater from the Tait Wells. Since the service pumps are not variable speed compatible, a bypass line is utilized via an electrically actuated butterfly valve to bleed off excess flow and ensure the City's water right limit is not violated.

The pump station sump features a sloped floor and desanding pumps to minimize grit ingestion into the service pumps by intermittently activating and discharging back to the river. The sump floor is also configured with a centrally constructed curb at the pump station gallery to offset the service pump suction bells from the floor and minimize sand entry. Judging from the amount of sand received at the headworks to the WTP and the expressed overhaul interval of the service pumps, these features are not effective.

Tait Wells

Two of four Tait Wells remain in functional condition, Well No. 1 constructed in the 1930's and Well No. 4 in 1992. Well No. 4 was constructed roughly 100 feet northeast of the river in a small protective building, and Well No. 1 is an outdoor facility located about 200 feet northeast of the river. One of the remaining wells (No. 2) was destroyed and the other (No. 3) is used as a monitoring well. The existing wells historically produce around 400 gpm to 500 gpm apiece and reportedly pump surface-influenced groundwater underneath the river to the Tait Diversion pump sump on the opposing side via an 8-inch asbestos concrete/16-inch welded steel pipeline. Various studies have attempted to characterize the connection between the Tait Wells and the San Lorenzo River, but none have been conclusive.

The Tait Wells generally are operated to dilute surface water/improve water quality when high turbidity exists in the diverted surface water. In addition the wells are relied upon when a deficit occurs in surface water availability. Although the wells are reported to have a low turbidity during periods of high turbidity in the river, they produce water high in iron and manganese that often exceeds the California Department of Public Health's (CDPH) secondary maximum contaminant levels (MCL's). In addition, the Tait Wells do not have annular seals that meet the CDPH's standards and are considered to be pumping underflow from the river. Water extracted from the Tait Wells is considered surface water and therefore requires the same level of treatments as the water pumped directly from the river.

Current Operating Procedures

The San Lorenzo River provides between 50% to 60% of the raw water supply to the Graham Hill Water Treatment Plant by way of the Tait Street Diversion and Tait Wells. The wells are used following episodic events to cut high turbidity in surface water during wet years and to supplement static water level in the pump sump (increase pump submergence) during dry years, usually in late summer. Otherwise the wells are used infrequently. Maintenance of the wells includes monthly exercising, periodic chlorine treatment to inhibit iron bacteria growth, and mechanical and/or chemical cleaning roughly every five years.

The Tait Diversion is typically in operation when river turbidity is below 10 NTU, and may be used at 25 NTU or less as a storm flow recedes. However, color in the water often limits use until it approaches 10 NTU. From a "daily operational" standpoint, the diversion is very low maintenance. An automatic air scour system is operated hourly for cleaning of the fish screens. Weekly visits are conducted to keep the trash rack and intake free of debris.

From a long term maintenance standpoint, the intake is extremely difficult to maintain. Sediment buildup in the intake structure has compromised the capacity of the diversion. Efforts to keep the screen completely clean and intake operational to design capacity has required significant effort and expense at times, with some attempts unsuccessful. In the past ten years, two attempts were made to clean the intake using suction dredging equipment. This exercise proved to be expensive, difficult to manage environmentally, and any positive results were quickly lost to re-sanding.

Though the intake is configured to allow control of the downstream outlet, this feature is rendered useless because sand deposits just downstream of the structure and spills into it. In the past, efforts were made to hydraulically dredge this area before the high flow season to promote greater flow and self-scouring conditions through the intake. This practice was discontinued because of turbidity issues.

River rock has also complicated keeping the intake free of sediment. While sand may be "flushable," eventually river rock deposits make up a good percentage of the sediments and are hard to move. Covering the top of the intake structure reduced this problem, but enough rock still passes through the upstream trash rack.

Water is conveyed from the screened intake to the pump station via gravity. Depending on water quality during the rainy season, it is estimated sediment loading within the wet well is least during this time of year. This is assumed to be the case due to lesser seasonal demand, higher water level within the river, and lower approach velocities at the fish screens. Conversely it is presumed once the river level subsides, sediment transported through the intake increases as a greater portion of river flow is conveyed through the structure. This is mitigated by the natural settling of sediment in the wet well upstream of the general service pumps.

The wet well was not designed for efficient removal of sand, nor do the general service pumps reach a typical service life. Although the service pumps are of high quality construction and designed to be somewhat abrasive handling, vertical turbine pumps cannot be economically fitted with the appropriate seals, bearings, and material hardness necessary to survive in this environment. They must be monitored for efficiency and replaced every two to three years.

The City attempts to remove abrasives from the sump using two submersible centrifugal pumps that operate at user-selected intervals. The pumps do not remove all the sand but limit the volume that accumulates within the wet well. The furthest upstream desanding pump is rated at roughly 75 gpm and is located in a collection box just downstream of the diversion pipe inlet into the wet well. This location is a high point in the wet well and detains a bulk of the sediment before entering the sump.

The second pump is rated at roughly 150 gpm and is located at the lowest point in the wet well, just upstream of the general service pumps. Both pumps are operated for roughly ten minutes at thirty minute intervals. When activated, the desanding pumps initially remove a substantial amount of sand. After pumping a few minutes no greater benefit is realized. Pumping frequency is adjusted to suit sand deposition. If pumping frequency is inadequate, the units become overloaded and fail.

The desanding pumps discharge into a storm drain inlet adjacent to the pump station. The drop inlet is surrounded by straw bales and wattles which decant the water before it gravity drains back to the river. The desanding system is functional and provides some benefit, but does not prevent sand entrainment through the pumps due to the range of incipient velocities they produce. Additionally, a baffle was installed in the wet well to interrupt the path of travel and reduce transport velocities. Unfortunately, this has not rectified the problem. As a result of desanding system deficiencies, the sump must be cleared of sediment several times a year with a VAC-truck.

Sediment that makes it past the desanding system is pumped to the headworks of the treatment plant. It accumulates in a channel ahead of the taste and odor mix chambers, and more so in the channel downstream. These channels were not designed to handle the degree of sediment loading incurred, and can only tolerate the resulting buildup for about six to seven years. The channels currently contain about fifty cubic yards of sand and will require the plant be taken off line for removal of the sediment.

Alternative Development

To the practical extent production can be maximized from the Tait Street Diversion and operation and maintenance demands can be effectively reduced, the SCWD is interested in determining cost effective alternatives or a combination thereof to remedy current challenges. Upon review of the project's background, supportive documentation, and discussions with City staff, Wood Rodgers envisions several corrective technologies are necessary or worthy of further exploration to suit project objectives.

The prospective general categories for addressing project objectives and design criteria are defined as follows:

- Fish Screen Improvements
- Source Grit Removal at Intake
- In-Line Grit Removal/Pre-Treatment System
- Capture of River Underflow
- Diversion Dam Improvements

By subdividing potential improvements by component, the associated key deficiencies are explained, corrective technologies described, and/or design parameters and approaches set forth.

Fish Screen Improvements

Problem Statement

The Tait Street Diversion and fish screens were installed in 1983, well before formalization of fish screening criteria published by CDFG and NMFS in 1993, and later modified in 1997 (NOAA) and June of 2000 (CDFG). Since that time certain physical and performance criteria have evolved that render the existing screens incompatible with the current standards. These deficiencies primarily relate to approach velocity, maximum screen opening size, and available screen area.

In light of the current operating environment within the intake structure, the effectiveness and hydraulic capacity of the two existing cylindrical fish screens are compromised. Although their design is fairly consistent with the latest federal and state criteria for fish screening, several factors must be addressed where there is inconsistency. These items are as follows:

- Maximum Allowable Screen Opening Size

  Regulatory agency criteria have since developed from the time the existing cylindrical screens were installed at the Tait Diversion. With the listing of steelhead has come more stringent screening requirements to protect fry-sized juveniles against entrainment. A reduction in fish screen opening size for steelhead fry was administered by CDFG in 1997 to prevent entrainment within the diverted water. The current criteria requires perforated plate openings not to exceed 3/32" in diameter or wedge wire slot widths not to exceed 1.75 mm. As a result, the existing screen material with a slot width of 0.094-inch is not consistent with the latest criteria prescribed at 0.0689-inch.

- Approach Velocity

  Current NMFS and CDFG fish screening criteria limit approach velocities (normal to screen face) to 0.33 fps for continuously cleaned screens. This velocity is deemed to be the sustained swimming speed of juvenile salmonids and the conservative limit at which the fish can avoid impingement at the screen face.

  The pair of tee-type cylindrical fish screens recommended and specified by Dewante and Stowell in 1982 were subsequently furnished by Johnson Screens. Per the manufacturer's submittal drawings, the in-place screens offer a gross surface area of 20 square feet each or 40 square feet in total. Assuming a perfect uniform distribution of approach velocities can be achieved over the available screen area (12.2 cfs divided by 40 square feet), the result equates to an average approach velocity of 0.30 fps. Based on prior experience, this condition never occurs in a dynamic environment where laminar flow does not exist.

  Velocity profile data provided by the manufacturer indicates that out of 18 point measurements recorded along the longitudinal axis of the screen, 8 of the values exceed the average baseline. Applying the said profile data suggests approximately 30% of the screen area will incur approach velocities exceeding the CDFG and NMFS criteria limit of 0.33 fps, otherwise termed "hot spots." In general the regulatory agencies will allow "hot spots" on new screen projects up to 10% of the total screen area without modification. The factory performance data from Johnson Screens indicates the fish screen modules are slightly undersized in light of recent criteria and informal allowances.

- Effective Screen Area

  The existing screen configuration requires considerable water depth to maintain complete use and exposure of available surface area. The current challenge of maintaining an intake structure free of sediment jeopardizes the ability of the fish screens to operate in accordance with regulatory criteria due to screen occlusion. Given the high sediment load and apparent rise in river thalweg due to sedimentation, corrective measures may not be 100% successful toward maintaining an unobstructed intake structure. Therefore, maintaining complete exposure of the existing screens' available surface is deemed unrealistic. With occlusion of screen area there is a proportional increase in approach velocity. The existing screens were sized with little contingency of surface area to spare in view of approach velocity criteria. The existing fish screens will not meet agency approach velocity criteria during any period when the screens are buried by sediment.

Corrective Measures

Two methods of preventing entrainment of fish in diverted water exist; either positive exclusion barriers (fish screens) or alternative behavioral devices. Fish screening physically prohibits fish from being diverted from the natural watercourse, whereas the latter relies on eliciting avoidance behavior of the target species.

Physical guidance devices and behavioral avoidance concepts have been studied since the 1960's to assess their effectiveness. Behavioral devices consist of instruments such as guidance louvers, lights, acoustics, temperature devices, chemicals, electric fields, bubble curtains, and so forth. They have proven unreliable and seldom do exhibit efficiencies above sixty (60) percent (Congress, 1995). Although behavioral devices are an ongoing controversy, they simply have not demonstrated the consistency and effectiveness of physical barrier screens. Very few have been permanently installed, and most that have are ultimately replaced with positive barrier screens. Behavioral devices are considered experimental and are not accepted by the regulatory agencies.

On the other hand, several fish screen types and configurations are available. Various configurations exist and have been employed with varying degrees of success. Commonly-used screen configurations are as follows: vertical, horizontal, or inclined fixed plate screens; drum screens; traveling screens; cylindrical screens; conical screens; Eicher screens; modular inclined screens; and submersible traveling screens (see photos on the next page). Screen materials typically used to exclude fish from raw water diversions are: slotted wedge wire, perforated plate, or woven wire fabric.

Photo 1. Cylindrical Screens

Photo 2. Cylindrical Screen

Photo 3. Chevron Screen

Photo 4. Chevron Screen

Photo 5. Inclined Plate Screen

Photo 6. Conical Screen

Photo 7. Inclined Plate Screen

Photo 8. Coanda Screen

Photo 9. Vert Cylinder Screens

Photo 10. ISI Cylinder Screen

Photo 11. Inclined Plate Screen

Photo 12. Air Burst Operation

Due to the challenges faced by the existing cylindrical screens, it is suggested an altogether different fish screen configuration be considered. An inverted flat plate fish screen constructed of wedge wire material is suggested as an improved screen arrangement to suit the high sediment buildup in the existing intake structure. An inverted plate screen can be arranged to fit within the existing intake structure with nominal modifications or in a new intake. This configuration of positive exclusion barrier can offer the following benefits:

- By arranging the screen panels in an inverted horizontal plane orientation, ample space is available within the existing intake structure to accommodate abundant screen area and thereby reduce overall approach velocities to regulatory standards for fish protection. (See Drawing B-2 provided in Appendix B)

- Buildup of sediment within the intake would have less of an impact on screen performance and typical operations.

- Inverted screen panels would occupy the upper region of the water column and decant water from the river accordingly. This arrangement would capitalize on the force of gravity and the inherent settling velocity of entrained solids drawing the material downward and away from the screen face. However, settling velocities for the range of sediments in question vary from roughly 0.04 fps for the finer particles (0.06 mm) to about 0.4 fps for the more coarse grained materials (1.0 mm) (Pierre, 1995, Table 5.4). Since the average approach velocity at the face of the fish screens would reach about 0.25 fps, it is uncertain how great a reduction in grit entrainment can be achieved by the proposed screen arrangement alone.

- The existing air scour cleaning system could be adapted to the new screen arrangement via air distribution manifolds behind the screens. Additionally, a new cleaning mechanism may be prudent with the different screen configuration. A traveling brush system could be included to supplement the compressed air system.

- The screen arrangement can be complimented by adjustable baffles to control and evenly distribute approach velocities over the screen face regardless of flow net characteristics and velocity fields within the intake.

Fish Screen and Intake Design Criteria

Considering the suggested fish screen improvements above, the following biological and hydraulic design parameters will be incorporated in the alternative development process to satisfy regulatory criteria for anadromous species:

a. Species of Concern: Juvenile steelhead (Oncorhynchus mykiss)

b. Juvenile Out-migration: January to June with the majority in April and May

c. Diversion Season: Year round

d. Design Flows and Velocities

- SCWD Water Right: 12.2 cfs.
- Screen Design Flow: 12.2 cfs.
- Bypass Flow: No requirement.
- Transport/Sweeping Velocity: Ambient.
- Maximum approach velocity perpendicular to screen face for continuously cleaned screens: 0.33 fps (CDFG, page 2/NMFS, page 4).

e. The wetted screen area is computed as follows:

$$A_{surface} = 150\% \times \frac{Q_{max}(cfs)}{0.33(fps)} = 150\% \times \frac{12.2cfs}{0.33\ fps} = 55\,sf$$

The above equation includes a 50% contingency in screen area to provide a substantial factor of safety against non-uniform velocity distribution. With a nominal amount of additional screen area, the ability to ensure approach velocities do not exceed established criteria is quite good.

f. The presence of fry-size steelhead is assumed. The slot widths of the screen fabric shall not exceed 1.75 mm or 0.0689 inch (CDFG, page 3/ NMFS, page 5).

g. The minimum porosity of the screen material will not be less than forty percent (40%). (CDFG, page 3/NMFS, page 6).

h. Screen material will be Type 304 stainless steel. Excess fouling shall be removed by operations personnel as required (CDFG, page 3-4/NMFS, page 6).

i. The fish screens will be cleaned as frequently as necessary to prevent flow impedance and violation of the approach velocity criteria. The standard cleaning cycle shall be determined by SCWD but must have the ability to occur every 5 minutes. (CDFG, page 2/NMFS, page 9).

j. The screen face shall consist of a flush, continuous plane over the entire bank of screen panels. (NMFS, pages 6).

k. Screens shall be fully submerged at all times during operation.

l. The fish screen will be protected from large debris by an existing debris deflector/trash rack to remain in place (NMFS, page 6). The existing intake has endured without structural damage and appears to be structurally robust relative to anticipated debris and bed load.

m. The screen will be configured to suit incremental raising of the intake structure should global sedimentation in San Lorenzo River cause the thalweg to rise. Additionally, the concept is compatible with an inflatable dam for sediment management. The flexible connections to compressed air piping will be readily adaptable.

n. The existing manifold vault will be used as a hydraulic stilling basin to receive weir or orifice flow from a port cut into the common wall shared by the intake structure.

Source Grit Removal

Problem Statement

Due to a history of intense storm events and high annual rainfall (30 inches to 60 inches per year), predominantly sandy topsoils, and relatively steep topography throughout the watershed, wash load into the San Lorenzo River is substantial. In fact, in the 25 years since the Tait Diversion was relocated the river thalweg has supposedly risen about 8 feet as a result of high sediment transport. Complete burial of the existing diversion dam suggests the mild slope or river profile at the project site has produced significant aggradation over time. In order for viable diversion practices to continue relative to the City's long range water supply plan, modifications to the intake are needed. Since it is a real possibility the river channel can continue to aggrade, proposed modifications must be readily adaptable to suit future adjustment if necessary.

The challenge with sedimentation in the San Lorenzo River as it relates to this Project is that sediment fallout within the intake structure hampers both fish screen performance and water supply operations. Sedimentation restricts raw water diversion by plugging the screens and promotes unwanted sand transport through downstream pumping equipment and into the City's WTP. The ongoing infill of alluvial material requires a countermeasure aimed at maintaining an unobstructed intake structure.

To understand the extent of the problem and future outlook regarding sedimentation within the San Lorenzo River, Wood Rodgers has consulted with the Regional Water Quality Control Board (pers. comm. L. McCann, Dec 8, 2006 and D. Roques, Jan 9, 2007). The RWQCB prepared a report, referred to as a TMDL (San Lorenzo River Total Maximum Daily Load for Sediment, September 2002) which presents a baseline understanding of sediment sources and transport characteristics within the San Lorenzo River watershed. The TMDL also establishes a point of index by which to contrast and monitor program implementation and results. The overlying intent of the TMDL is to reduce sediment loading in the San Lorenzo River and its tributaries such that resource benefits are optimized, i.e. water quality, water supply, fisheries habitat, etc. The RWQCB will qualify ongoing sedimentation conditions by performing reassessments every three years.

The TMDL indicates sedimentation is attributed to non-point sources including unsurfaced roadways (28.9%), channel erosion (14.3%), mass wasting or slides (41.7%), and general wash load or other miscellaneous sources (15.1%). The breakdown of sources illustrates sedimentation characteristics of the watershed are highly tied to mass wasting (mostly uncontrollable – estimated only 10% reduction by program implementation) and roadways (highly controllable – estimated up to 50% reduction by program implementation). Since sedimentation characteristics are highly tied to episodic hydrologic events and uncontrollable sediment discharge sources within the watershed, it is not possible to predict whether the river thalweg will remain in its current condition in the future.

However, according to the TMDL and input from those above, there is promise that sedimentation in the watershed has stabilized and conditions within the river will not worsen in the future. Based on anecdotal input from SCWD staff, it appears the river has reached a state of equilibrium and is somewhat self-sustaining. Additionally, the ceasing of timber harvesting and near build-out of the watershed are expected to reduce wash load into the river from load rates sustained in the past.

As a whole, it is likely river grade will not vary significantly in the future. Furthermore, the authors of the TMDL implementation plan are optimistic that measurable improvements will occur within the 25-year implementation horizon (Section 8.5) and future sediment loading in the San Lorenzo River will be lessened considerably.

Despite the positive outlook, it is wise to consider corrective measures that are readily adaptable to adjustment in elevation should the river thalweg rise in the future. Sediment management and intake improvements will be developed with the understanding that aggradation could continue in the future. Intake modifications will be arranged to preclude a major overhaul of the facilities should this occur.

Corrective Measures

Regardless of fish screen configuration, a grit chamber/grit removal system is suggested at the point of diversion. Two options are considered. Either a new intake can be constructed or the existing intake structure can be retrofitted (see Figures B-3 and B-4 in Appendix B). With respect to a new off-channel intake, it would be best served by a traveling rake system used to convey sediment to a roll-off container or spoil pit. If the existing intake were modified, a series of recesses or grit chambers constructed into the floor slab would be a practical method of minimizing sediment buildup.

The objective of either concept would be to provide preventative maintenance by periodically activating a sediment removal system or desanding pump(s) to remove manageable volumes of sand from the intake at regular intervals. A spoil container, settling basin, or grit classifier would be required at the point of discharge to separate sand from raw water before returning water to the river or wet well. Returning decanted water back to the river may require regulatory agency approval.

A new intake facility could be constructed off-channel adjacent to the existing diversion. The new structure is envisioned to consist of an intake channel, fish screen compartment using the screen configuration discussed above, mechanical rake system, and return channel. It is suggested the design of the structure emulate the concept of a rectangular sludge collector or sedimentation basin commonly used in the water and wastewater industry. The floor of the fish screen compartment or collector would be inclined and a catenary rake system used to drag sediment from the intake to a convenient spoil point. The rake system would involve multiple scraper arms or flights similar to that used for traditional sludge basins. The rake system could be programmed to operate at necessary intervals to limit sediment buildup within the structure to manageable levels. The concept is further illustrated in Photo 13 and Figures 3 and 4 below. The rake systems are manufactured by a number of equipment supplies such as Siemens (Envirex), E&I Corporation, FMC Corporation, and Gebhart Industrial Sales.

Photo 13.
Rake System Drive Head

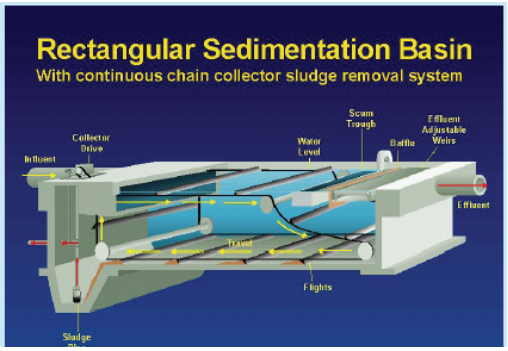
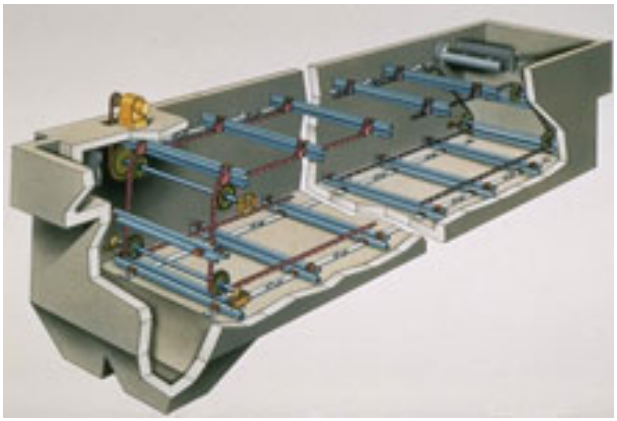


Figure 3.
Collector and Grit Removal System

Figure 4.
Collector and Grit Removal System



The concepts shown above would be slightly modified in that a sludge pit at the end of rake travel would not be included in the design, rather the floor of the "collector" would be ramped such that deposited material would be raked to an accessible spoil area that allows for material removal. The advantage of this concept is that it requires no flushing or bypass water to mobilize or transport sediment and will keep the intake/fish screen structure free of material that could otherwise compromise operations. This will ensure bulk sediment does not adversely affect screen performance and should significantly reduce the volume of grit transported to the pump station wet well. By locating a new intake facility outside the limits of the river channel, this alternative is more accessible for maintenance checks and repairs. The new intake concept will provide a reliable approach toward addressing desanding challenges and will greatly simplify sediment disposal. Figure B-4 in Appendix B includes a conceptual illustration of a new intake facility and source grit removal system.

As mentioned above, a second option exists for source grit removal. A series of three hoppers can be constructed within the base slab and aggressively sloped to ejector piping inlets at the bottom of each. Since sufficient vertical relief does not exist at the site to support gravity discharge, the ejector piping must be routed to either a wet pit or dry pit pump arrangement to pull water and sediment from the intake. The piping can be manifolded with necessary valving to a single or pair of abrasive handling pumps.

A similar concept was designed for Nevada Irrigation District's Cascade Pipeline headworks facility on Deer Creek. Representative construction photos are provided below for reference.

Photo 14.
Overall View of Intake Structure

Photo 15.
Grit Basins and Ejector Manifold

Photo 16.
Finished Grit Chamber

Sediment Removal Design Criteria

In consideration of the grit removal systems suggested above, the following hydraulic design parameters will be incorporated in the alternative development process:

a. Grain Size Distribution:

To obtain a reasonable representation of sediment grain size distribution, sieve analyses were conducted on soil samples collected at four locations; upstream of the intake, downstream of the intake, at the desanding pump discharge, and within the WTP headworks. The results of the tests indicate a uniformly graded, coarse sand comprises the bulk of the bed load within the river. The grain size distribution is as follows:

Sieve Size (mm)	Cumulative Percent Passing			
	Upstream of Intake Structure	Downstream of Intake Structure	Desanding Pump Discharge	WTP Headworks
#4 (4.76)	100	98	100	100
#8 (2.38)	99	85	99	100
#16 (1.18)	95	69	92	99
#30 (0.60)	37	29	53	85
#50 (0.30)	2	4	12	20
#100 (0.149)	1	1	3	2
#200 (0.074)	0.2	0.4	0.5	0.4

According to the gradations above, the instream samples consist of coarse sand per AASHTO M-146 and ASTM D422 characterizations (0.42 mm to 2.0 mm) with a higher amount of the fine sands (0.074 mm to 0.42 mm) being delivered to the WTP headworks.

b. Sediment Transport Velocity

It is conservatively assumed that incipient motion will be required to mobilize the largest grain size material collected in each grit hopper or collector, i.e. #4 Sieve (5 mm). For the grain size in question, a velocity of 2.5 fps is required to initiate sediment movement. To prevent sediment collection in the sand ejector piping, a safety factor of two is deemed appropriate to address larger gravel particles. This equates to a conservative fluid transport velocity of 5.0 fps to ensure movement of sediment from the intake to the desanding pump(s). An example graphic is provided below which relates fluid velocity to particle size for self-scouring, non-eroding channels with a non-cohesive bed substrate in channels.

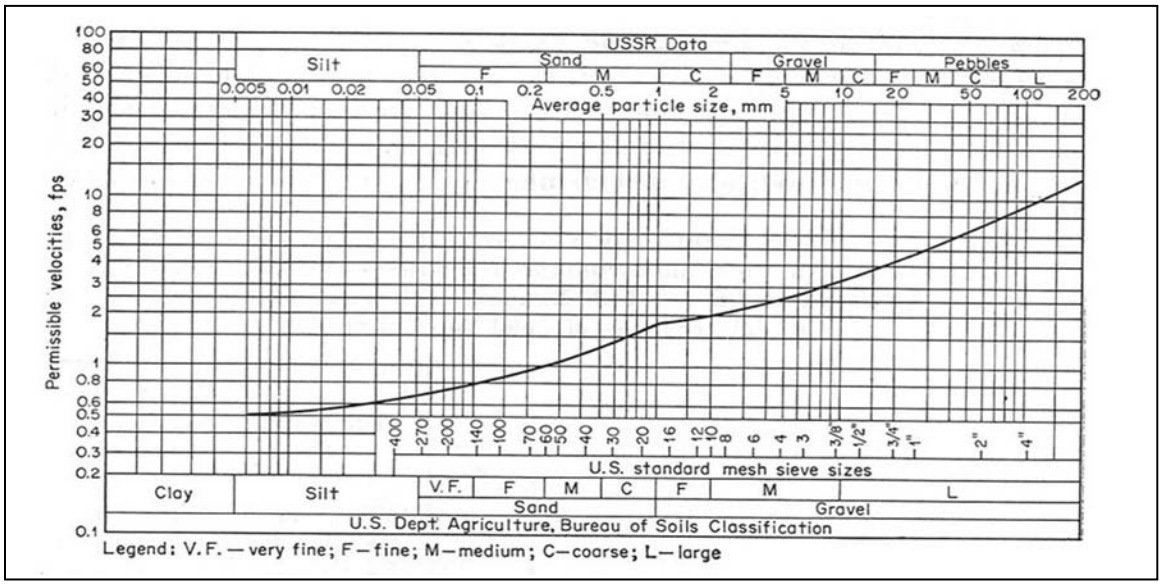


Figure 7-3.

"Open Channel Hydraulics," V.T. Chow, 1988.

c. Sand Ejector Piping

It is proposed 6-inch diameter piping be used for the sand ejector lines connecting to the suction(s) of the desanding pump(s) or wet well. It is recommended high density polyethylene pipe be used due to its resiliency, corrosion resistance, and abrasive handling capabilities.

d. Flushing Rate

To provide a scouring velocity per the above pipe sizing and fluid velocity criteria, a minimum flow rate of 450 gpm is required.

e. Grit Removal Pump Selection

The modified intake/grit chamber alternative demands a grit removal pump or combination of pumps suited for a high wear environment and abrasive handling service. Pumps used in the mining industry feature the type of construction best suited for the rigors of pumping slurry with a high solids concentration. A wet pit submersible or dry pit centrifugal pump is suggested for this application in a vertical orientation.

A variety of wear resistant impeller configurations are used for abrasive handling pumps as follows; vertical screw, recessed vortex, or enclosed multi-vane. The vertical screw impeller lifts the carrier liquid and entrained solids through a helical flow pattern therefore preventing high centrifugal force separating abrasives outward against the volute. The vortex impeller is recessed in the roof of the volute to keep the impeller out of the flow path. This minimizes contact between the impeller and abrasives and increases the flow throughlet area thus decreasing velocity. The multi-vane impeller features a backswept design to ensure a more

homogenous flow between the vanes, thereby minimizing the separation of solids and carrier fluid and resulting in low wear rates.

In either case a hardened impeller and volute or lining sleeve(s) are required to provide the needed durability and abrasion resistance of the rotating element and casing. A high chromium content cast iron, Ni-Hard alloy, or rubber lining of the volute interior are all available options. The impellers are generally hardened to 600 Brinell hardness/57 Rockwell C and the volutes to 300 Brinnell hardness. An example of pump makes and models meeting the duty conditions described above are as follows: ITT/Flygt Model HT 5520 MT (Dry-Vertical) or HP (Wet-Vertical); ITT/Goulds Model JCU Submersible Slurry Pump (Wet-Vertical); Wemco-Hidrostal Model E5K-LM Immersible Pump (Wet-Vertical).

Example photos of the three possible pump types are provided below for reference.

Photo 17.
Flygt Pump

Photo 18.
Goulds Pump

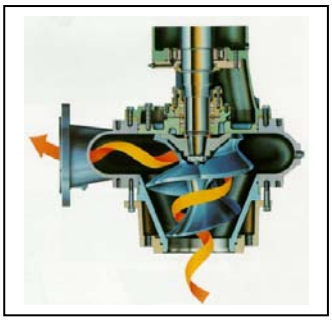


Photo 19.
Wemco Pump

Another alternative is an adaptation of an airlift pump known as the USFilter/Geyser hybrid pump. It is a pump technology developed to provide grit removal from vortex-type grit chambers in the wastewater industry. The pump operates off the principle of air introduced into the lower end of the column pipe. The buoyancy of the air pocket rising in the column once released combined with continual injection of air decreasing the density of water in the column pipe lifts the volume of water above and expels it through the discharge. This also generates high suction at the bell. Recurring cycles of this operation produces an intermittent flow pattern with no moving parts in the process that would otherwise be susceptible to abrasion and wear. Since SCWD already has a compressed air system in place for screen cleaning and surge suppression, this type of pump may make sense for both the source grit removal improvements and the in-line grit removal system discussed below. Examples of this pump are provided below for reference.

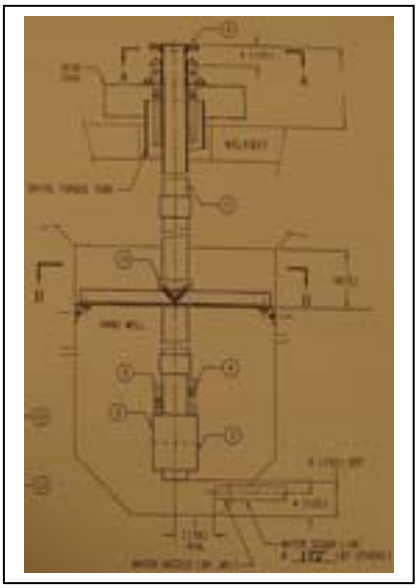


Fig 5.
Drawing of Geyser Pump

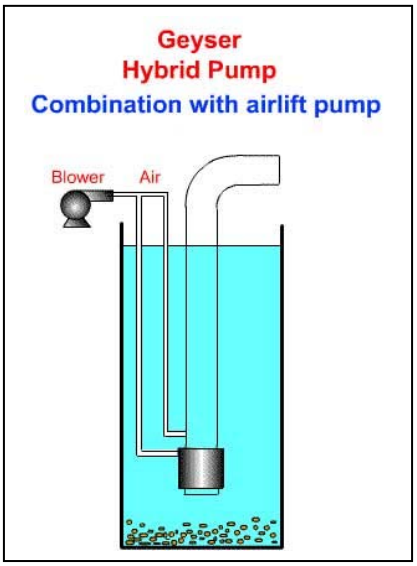


Fig 6.
Schematic of Geyser Pump

The merits and liability of each pump type will be further explored in the alternative formulation process. The type which best serves the outcome of the combined solution and most preferred by the City will be advanced in the final recommendations of this study.

f. Discharge and Grit Separation Parameters

For the new intake alternative, grit separation is not applicable. Sediments would be raked from the intake to a spoil area in a relatively dry condition for removal and disposal. The modified intake/grit chamber requires a different approach to separating grit from the carrier liquid at point of discharge. A technology is needed to allow the waste product to be conveniently managed and disposed of while at the same time routing the sediment-free supernatant or carrier stream to the river or pump station wet well. Two possible technologies for accomplishing this task are a sedimentation basin and a grit classifier.

A sedimentation basin relies on the settling velocity of the target grain size and the required settling time in the basin. For this application, it will be reasonable to remove particles down to the lower end of the grain size spectrum per the aforementioned sieve analyses (#200 Sieve). The settling velocity for this particle size is roughly 0.075 fps with horizontal velocity limited to 0.5 fps to prevent scour (Water Supply and Pollution Control, Viessman et al, 1993). A 10-foot by 20-foot basin geometry and 2-foot sill for decanting is deemed appropriate at this stage. The basin would be evacuated when collected sediment is roughly 1 foot in depth. Flow received in the basin would be distributed across the cross-sectional area via a removable baffle, and the supernatant would decant over a weir into a collection basin at the downstream end. Underground piping would return water to the point of discharge. An ideal location for siting the basin is at the north corner of the pump station compound.

An optional classifier would consist of a screw-type grit washer, conveyor, or decanting container, depending on the anticipated daily sediment removal and compatibility with the

in-line grit removal system further explained below. These technologies are initially deemed more maintenance prone due to a number of moving parts. It is Wood Rodgers' opinion the cost and complexity of such a device is unwarranted for the project. Adequate space is available for a simple sedimentation basin and therefore a classifier is considered excessive.

g. Miscellaneous

1. SCWD has reported significant debris and bed load can be expected. Debris has been characterized as leaves to as much as trees during significant storm events. Stones to 12 inches in the maximum dimension have been observed. To minimize the extent of material to be dealt with by the grit removal systems, it is suggested either a new trash rack be provided or the member spacing of the existing upstream trash rack be reduced. Additional pickets can be added to suit. In addition it is suggested a similar trash rack be added at the downstream end to prevent adult steelhead from gaining access to the intake and becoming blocked by the upstream trash rack. The barriers or trash racks should feature a member clearance of one inch to avoid gilling of adult fish and will likely require more maintenance than currently required. The existing trash rack features a clear spacing of 4 inches.

2. Because the thalweg of the river at the point of diversion is significantly higher than the invert of the existing intake structure, it is suggested the roller gate slots at the upstream and downstream ends be used to create a sediment sill for an alternative which utilizes the existing intake. Bulkheads or flashboards will retain and minimize the amount of sediment carried into the existing intake structure. It is recommended the flow area over the stoplogs be maintained to limit horizontal velocities into the existing intake structure to less than 1.0 fps.

3. The new intake structure should be configured with both inlet and return channels. The channels should be designed to maintain a minimum 2.0 fps velocity to promote sediment transport of the bulk of the potential sediments to the screen/collector structure. If dam improvements are needed to offset head loss caused by the in-line grit removal concept as explained below, it could aid in sediment transport regardless of diversion rate. In any case, a passable route will be needed for fish. The catenary rake system suggested for the new intake alternative is a widely used product in the wastewater industry and is expected to be a good fit for this application.

4. The grit removal pumps are expected to be able to pass up to roughly a one-inch diameter object without damage. Therefore the horizontal entrance plane of the hoppers should be screened with removable expanded metal covers with no greater than ¾-inch maximum openings. The panels would serve to screen out coarse gravels passing through the trash racks that exceed the passable sphere capability of the pumps. The proposed concept will need to be approved by CDFG and NMFS to permit the diversion of relatively small amounts of water during intermittent grit removal operations.

5. Turbidity conditions will not be improved by an intake grit removal system.

In-Line Grit Removal/Pre-Treatment

Problem Statement

Supplemental to the source grit removal section above, the process of ingesting entrained sediment at the point of diversion takes its toll on the SCWD's general service pumps and poses significant maintenance problems at the WTP. It is estimated roughly five cubic yards of sand is removed twice to several times a year from the pump station wet well (email from G. Braquet, Nov 7, 2006). The frequency of sediment buildup and removal is directly related to the deficiencies of the current desanding system. It is estimated the SCWD spends approximately $3,100 - $6,200 a year removing sediment from the sump.

Regardless of sump cleaning frequency, the passage of grit through the general service pumps is assumed to be continuous given the amount of sediment stockpiling in the WTP headworks and the frequency of pump replacement or rebuilding. Removing sediment from the raw water upstream of the pump station is an important endeavor toward reducing facility life cycle costs. It is estimated the SCWD spends about $45,000 every two to three years rebuilding or replacing the three service pumps that should realistically provide ten to fifteen years of service between overhauls. The two sand pumps cost about $7,000 (total) every two to three years and the intake cleaning costs about $6,200 to $9,300 each year. Furthermore, roughly $12,000 - $18,000 is spent every six to seven years removing grit from the WTP headworks. This activity is time consuming, requires a shutdown of the plant, and must be done by hand.

In addition to grit entrainment, turbidity has been identified as a problem within the watershed. The opportunity to operate the Project is restricted to times of year when the turbidity in the river is within the SCWD's tolerable range to accommodate. The WTP is capable of reliably treating raw water with a turbidity level up to 25 NTU. As part of the monitoring plan of the TMDL, the SCWD monitors water quality at the existing intake using a turbidimeter. This real time data is also used to determine the appropriate time for discontinuing diversion from the San Lorenzo River. Trends and operating experience have led to standard operating protocol being instituted whereby the diversion is taken off-line when measured levels of turbidity exceed 10 NTU on the ascending limb of the hydrograph. This threshold is generally indicative of worsening water quality conditions within the river. Conversely, on the descending limb the diversion would be reinstated when levels return to 25 NTU after a storm has passed.

Turbidity concentration is mostly attributed to rainfall runoff and resultant wash load flowing into the San Lorenzo River (TMDL, RWQCB, 2002) and has been measured to exceed 2,000 NTU. In addition, organic matter may be a significant contributor. It appears turbidity is directly correlated to the intensity of the rainfall event and flow within the San Lorenzo River (Draft SLR/Newell Turbidity and Flow WY 06, SCWD, C. Berry). Because the limit of turbidity the WTP can accommodate is roughly 25 NTU (SOP Related to the San Lorenzo River Source and RFP for Tait Street Diversion Sanding Study, SCWD, J. Bentley/J. Hyman) and turbidity can exceed this limit for considerable durations in the winter and spring months, the usefulness of the Project is restricted.

There is an impression that turbidity impacts are getting "worse". Turbidity monitoring throughout the watershed is part of the implementation and monitoring phase of the TMDL in order to better define the impacts as well as the sources of the turbidity. Implementing the recommendations of the TMDL for sediment reduction is also expected to improve turbidity in the long run. At this point in time there are no readily apparent solutions to specifically address turbidity reduction. It is expected

sediment delivery will continue for many years, so it must be assumed operations and proposed modifications will continue to face impacts from turbidity.

Corrective Measures

The SCWD's aging treatment plant is faced with increasing demands and elevated requirements for pathogen reduction and disinfection of drinking water. With respect to turbidity there are no practical technologies known at this time, short of a conventional water treatment plant, that will reduce turbidity from that encountered in the San Lorenzo River to within the SCWD's stated influent tolerances. Since the SCWD prefers to limit treatment facilities to a single location, no corrective pre-treatment measures can be practically employed at the Tait Diversion to effectively reduce turbidity in water supplied to the WTP, with the exception of subsurface collection described below. It is acknowledged that upcoming renovations to the Graham Hill WTP treatment scheme via permeable membrane filtration chemical which will be complimented by coagulation and flocculation prior to membrane filtration. This will provide greater flexibility to the SCWD as it relates to being able to receive and treat higher turbidity water than it does currently. Since treatment capacity using microfiltration will be significantly reduced as a result of influent quality and membrane fouling, it is recommended the SCWD review this topic with its plant expansion design consultant.

On the other hand, grit removal is entirely possible with modern technology. A redundant technology to that described above in the source grit removal section is available to compliment the grit chamber and improve confidence that abrasives will be removed from the raw water. A vortex-type grit trap or separator can be situated near the intake structure or corp yard to further ensure removal of entrained sediment. The mechanism can strain sediments and deposit into a recess or collection basin where they are pumped out to a static or mechanical device for convenient disposal. The settling basin described above or grit classifier explained below can be arranged to jointly serve the two systems if implemented.

Design Criteria for Grit Separators

Two grit removal systems are under consideration:

- A HEADCELL Settleable Solids Concentrator manufactured by Eutek Systems
- A PISTA Grit Removal System manufactured by Smith and Loveless

The two systems are illustrated in Figures 7 through 9. The operating concepts are similar but features and components of the two systems are significantly different. A supplemental grit classifier or sedimentation basin is common to either system for final dewatering of the collected sediment.

a. Eutek Systems HEADCELL

The HEADCELL includes no moving parts or mechanical components. It consists of a stack of nested trays supported by a stainless steel frame. Influent is introduced tangentially to the trays to establish a gentle vortex. As illustrated in Figure 7, the grit falls to the bottom of the unit with the effluent flowing to the outside of the stacks, passing between the trays. Complete removal of particles larger than 100 microns is expected.

The size of a HEADCELL required for a flow of 12.2 cfs is approximately 9 feet in diameter, which must be installed in a square concrete basin with an interior dimension of 12-feet by 12 feet and a depth of approximately 20 feet. The HEADCELL can be installed in a new structure adjacent to the existing intake as shown in Drawing B-3 of Appendix B, with the top elevation matching topography depending on location.

A continuous flow stream is needed to move grit from the HEADCELL collector to the point of discharge. A one-inch water line connected to the City's main would fluidize sediments that collect in the bottom hopper. The one-inch water line would connect to a venturi attached to a two-inch suction pipe. The suction pipe would extend to the bottom of the HEADCELL and would maintain a continuous carrier stream to keep grit in constant motion. The water line would need to provide roughly 50 gpm in order to induce about 100 gpm in the suction pipe. The total 150 gpm would be in constant circulation from the HEADCELL to the sedimentation basin and back to the HEADCELL structure or pump station wet well. With this efficient arrangement, a grit removal pump as described above would not be required for this type of grit separator.

Regarding hydraulic performance, a maximum of one foot of head loss through the grit separator is stated by the manufacturer. Since pump submergence at the wet well is already in jeopardy according to SCWD O&M staff, it is thought the additional head loss caused by the separator may be a significant problem. In review of comparable characteristic curves for the existing multi-stage vertical turbine pumps, it is understood 30 inches to 36 inches of submergence is required to preempt vortice formation, air entrainment, and cavitation.

Per the as-built plans the suction bells of the pumps are set at ~El. 2.75 NGVD. With the dam crest at ~El. 10.0 and the minimum sump water surface elevation at El. 5.75, roughly 4 feet of head loss would have to occur through the influent works to encroach on needed submergence. It is suspected submergence will not be an issue but this topic should be field confirmed by the City. As to net positive suction head (NPSH), this topic is a non-issue as the required pressure for comparable pumps is well below ambient atmospheric pressure. If SCWD's concerns with reduction in submergence prevail, dam improvements may be needed to offset head loss impacts through the grit separator.

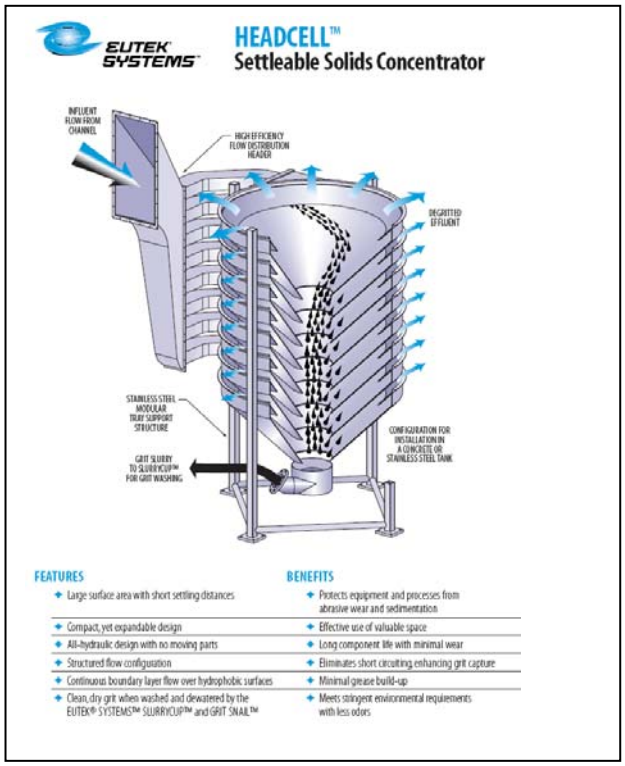


Figure 7.
Eutek Systems HEADCELL Vortex Grit Separator

b. Smith & Loveless PISTA Grit Trap

The PISTA grit removal system consists of a circular chamber approximately 12 feet in diameter by approximately 6 feet deep, and a second, smaller circular chamber where grit is collected and pumped out. The total depth of the system is approximately 12 feet. The upper chamber is flat-bottomed, with a rotating axial flow propeller mounted on a hollow drive shaft at the chamber bottom. The settled grit is drawn to the center by the flow induced by the propeller, and then falls into the grit storage chamber below. Grit, along with a carrier stream is pumped from the storage chamber through the hollow drive shaft by a top mounted grit pump furnished with the PISTA system. Grit would be separated from the carrier stream at the sedimentation basin and recirculated back to the pump station wet well. Grit removal performance and headloss are approximately the same as HEADCELL.

The PISTA system would require installation in a structure with the top elevation above maximum high water level.

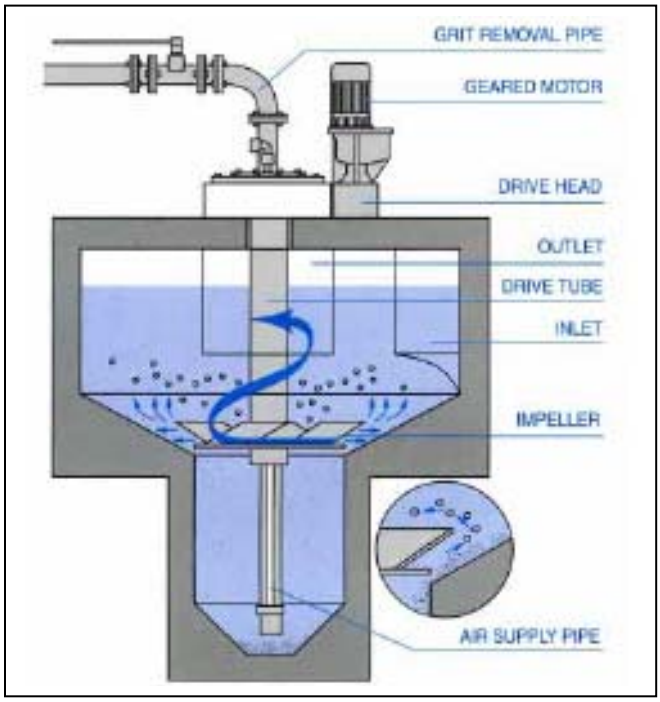


Figure 8.
Vortex-Style Grit Separator

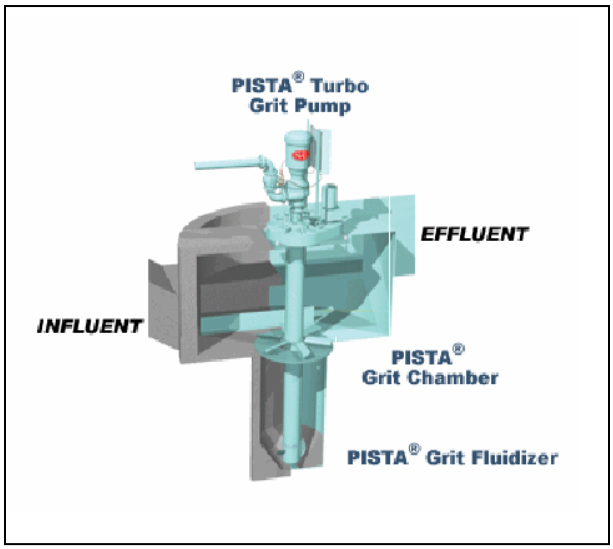


Figure 9.
PISTA Grit Trap

c. Grit Classifier

Grit separation equipment is available from both manufacturers. Eutek offers their TEACUP Solids Classifier and Grit Snail to completely dewater the grit. Smith and Loveless offers the PISTA Grit Screw Conveyor, which performs dewatering using a single piece of equipment. The cleaned carrier stream flows would be returned to the pump station wet well.

Both systems include a grit conveyor requiring a space of about 10 feet wide by 15 feet long. Both systems can dewater up to 2 cubic yards of grit per hour and discharge to a bin or hopper for convenient disposal. Typical configurations are illustrated below in Figures 10 and 11.

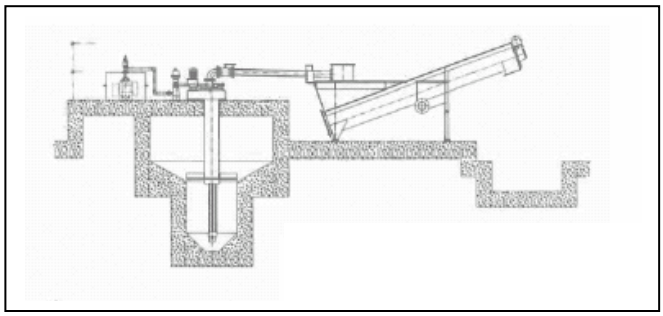


Figure 10.
Grit Separator and Classifier Layout

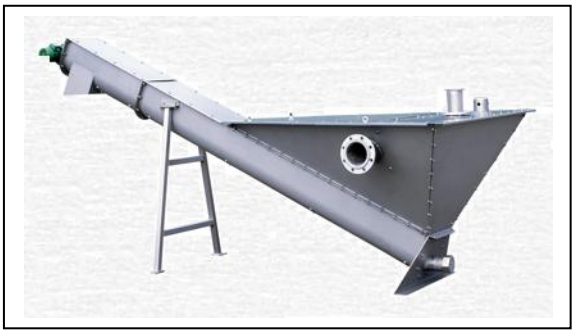


Figure 11.
Example Grit Classifier

Because a sedimentation basin involves no moving parts, is less expensive than a classifier system, and could be conveniently arranged within City property it is presumed the classifier system would not be necessary. A 10-foot by 20-foot basin geometry with a 2-foot sill is appropriate.

d. Turbidity Reduction

A maximum reduction in turbidity of approximately 10% is expected with either system, as neither will remove particles smaller than 100 microns. Reducing turbidity to the maximum of 25 NTU desired by the City would require chemical treatment, which is not practical at the intake location. As indicated at the kickoff meeting, any treatment modifications would be completed at the treatment plant.

Capture of River Underflow

Problem Statement

As discussed above, the existing Tait Wells supplement the supply from the Tait Diversion when supplies are unavailable or turbidity exceeds the current effective limit for treatment (25 NTU). Although the Tait Wells produce lower turbidity water, they have other water quality problems, especially with iron and manganese. Additionally, there have been various operational problems with the wells, including equipment failures and flooding of the well site. Numerous attempts over the last 25 years to identify further groundwater or river underflow supplies for the City have been unsuccessful.

These problems are discussed in more detail below:

- Water Quality

  The Tait Wells contain iron and manganese in concentrations that generally exceed the California Department of Public Health (CDPH) Maximum Contaminant Level (MCL). These concentrations increase with distance from the San Lorenzo River, as shown in the table below.

TABLE A. WATER QUALITY SUMMARY[1]

Source	Distance from River (feet)	Specific Conductance (μmhos/cm)		Manganese (μg/L)		Iron (μg/L)	
		Avg	Min-Max	Avg	Min-Max	Avg	Min-Max
San Lorenzo River	-	400	333-470	25	0-47	200	100-610
Well 4	~100	475	375-535	100	20-240	65	0-200
Well 1	~200	500	430-610	225	140-320	475[2]	330-570
Well 2	~375	500	475-555	300	232-360	3000	850-4200
Well 3	~400	475	455-510	525	430-600	2400	1630-3900

Concentrations of manganese are higher in all of the Tait Wells than in the San Lorenzo River, and increase with distance from the river. They generally exceed the secondary (aesthetic) MCL of 50 μg/L, and in Well 3 (now a monitoring well) have exceeded the notification level of 500 μg/L. Concentrations of iron are higher in the Tait Wells than in the San Lorenzo River (with the exception of Well 4) and

[1] All data is from the CDPH Water Quality Database from April 1987 to November 2004.
[2] Single anomalous result of 4900 μg/L omitted.

generally exceed the secondary MCL of 300 µg/L. Iron concentrations generally increase with distance from the river, with a notable (five-fold) increase from Well 1 to Wells 2 and 3. Specific conductance is slightly higher in the Tait Wells than in the San Lorenzo River; however, unlike iron and manganese, concentrations are fairly constant among all of the wells.

A review of well construction data from the Tait Wells, along with data from the 1981 Ranney Collector Study, indicates that water quality with regard to iron and manganese may also vary with well depth. Specifically, it appears that wells that are completed below a significant clay or silt layer may encounter higher concentrations of manganese and (especially) iron. Analytical results for metals from the 1981 Ranney Collector Study may be skewed high by turbidity in the samples.

- Operational Problems

  The location of the Tait Wells along the banks of the San Lorenzo River makes them vulnerable to flooding and inundation by surface water. Since water from the wells is treated like surface water, disinfection is not a significant issue; however, bacterial incrustation can result from surface water inundation, which can reduce well efficiency and lifespan. Additionally, electrical and other equipment can be damaged or destroyed by waterlogging.

  Other reported operational problems with the Tait Wells are likely related to the age of the wells and related equipment.

- Previous Attempts to Target River Underflow

  Previous attempts to target underflow from the San Lorenzo River, or groundwater, in other areas of the City have been largely unsuccessful. A review of these studies shows that (with few exceptions) they were conducted at locations south of the existing Tait Well field. Test holes and wells generally encountered fine grained aquifer materials, and the data collected did not support the conclusion of direct connection with the San Lorenzo River.

  The Tait Wells are located at the southern edge of a narrow valley along the San Lorenzo River. This valley extends approximately one mile north of the Tait Wells, with a width of 300 feet to ¼ mile on the east side of the river, before the river becomes very channelized and the valley ends. South of the Tait Wells, this valley widens into the lowlands that extend south to the Pacific Ocean. Generally, these lowlands are alluvial or floodplain deposits, and are characterized by finer grained deposits related to the larger depositional areas and associated lower flow (and consequently low sediment transport) rates. In contrast, narrow valleys with limited areas have generally higher flow (and sediment transport) rates, and will have coarser grained deposits. This understanding is supported by the available borehole logs provided by the City of Santa Cruz.

Recommendations

In light of the problems discussed above, several recommendations can be formulated to best target underflow from the San Lorenzo River. At this stage, "well" is used to refer to either shallow vertical wells or radial collector wells. The relative merits of these two approaches will be discussed in subsequent work. Recommendations are as follows:

- The SCWD should monitor key water quality parameters (pH, specific conductance) in the Tait Wells and in the San Lorenzo River on a monthly basis to establish an ongoing dataset to better understand the connection between the wells and the river.

- Any available well records for the narrow valley north of the Tait Wells should be obtained and evaluated to determine whether the geology is consistent with the understanding presented above.

- New wells should be located on the eastern side of the San Lorenzo River and as close to the river as feasible. The area immediately north of the Tait Wells should be considered if additional wells are needed.

- New wells should target all coarse grained sediments that correspond to the underflow from the San Lorenzo River.

- New wells should be constructed by qualified and experienced water well drilling contractors, with appropriate drilling fluid control programs, and should be designed to provide proper sand control. Wells should be fully developed to be as efficient as possible.

- The SCWD should consider compiling all of the available borehole geologic data collected to date for the areas near the San Lorenzo River within the City of Santa Cruz, in order to begin developing detailed geologic cross-sections that document the historic channels of the San Lorenzo River to assist in future projects that may target river underflow.

Well Design Criteria

Based on field observations and the considerations above, Wood Rodgers prepared a technical memorandum outlining site exploration and monitoring well construction at the Tait Well site and the Ocean Street Extension Well site. Wood Rodgers' technical memorandum and the Ranney Collector evaluation are provided in Appendix E. Conceptual drawings of a Ranney Collector and Casing Path Well are shown in Figures 12 and 13. Site-specific well designs for the Tait Street and Ocean Street sites are provided in Appendix E. Also included in Appendix E are detailed cost estimates for the construction of the work of each site.

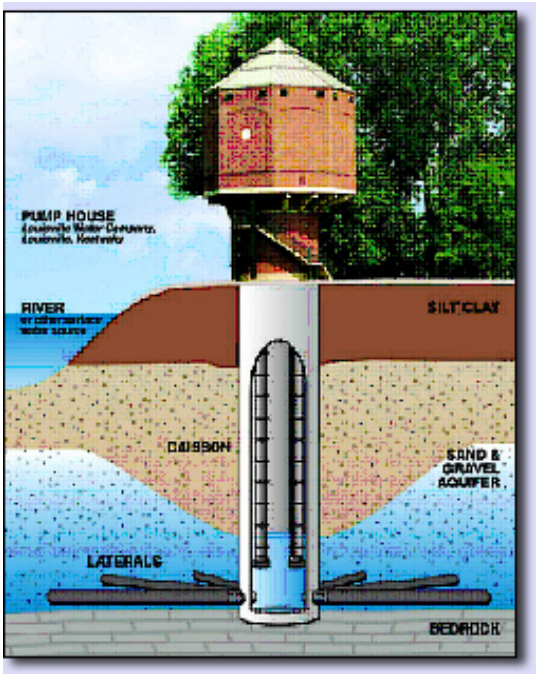


Figure 12.
Ranney Collector

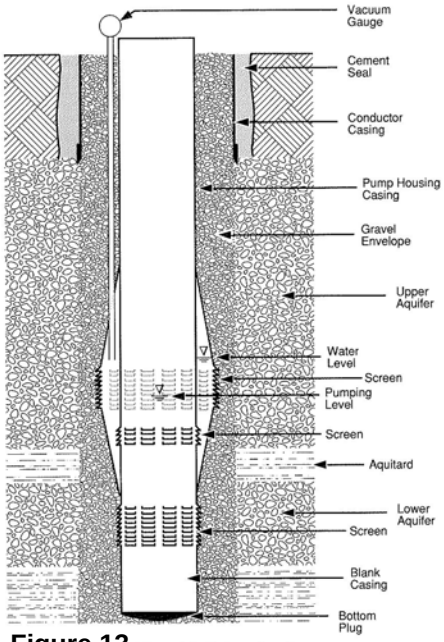


Figure 13.
Casing Path Well

Well Pipelines and Capacities

With two alternate vertical/collector well locations, distinctly different operating applications apply to each. At the Tait Street parcel, the existing pipeline used to transmit water from the existing Tait Well 4 to the San Lorenzo Pump Station can be tapped into. The new vertical or collector wells on the east side of the river would pump into the existing 16-inch raw water main which discharges to atmosphere in the pump sump on the west side, roughly 200 lineal feet from the prospective well site.

According to monitoring well results, the total combined well yield at the Tait Street site is expected to vary from ~ 800 gpm or 1.8 cfs (Well 4 and a new shallow vertical well) to ~1,500 gpm or 3.3 cfs (Well 4 and a new collector well) per Ranney Collector Wells. This range of flows is compatible with the existing raw water pipeline, producing velocities of 2 fps to 4 fps in the line. The well pump station discharge piping would be tapped into the existing raw water main with a mechanical tapping sleeve and buried isolation valve, making for a straightforward and economical transmission system.

Piping and pumping conditions at the Ocean Street site are considerably different. According to monitoring well results, it is expected that a vertical well at that side will produce ~700 gpm or 1.6 cfs and a collector well ~1,000 gpm or 2.2 cfs per Ranney Collector Wells. A 12 inch raw water main routed underneath Ocean Street is appropriate to convey raw water to a point of connection with the existing WTP influent line at the base of Graham Hill, approximately 2,000 lineal feet from

the well site. The pipe size suggested will accommodate higher flow than that initially expected from the collector well.

Either cut-and-cover or HDD (horizontal directional drill) methods would be appropriate depending on access constraints. It is understood that secondary access is available to the public, so shutting down the Ocean Street extension to construct the pipeline may be feasible. This would be preferred since the cost of HDD construction is roughly three times that of open trench construction. It is assumed at this point that the pipeline would be constructed using cut-and-cover methods. The new pipeline would be tapped into the existing raw water main with a mechanical tapping sleeve and buried isolation valve. Pressure class of piping would be 200 psi minimum due to the significant static lift to the WTP.

Diversion Dam Improvements

The existing Tait Diversion features a gravity concrete weir spanning the width of the San Lorenzo River. Over time the river channel has aggraded and the dam no longer functions to check water upstream, but rather exists as more of a grade stabilization structure. As a result, no head differential exists across the structure and the intake has become a low point in the river channel. Similar to the City's Felton Diversion upriver and sediment management improvements recommended for the City's Majors, Laguna, and Reggiardo Creek diversions, an inflatable dam or pneumatic spillway gate can be employed as an effective means of mitigating sedimentation at the Tait Diversion.

By impounding water above the point of diversion, the intake facilities could be raised above the river bottom to avoid drawing in sediment. With an adjustable weir, the dam could be lowered to maintain sediment transport during high bed load conditions and serve to flush the river channel in the vicinity of the diversion. In addition, raising the water level upstream could be used to concentrate bypass flows through the intake promoting self-cleaning hydraulics. An example of this technology is shown below.

Figure 14
Upstream View

Figure 15
Downstream View

Figure 16
In Service

A pneumatically controlled spillway gate, or rubber dam, is designed to mechanically attach to a reinforced concrete grade beam or footing across the river channel. The spillway gate consists of an arched gate panel that is anchored to the spillway deck and rests on top or upstream of a nylon-reinforced rubber membrane body or bladder. Although the rubber body is resilient, the steel gate panel also serves to protect the body from puncture. In contrast to earlier rubber dam systems, the spillway gate concept also provides enhanced repeatability in terms of maintaining desired impoundment stage set points. The proposed

spillway gate system is comprised of an anchorage assembly, cast-in-place drain and air piping, rubber body, galvanized steel gate panel, end seals, air compressor, and an automated pressure control/regulating system.

As a result of implementing a spillway gate, impounding water would also produce a barrier to in-migrant fish. Therefore, a fish ladder would be needed to facilitate fish passage. Producing a new barrier in the river would require buy-in from the regulatory agencies and would involve a new fish ladder to maintain.

For this application an approximate 40-foot long by 3-foot high spillway gate and foundation would be appropriate. An approximate 40-foot long by 6-foot wide fish ladder would also be expected. A new fish ladder would add approximately $250,000 and a new spillway gate system would add approximately $500,000 to the overall cost of the Project.

The addition of dam improvements produces a number of benefits and liabilities to the Project which should be deliberately considered. As for their impact to the alternatives comparison process, the dam improvements are universal to all alternatives considered in this study and therefore have no discriminating effects on alternative comparisons. The technology is only discussed in this report. If other suggested improvements are able to produce the intended benefits, the dam improvements discussed herein are not warranted.

Construction Requirements

Implementing the technologies and alternatives presented in this report involves both common and specialized construction methods. Instream work for the on-river features requires cofferdamming, bypassing, and dewatering activities to provide and maintain a dry working space. To protect existing infrastructure and ongoing operations during construction, sheeting and shoring (sheet piles) might be required to support deep excavations and prevent disturbance to existing facilities. Typical earthwork activities such as clearing, grubbing, excavation, spoiling, backfilling, slope protection, and surfacing would apply for the alternatives considered.

In general adequate space exists at both sites for accommodating the proposed technologies, although access and working space is constrained by vegetation, topography, existing improvements, and property boundaries. Serving utilities are available at the Tait Street Site whereas extension of power and piping is needed to serve the Ocean Street site. It appears three-phase overhead power exists up to the point on Ocean Street where the City's raw water main redirects uphill to the WTP. Extension of power and piping from this location is approximately one-half mile north. Figures 17 and 18 below illustrate site locations and basic feature layouts.

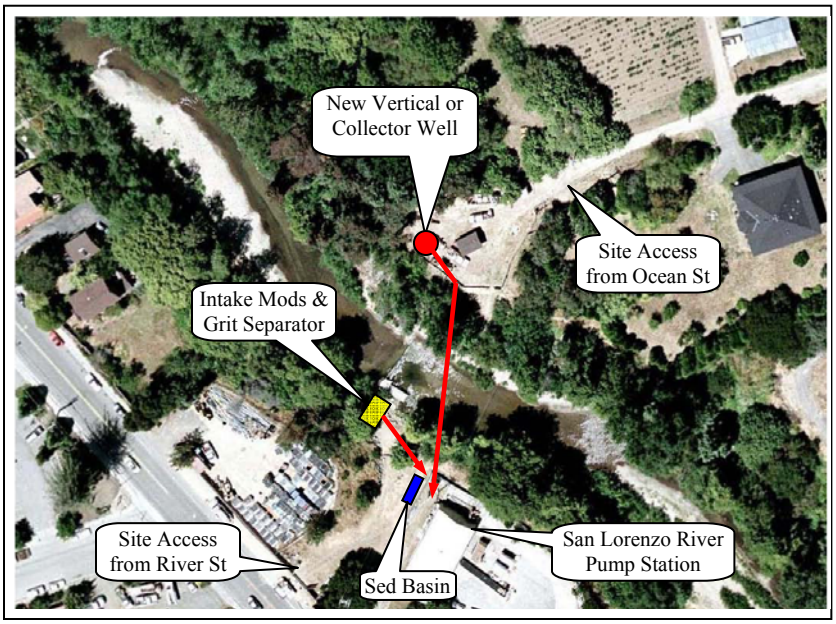


Figure 17.
Tait Street Site

0 ft. 100 ft.

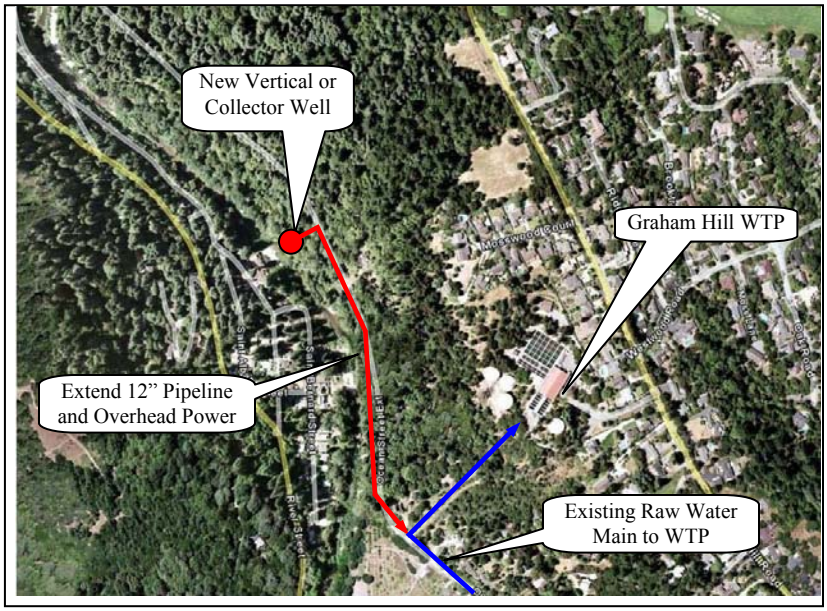


Figure 18.
Ocean Street extension Site

0 ft. 500 ft.

Instream work at the Tait Street site must be conducted between July and October due to regulatory agency permitting requirements. Vertical or collector wells at the Tait Street site can be constructed within the existing well site boundaries with little difficulty. These improvements can make use of existing utilities and City infrastructure. At the Ocean Street extension site, access would need to be established to the well site off of Ocean Street extension, and an area would have to be cleared to receive the well facilities. Utilities and piping would need to be extended roughly one-half mile to

serve the Ocean Street extension well facilities. Constrained access may dictate construction methods along the Ocean Street Extension route as explained earlier in this report.

Construction of the gravity diversion and grit removal technologies is not overly complicated or specialized. Construct of the subsurface component of the vertical and collector wells requires specialized drillers and contractors. A large pool of contractors for vertical wells exists, but the pool of contractors for collector wells is extremely small. Top-side contractors would be more available to carry out the improvements at the surface.

For the most part, the improvements considered in this study can be constructed with common industry practices and equipment. The technologies do, however, involve some specialized construction as well as mechanical and electrical equipment. Basic industry materials and equipment make up the bulk of the project such as pumps and motors, piping and plumbing, custom fabricated metalwork, pre-cast and cast-in-place concrete, structural steel, and other miscellaneous building materials.

Operational Modifications

The technologies described in this report, when assembled to form alternatives, impart some changes to current operations. The alternatives described in the following section of this report consist of gravity diversion improvements, vertical and collector wells, and combinations thereof. The gravity diversion alternatives would continue to operate in similar fashion as the Tait Diversion presently does. Water would be drawn through the fish screened intake structure when the San Lorenzo River Pump Station (SLR) units are activated. The key difference is the raw water would travel through a grit separator before reaching the pump station. The objective is to remove damaging abrasives from the diverted water prior to reaching the pump station.

To meet this objective three different operating processes would occur with the aforementioned grit removal technologies.

Grit Chambers

The grit chambers in the modified intake structure would be coupled with a desanding pump station. The station would be triggered at programmed intervals to draw accumulated sediment from the hoppers in the intake structure. The general service pumps at the SLR station would temporarily reduce speed (when diversions are greater than 11.2 cfs), the desanding pump(s) would kick-on, sediment-laden water would be pumped to a sedimentation basin, and the carrier water would decant and return to the diversion system, either at the grit separator structure or SLR sump. Once flow connectivity was made between the sedimentation basin and the diversion system, the SLR general service pumps would ramp back up to their former speed. This sub-logic routine could be programmed in a local PLC to orchestrate the operation.

Grit Separator

Water drawn through the screens would pass through the HEADCELL unit previously described. As entrained sediment settled to the bottom of the unit a suction pipe would draw in the material using a carrier stream and discharge it into the sedimentation basin. With a 50 gpm water supply connection taken off the SLR discharge pipeline, a continuous suction could be produced with a 150 gpm carrier

stream. This operation could be performed continuously or at intervals as needed to prevent sediment buildup within the grit separator. Once flow connectivity was made between the sedimentation basin and diversion system, the diversion operation would not be affected by this system.

Traveling Rake System

A catenary raking system would be operated as needed to rake sediments from the intake structure into a spoil structure or container. This operation could be programmed to occur at user selected intervals and durations. This technology would not use water to convey or move sediment from the structure.

Well Operations

Well operations, whether for vertical or collector wells, would most likely be managed manually. The well pump station(s) would be activated when turbidity in the San Lorenzo River is high or surface water availability is low. The wells could be operated to cut surface water and improve water quality, supplement surface water flow, and maintain water supply when surface water is unavailable in the river. Coordinating flow contribution between the Tait Diversion, the existing Tait Well 4, and the proposed wells at the Tait and Ocean Street extension sites would require some intelligent interface depending on needs and existing conditions.

Comparison of Alternatives

Process of Comparison

To address sanding and fish protection challenges at the Tait Diversion, a variety of corrective concepts have been identified. In order to determine the optimum solution, the concepts must be packaged into discrete alternatives and compared against one another. The time and effort required to conduct an alternative comparison is generally more economical than deploying the wrong solution. Accordingly, five potential alternatives are presented below to determine which best fits project objectives and SCWD's long-term water supply goals. These alternatives are as follows:

- **Alternative No. 1 – Surface Water Intake Retrofit**

  This alternative consists of retrofitting the existing intake facilities with new fish screens and sediment mitigation technologies. This alternative involves modifications to the existing screened intake structure and manifold chamber to receive new inverted fish screens and grit chamber in the intake floor. Pre-manufactured flat-plate screen modules and a traveling brush cleaning system would be installed upon removal of the existing cylindrical screens and diversion pipe manifold. Structural modifications would be made to existing structures as needed to divert water from the river into the intake pipeline. Recessed grit chambers, or hoppers, would be constructed into the intake floor and coupled to ejector piping and a desanding pump station. The system would draw sediments from the intake structure and discharge them into a sed basin at the north corner of the pump station compound. A vortex grit separator is included in this alternative and would be installed in a subsurface structure adjacent to the intake structure. A suction piping system would be installed to transport sediment from the separator to the sedimentation basin. Drawings B-2 and B-3 of Appendix B illustrate the key features of this alternative. This alternative would be capable of diverting 12.2 cfs. Improvements to the existing diversion dam are not part of this option.

- **Alternative No. 2 – New Surface Water Intake**

  This alternative involves constructing a new screened intake structure paralleling the existing intake and river. The existing diversion would be protected in place for redundancy purposes. The new off-channel intake would include inlet and return channels, a fish screen/grit collector structure, a catenary sediment rake system, and a spoil structure. Pre-manufactured inverted screen modules and a brush cleaning system as described for Alternative No. 1 are included in this alternative. In addition, a vortex grit separator is included to strain sediment form the diverted water. See Drawing B-4 of Appendix B for an illustration of alternative features. This alternative would be capable of diverting 12.2 cfs. Improvements to the existing diversion dam are not part of this option.

- **Alternative No. 3 – Combined Intake Improvements and River Wells**

  This alternative is a combination of Alternative No. 1 and two separate vertical wells, one at the Ocean Street extension site and one at the Tait Street site. This alternative involves constructing two shallow (70-feet deep) vertical casing path wells to capture river underflow. The wells would include submersible turbine pumps and motors, buried valving and piping, a pair of elevated control platforms (with adequate freeboard above

the flood plain) with enclosures housing electrical switchgear and MCC's, and minimal site improvements. Piping and electrical service to the Ocean Street extension site is included with this alternative. The wells would not achieve the full diversion entitlement per the test well program results included in this report. They would, however, be used to supplement the gravity diversion or provide water when surface water conditions are poor. The Tait Street well is expected to produce ~300 gpm and the Ocean Street extension well ~700 gpm. The wells would operate in conjunction with the gravity diversion to achieve the full diversion entitlement.

- **Alternative No. 4 – Combined Intake Improvements and Radial Collector Wells**

This alternative is a combination of Alternative No. 1 and two separate collector wells (Ranney Collectors), one at Tait Street and one at Ocean Street extension to capture river underflow. Ranney-type collector wells would include a caisson wet well, influent piping laterals, vertical turbines pumps, top set motors, valving, manifolds and piping, control enclosures on top of the caissons housing electrical switchgear and MCC's, and minimal site improvements. Piping and electrical service to the Ocean Street extension site is included with this alternative. The top of the caisson wet well would extend above ground with adequate freeboard above the flood plain to protect electrical equipment and motors. The wells would not achieve the full diversion entitlement per the Ranney Collector evaluation included in this report. They would, however, be used to supplement the gravity diversion or provide water when surface water conditions are poor. The Tait Street well is expected to produce ~1,000 gpm and the Ocean Street extension well site will need further hydrogeologic investigation and testing to determine yield. The wells would operate in conjunction with the gravity diversion to achieve the full diversion entitlement.

- **Alternative No. 5 – No Action**

The existing facilities would be operated and maintained as they presently are. No improvements would be made.

The five alternatives above are compared using a weighted decision matrix, or Pugh Method. This method is a practical decision-support tool that applies a quantitative approach to ranking alternatives based on a variety of criteria. The process enables decision makers to compare alternatives on a holistic level by evaluating, rating, and combining cumulative scores. Rather than simply listing the positive and negative aspects of each option, a matrix defining the concepts versus needs addresses multiple factors and gives the owner a sense of individual characteristic performance and overall score. There are four basic steps to a Pugh Method matrix as it applies to this study.

1. Project characteristics are chosen and weighted based on their relative importance on a scale from 0 to 10.
2. Each alternative is evaluated by how well it addresses each characteristic on a scale from 0 (worst) to 10 (best).
3. Each alternative is scored for each characteristic, and the ranking score is the product of the weighting and scoring.
4. The ranking scores are summed for each alternative, and the best score normalized at 100 and all others prorated accordingly for convenient comparison.

The matrix should be used as a tool rather than an answer. It should be used to explain the strengths, weakness, and differences among the alternatives rather than as just a simple comparison. Though the matrix provides a final relative score by which alternatives are compared, the highest score may not necessarily represent the best option for the owner. Interested parties may likely weigh characteristics differently depending on their roles, responsibilities, and authority with respect to the Project. Each entity might therefore have a different final ranking of alternatives.

This method of comparison provides an opportunity to objectively assess how well each alternative fits the owner's needs, and in addition, helps look for possible improvements in their designs. The characteristics used in evaluating and comparing the alternatives are discussed in detail below. Any low scoring characteristic can be further investigated to see if a modification to the design could raise the ranking score. Independent reviewers can modify the weights and resulting scores to reflect their interests and test the sensitivity of overall scoring.

The comparisons and recommendations for improvements are based on collective input from Wood Rodgers and the City. Where the City is unable to weigh in on particular aspects of the study, Wood Rodgers' professional judgment and experience designing, evaluating, and constructing surface water intakes, fish screens, and wells are applied to the process. The comparisons have initially been made "blind", meaning Wood Rodgers assigned an initial estimate of characteristic value. Input from the City has been used to supplement the initial assumptions and the cumulative scores weighted appropriately. Optimistically, the final scoring is representative of an objective alternative comparison process.

Characteristics Compared

As explained above, a Pugh comparison matrix is used to compare how alternatives meet all conditions and objectives deemed important to involved parties. Individual criteria are explained below. Scoring for each parameter is included in brackets for each alternative. The associated weighting and ranking values of each criterion are presented in the detailed schedule of the "Comparison Summary" section of this report. The evaluations are broken down into seven general categories; fish protection, water supply, sediment and debris, operation and maintenance, design and construction, and environmental and permitting.

Since project cost is a basic element of alternative comparison, but the value of cost is entirely subjective to financing parties, the cost factor is not scored as a characteristic within the comparison matrix. Values are simply provided in this report for informational purposes.

Fish Protection

The federal listing of anadromous steelhead trout and coho salmon requires particular measures for preventing entrainment and impingement at direct diversions. Fish protection is broken into three characteristics described below for the purpose of comparison and evaluation of components.

Entrainment Prevention

The dominant concern associated with fish protection is preventing adults and juveniles from being redirected from a natural watercourse to a point of no return. In any case where this occurs, the determination has been made by the Endangered Species Act that the species are subject to "harm." Therefore, a positive method of excluding fish from diverted water is required for listed species of the fry-size life stage and up. Screening must be provided according to regulatory agency standards up to the maximum rate of diversion.

Alternative No. 1 – Intake Retrofit [8]

According to standard engineering practice and as explained earlier in this report, the suggested fish screen improvements will adequately protect the target species and life stages from entrainment. It is recommended NMFS and CDFG concurrence be obtained prior to final scoring. It is unknown whether the unscreened grit chambers will be acceptable to the regulatory agencies.

Alternative No. 2 – New Intake [10]

Same as above for Alt No. 1 with the exception that no unscreened grit chambers are proposed.

Alternative No. 3 – Intake Improvements/Vertical Wells [9]

Due to collection of subsurface flow drawn through an appreciable surface area of the streambed, the target species and life stages are protected against entrainment. Combining with Alt No. 1 reduces the score slightly

Alternative No. 4 – Intake Improvements/Collector Wells [9]

Same as above for Alt No. 3.

Alternative No. 5 – No Action [5]

Existing screens do not meet criteria.

Impingement Prevention

This characteristic pertains to limiting approach velocities at points of diversion to less than the physical swimming capabilities of juvenile salmonids per CDFG's and NOAA's fish screening criteria. Although CDFG's criteria allows for a design approach velocity of 0.4 fps for self-contained screens at small pumped intakes (<40cfs), no such allowance is made in NOAA's criteria. Therefore an approach velocity of 0.33 fps is considered to be the governing criteria for fish screen design.

Alternative No. 1 – Intake Retrofit [10]

The proposed fish screen improvements provide ample surface area to ensure approach velocities at the fish screen are held to the criteria limit. In addition, the adjustable baffles will aid in ensuring the approach velocities are uniformly distributed over the surfaced

areas of the screens. It is recommended NOAA and CDFG concurrence be obtained prior to final scoring.

Alternative No. 2 – New Intake [10]

Same as above for Alt No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [10]

Due to collection of subsurface flow drawn through an appreciable surface area of the streambed, the target species and life stages are protected against impingement.

Alternative No. 4 – Intake Improvements/Collector Wells [10]

Same as above for Alt No. 3.

Alternative No. 5 – No Action [3]

Existing screens do not meet criteria.

Post-Construction Evaluation

This characteristic involves the need for a hydraulic performance evaluation in light of design criteria. CDFG and NOAA generally require new fish screen projects be field evaluated after completion.

Alternative No. 1 – Intake Retrofit [8]

The proposed fish screen requires velocity testing in the field to validate compliance with design criteria. This testing is a low cost activity generally conducted for documentation purposes. With contingency in screen area there is little risk the screens will not comply with screening criteria.

Alternative No. 2 – New Intake [8]

Same as above for Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [8]

Testing or criteria conformance is not applicable to wells but screen component requires testing.

Alternative No. 4 – Alt No. 4 – Intake Improvements/Collector Wells [8]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [10]

No testing required.

Water Supply

The Tait Diversion is an invaluable component of SCWD's water supply system. The goal of this project is to maximize the City's ability to capture and divert raw water from the San Lorenzo River.

Access to Raw Water

Water is generally always available at the current point of diversion. As previously stated, the City's maximum allotted diversion rate is available more than 75% of the time in the San Lorenzo River. This characteristic pertains to the ability of the alternative to acquire, collect, and divert raw water from the river.

Alternative No. 1 – Intake Retrofit [6]

This option is able to divert so long as surface water is available in the river. Once it flows subterranean, this method of diverting is no longer possible.

Alternative No. 2 – New Intake [6]

Same as above for Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [8]

This option has the ability to tap subsurface storage regardless of whether surface water is present in the river or whether flooding conditions occur. This option capitalizes on the benefits of both surface water diversion and wells. The versatility of using either diversion method allows this alternative to score well.

Alternative No. 4 – Intake Improvements/Collector Wells [10]

Same as above for Alternative No. 3 except that horizontally radiating well screens have greater access to water than vertical wells.

Alternative No. 5 – No Action [5]

Current intake is not accessible to water right at all times due to sedimentation and screen blockage.

Efficiency of Raw Water Usage

It is reported the Tait Diversion is the City's most economical source of raw water. Due to close proximity to the Graham Hill WTP and static water level typically above ground surface, this source has proven to be a cost effective system to operate.

Alternative No. 1 – Intake Retrofit [10]

The gravity capability of direct diverting to the pump station makes this alternative an efficient delivery source. Energy usage would remain unchanged from that currently incurred, with exception of a small desanding pump.

Alternative No. 2 – New Intake [10]

Same as above for Alternative No. 1, with the exception that a rake system would be used in lieu of a pump.

Alternative No. 3 – Intake Improvements/Vertical Wells [7]

Requires pumping from a pumping water level below the hydraulic gradient in the river due to drawdown effects. Well(s) located at the Ocean Street extension parcel improve efficiency by pumping from a higher hydraulic gradient and having less distance to pump to the WTP (friction/minor losses reduced as a result of being roughly one-half mile closer to the WTP). Energy usage will be higher than current usage.

Alternative No. 4 – Intake Improvements/Collector Wells [7]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [10]

Maintaining a gravity diversion allows this option to score the same as for Alternative No. 1.

Reliability of Diversion

This characteristic applies to the long term dependability of raw water diversion from the San Lorenzo River. Topics that can diminish reliability include river stability, aggradations, seasonal bio-fouling, loss in porosity of streambed due to occlusion, etc.

Alternative No. 1 – Intake Retrofit [7]

Gravity diversions are considered the most reliable form of water supply as they are accessible, can be made to be self-cleaning, and are field proven through numerous installations worldwide. Since the horizontal alignment of the river channel at point of diversion is extremely stable, this alternative is expected to be immune to future geomorphologic changes. Since the screen modules and intake can be raised to suit potential aggradation of the riverbed, this alternative will not face the same misfortunes as the existing screens.

Alternative No. 2 – New Intake [7]

Same as above for Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [10]

Subsurface pumping adjacent to a watercourse is susceptible to long term yield degradation and a greater degree of uncertainty than gravity diversions. Once plugged, they are not easily maintained and permeability can be greatly altered.

Alternative No. 4 – Intake Improvements/Collector Wells [10]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [6]

This option offers less flexibility than Alternatives No. 1 and No. 2.

Flexibility and Redundancy of Diversion

This characteristic applies to the flexibility of operations and redundancy of sources for diverting raw water from the San Lorenzo River. Multiple intakes, multiple wells, and different sources of water supply improve the City's infrastructure redundancy and the ability to choose which facilities should be used.

Alternative No. 1 – Intake Retrofit [5]

This alternative offers the least protection and greatest risk of all five alternatives in terms of water supply assurance. Only surface water can be utilized by this option and if taken out of service, only the low producing Tait Wells are available to fill the void.

Alternative No. 2 – New Intake [6]

If the existing intake is protected in place, the two diversion facilities could provide some benefit. This option therefore has some limited redundancy but still relies on surface water as its primary source.

Alternative No. 3 – Intake Improvements/Vertical Wells [7]

Assuming the full water right entitlement can be achieved, with multiple and possibly redundant wells this option is fairly versatile. Keeping the existing diversion could also prove beneficial.

Alternative No. 4 – Intake Improvements/Collector Wells [7]

This option scores the same as Alternative No. 3.

Alternative No. 5 – No Action [3]

This alternative is the most limited of all options.

Sediment and Debris

Sediment loading and turbidity in the San Lorenzo River are restrictive towards the use of surface water. Entrained grit compromises fish screen operations, damages equipment, and requires labor intensive removal from the pump station wet well, intake, and WTP headworks. Debris can range from leaves to large woody materials but is generally not onerous or prohibitive towards operations.

Sediment Intercept and Management

The San Lorenzo River experiences high sediment loading corresponding to rainfall events. Preventing grit buildup and transport into downstream mechanical equipment and structures is imperative. The main objective of this study is to develop means of managing sediment whereby its effects on operations are negligible.

Alternative No. 1 – Intake Retrofit [8]

This option is designed to remove entrained abrasives from diverted water. Redundant mechanisms are proposed to filter out damaging sediments and minimize the opportunities for buildup in the named structures above. The intake grit chambers will maintain a sediment-free intake structure and the vortex grit separator will intercept grit passing through the fish screens. The City will need to periodically remove and dispose of accumulated material discharged to the proposed sedimentation basin. It is recommended NOAA and CDFG concurrence be obtained for the intake grit chamber system prior to final scoring.

Alternative No. 2 – New Intake [9]

The catenary rake system will manage sediment removal from within the fish screen/collector structure and will not present fish hazards. The vortex separator will ensure grit is removed from the influent to the wet well.

Alternative No. 3 – Intake Improvements/Vertical Wells [8]

This option scores the same as Alternative No. 1 since it has the same intake. The vertical wells are not subject to sediment transport impacts within the San Lorenzo River.

Alternative No. 4 – Intake Improvements/Collector Wells [8]

This option scores the same as Alternative No. 3.

Alternative No. 5 – No Action [1]

The current facilities are the reason for this project.

Turbidity Reduction

Turbidity limits SCWD's opportunities to divert raw water from the San Lorenzo River. Diversion of turbid water must be handled by the WTP process scheme downstream of the diversion. This characteristic is highly related to water supply reliability for subsurface collection techniques. High turbidity episodes generally correlate to periods when demands are least.

Alternative No. 1 – Intake Retrofit [1]

This option will not significantly reduce turbidity levels within the diverted water.

Alternative No. 2 – New Intake [1]

Same as above for Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [8]

This option is expected to reduce turbidity due to the natural ability of the soil strata to filter out fine particulates. It is not known how susceptible soil permeability is to overloading. Straining turbidity through existing soils may render this option unusable over time. This option takes advantage of the benefits of subsurface diversion but offers ability to directly divert when turbidity levels diminish.

Alternative No. 4 – Intake Improvements/Collector Wells [8]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [1]

Same as above for Alternative No. 1.

Debris Management

Instream structures are vulnerable to debris loading. Debris can impair operations and performance if allowed to accumulate unchecked, thus compromising effectiveness. This characteristic applies to the likelihood and the consequence of debris accumulation.

Alternative No. 1 – Intake Retrofit [6]

The existing intake structure is well protected by a substantial trash rack at the upstream end. Per the City, debris loading does not tend to greatly affect operations, however must be periodically removed. Normal debris maintenance includes routine inspections following significant storm events and manual cleaning of the trash rack. Since the rack

is proposed to be modified, the size of the material entering the intake structure will be small and is expected to flush out of the intake. According to SCWD operations personnel, debris maintenance is generally not considered problematic or highly demanding. Modifying the trash rack may demand greater maintenance.

Alternative No. 2 – New Intake [8]

A new intake structure will be protected by trash racks to minimize debris entry. With inlet and return channels oriented normal to river flow, debris obstruction is expected to be better than Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [7]

Since this option is outside the natural flow way and can be configured with little to no projection above the ground surface, debris loading will have no effect. By incorporating the gravity diversion, scoring is adversely affected.

Alternative No. 4 – Intake Improvements/Collector Wells [7]

This option involves a substantial caisson extending well above the ground surface. However, the alternative can be located outside the typical floodplain and would not be highly susceptible to debris load. This alternative scores the same as Alternative No. 3.

Alternative No. 5 – No Action [6]

With the same intake as Alternative No. 1, the scores are the same.

Operations and Maintenance

Specific operating and maintenance procedures are associated with each alternative. To ensure water supply and fish protection objectives are met, certain operating exercises must be carried out. Like any operating facility, maintenance is part and parcel to a functional and reliable project. This topic covers the O&M aspects of each option.

Operating Demands

Operations of the alternatives will vary with respect to complexity and protocol. In order for the options to meet intended objectives specific operating routines must be followed. Utility power must be available for any alternative to function.

Alternative No. 1 – Intake Retrofit [7]

This alternative involves static and dynamic elements. Aspects that require routine, automated processes for proper operation are as follows: 1) fish screen cleaning via the compressed air burst system (and traveling brush if included); 2) desanding pump operations to manage sediment within the intake structure; and 3) continuous process stream to transport grit from vortex grit separator to sed basin. The existing pump station will remain unaffected by this alternative. Turbidity and flow monitoring is required.

Alternative No. 2 – New Intake [7]

Same as above for Alternative No. 1 with the exception that the catenary rake system is substituted for the desanding pump system.

Alternative No. 3 – Intake Improvements/Vertical Wells [6]

This option requires the operation of new pumps and coordination between wells and gravity diversion. SCADA provisions will allow for local/manual/auto prompting of pump/motor units and flow monitoring.

Alternative No. 4 – Intake Improvements/Collector Wells [6]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [9]

Has the least amount of equipment and operating protocols.

Maintenance Demands

Alternative No. 1 – Intake Retrofit [7]

Requires more attention than subsurface diversion concepts. Requires slightly more maintenance than that currently performed at the Tait Diversion due to the addition of grit chambers, sedimentation basin., and trash rack modifications.

Alternative No. 2 – New Intake [8]

Ranks slightly higher than Alternative No. 1 as pump maintenance is expected to be slightly more involved and frequent than the rake system.

Alternative No. 3 – Intake Improvements/Vertical Wells [5]

Requires periodic well maintenance and pump/motor overhaul approximately every ten years. Requires more maintenance than Alternative No. 1.

Alternative No. 4 – Intake Improvements/Collector Wells [3]

Maintenance of collector wells is performed by highly specialized contractors. The number of contractors that can perform this specialized work is very limited, and there are none located in California.

Alternative No. 5 – No Action [4]

Requires considerable maintenance to deal with sediment load.

Functional Lifespan of Facilities

Alternative No. 1 – Intake Retrofit [7]

Cast-in-place concrete and stainless steel weldments will last indefinitely. Service lives of over a hundred years are realistic. Desanding pumps are expected to have a service life of five to ten years depending on hours of service required to maintain an operational facility.

Alternative No. 2 – New Intake [7]

Same as above for Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [6]

Requires little routine maintenance but pump/motor overhaul approximately every ten years. Wells may be lost over time due to reduction in permeability.

Alternative No. 4 – Intake Improvements/Collector Wells [6]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [4]

25-year old facility has a shorter service life than new facilities.

Design and Construction

The design and construction methods of the corrective alternatives vary in scope and complexity. In addition, certain constraints apply to retrofitting existing structures as opposed to new facilities and vice versa. The design considerations and parameters are explained at a preliminary level in the preceding section of this report, whereas construction issues are discussed below.

Design Certainty

The certainty of design pertains to whether the suggested improvements can be engineered to provide the intended benefits with absolute confidence. Considerations include verification of existing constraints and facilities, hydraulic reliability, acceptable fish protection, structural stability and integrity, and application of proven technologies and sound engineering principles.

Alternative No. 1 – Intake Retrofit [7]

All elements of this alternative stem from field proven technology and successful past designs, i.e. flat plate fish screens, commonly used cleaning mechanisms, proven grit management technologies, an intake structure that has withstood the elements for 25-years with no sign of failure, and mechanical equipment that has been used extensively on like projects. As-builts are in reasonably good condition and it is expected site conditions and conflicts can be defined in advance of issuing bid documents.

Alternative No. 2 – New Intake [8]

Same as above for Alternative No. 1 except that more new construction and less retrofitting involved.

Alternative No. 3 – Intake Improvements/Vertical Wells [6]

Some exposure exists as a result of differing site conditions between one well versus the next and long term yield decay. Well development will provide initial yield assessment but is no guarantee toward future performance. Correlation to well performance in the vicinity can elevate confidence level.

Alternative No. 4 – Intake Improvements/Collector Wells [6]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [10]

No design required.

Construction Complexities

Complexities of construction include the extent of work, access and spatial constraints, depths of excavations, public and construction personnel safety, disturbance to existing improvements, conflicts with existing structures, bypassing and dewatering, cofferdamming requirements, and allowable duration of construction. These complexities are also reflected in the construction cost estimates provided in Appendix C.

Alternative No. 1 – Intake Retrofit [5]

Construction of diversion upgrades involves in stream construction, cofferdamming and dewatering, maintaining SCWD's diversions during construction, and the difficulties of working amidst existing facilities. Disturbance to existing structures and features is required. Deep excavations and stability of existing structures will be critical during periods of adjacent excavation. Common construction means and methods would be used. In channel work would be limited to the time constraints of the CDFG Streambed Alteration Agreement, July 1 to October 15. Site access is relatively good. Contractor pool would be the best of all options. Equipment and materials are commonly produced, and lead times would not be unusual.

Alternative No. 2 – New Intake [3]

Construction involves significant excavation and shoring in comparison to Alternative No. 1. New concrete construction is substantial. Maintaining operation of existing intake requires some accommodation. The existing diversion can be left in place as a backup for future use if needed.

Alternative No. 3 – Intake Improvements/Vertical Wells [5]

Cofferdamming, dewatering, and bypassing would be the same as for Alternative No. 1. Potential for conflicts would be the same. Individual wells would be spaced amply apart from one another, enabling concurrent construction at multiple locations. Common construction means and methods would be used and conventional drilling practices applied. Construction type is slightly more specialized than Alternative No. 1 and contractor pool slightly more limited. No particular schedule constraints are foreseen. Site access and navigation around existing vegetation could be problematic. Equipment and materials are commonly produced, and lead times would not be unusual.

Alternative No. 4 – Intake Improvements/Collector Wells [3]

Same as Alternative No. 3 except that the construction contractors are highly specialized and competition extremely limited.

Alternative No. 5 – No Action [10]

No construction.

Environmental and Permitting

Each alternative involves a unique, albeit minor, impact to the environment in which it is sited. This topic takes into consideration the effects each alternative has regarding disturbance to existing vegetation, potential biological impacts, air and water pollution, soils disturbance, conveyance capacity of the river channel, transportation and traffic, noise, aesthetics, public safety, and future land use. In addition, a characteristic is included for the anticipated permitting procedures tied to each alternative.

Environmental Impacts

Alternative No. 1 – Intake Retrofit [8]

This option will include the utilization of existing structures and construction of new improvements. The footprint of disturbance would be limited to a localized area and would not be expected to have significant impacts on the environment. Added air pollution would be related to heavy equipment during construction and water pollution would need to be addressed by BMP's in the contractor's dewatering plan. Otherwise, no long term impacts would be produced by this alternative. The site is devoid of vegetation so impacts would be moot. Due to deep excavations, soil disturbance would be moderate unless shoring systems were used. The contractor's temporary diversion system would need to be conscientious of biological protection. The finished product would coalesce with existing improvements and would not encroach within the river section any more than the existing diversion facilities. Aesthetics, traffic, noise, public safety, and future land use would not be greatly affected by this alternative.

Alternative No. 2 – New Intake [7]

Although this option would involve a greater localized disturbance than Alternative No. 1, it will be predominantly outside the river channel. Otherwise, impacts are comparable to Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [6]

This option will involve subsurface infrastructure, with the exception of a consolidated control building. Disturbance would be limited to a localized area at each well site and would not be expected to have significant impacts on the environment. Added air, water, and noise pollution would be temporary and related to heavy equipment during construction. Water pollution would need to be addressed by BMP's in the contractor's water pollution control plan. Moderate disturbance to existing vegetation could occur. Drill tailings may need to be hauled off site. Biological constraints are expected to be nonexistent. The finished product would primarily be below ground and would not encroach within the river section. Aesthetics, traffic, noise, and public safety would not be affected by this alternative. Future land use could be impacted due to DPH clearance criteria and area of coverage of the well field.

Alternative No. 4 – Intake Improvements/Collector Wells [7]

Same as above for Alternative No. 3 with some exceptions. This alternative would involve a reduced top side footprint, and lesser disturbance to existing vegetation. Future land use would be less impacted. The well caissons will extend above grade to extend above the floodplain, therefore the top side enclosures or pump houses would be visible.

As the facilities would be more consolidated, it scores slightly better than Alternative No. 3.

Alternative No. 5 – No Action [10]

No additional impacts over current options. Disturbance to the stream would be required for maintenance options.

Permitting

Many of the permitting issues are discussed in other attributes but accounted for in this characteristic. Environmental compliance is expected to involve CEQA processes for each alternative. Since a federal nexus will not exist within the Project, the NEPA process is not anticipated (pers. comm. C. Berry, March 7, 2007). However, regulatory permits such as the USACOE 404, CDFG 1600, Water Quality Control Board 401 permits, and water rights licensing will be similar for all options. Standard provisions for instream work would apply to intake improvements. Reassignment of water rights would apply to the subsurface alternatives.

Acceptability and preferences of specific designs by the permitting resource agencies are considerations that aren't included elsewhere in this study. At a minimum, a collaborative effort with regulatory agencies should be conducted prior to final alternative selection.

Alternative No. 1 – Intake Retrofit [6]

This option will involve the CEQA process and an environmental document due to the presence of listed fish species, as well as the permits described above.

Alternative No. 2 – New Intake [6]

Same as above for Alternative No. 1.

Alternative No. 3 – Intake Improvements/Vertical Wells [4]

Requires a "Petition to Change Point of Diversion" be submitted to the State Water Resources Control Board due to the substantial distance between the proposed and existing diversion locations. Since wells are for producing raw water upstream of the WTP, the City will permit the wells and resulting information will be provided to the DPH. Environmental compliance is expected to be similar to the surface water intakes due to potential for presence of listed plants, birds, amphibians, and reptiles.

Alternative No. 4 – Intake Improvements/Collector Wells [4]

Same as above for Alternative No. 3.

Alternative No. 5 – No Action [10]

Requires no permits.

Comparison Summary Table

Each of the characteristics described above are weighted by their levels of importance and multiplied by how well each alternative achieves the characteristic. The resulting weighted scores are then summed for each alternative. Table C on the following page shows the input weights and scores for each alternative. The first column lists the characteristics, and the second column indicates the weight applied to each option for each characteristic. The weighting scale is from 0 to 10 with 0 meaning the characteristic is of no importance and 10 meaning it is essential to the success of the project.

Ranking scores are also on a scale of 0 to 10, with 0 meaning the option does not at all satisfy the characteristic and 10 meaning that it satisfies the characteristic to the point that it could not be further enhanced.

Table B below summarizes two sets of totals from Table C. The overall score is shown, and a second score considering only the water supply and sediment/debris management characteristics is provided as well. The scores in Table B are normalized to 100 for easier interpretation so the highest overall score and the highest water supply/sediment score are each 100.

Though this method results in a final relative score approach, the highest score may not represent the best option. Various parities will likely weigh characteristics differently depending on their responsibilities, authority, and perspective. Each party might therefore have a different final ranking of alternatives.

Table B. Summary of Normalized Weighted Score Totals

Alternative	Overall Score	Water Supply & Sediment/Debris
Alternative No. 1 – Intake Retrofit	95	76
Alternative No. 2 – New Intake	100	82
Alternative No. 3 – Intake/Vertical Wells	99	96
Alternative No. 4 – Intake/Collector Wells	99	100
Alternative No. 5 – No Action	80	52

Table C on the following page represents the detailed scoring matrix for the Project. Values in the comparison matrix can be reviewed and modified to assess sensitivities. The process of refining scores may lead to modifications to the suggested alternatives.

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TABLE C - ALTERNATIVES SCORING MATRIX

Characteristic	Weight 0-10	Alt No. 1 Intake Retrofit		Alt No. 2 New Intake		Alt No. 3 Intake Mods/ Vertical Wells		Alt No. 4 Intake Mods/ Collector Wells		Alt No. 5 No Action Alternative	
		Ranking Score	Weighted Product	Ranking Score	Weighted Product	Ranking Score	Weighted Product	Ranking Score	Weighted Product	Ranking Score	Weighted Product
Fish Protection											
Entrainment Prevention	**10**	8	80	10	100	9	90	9	90	5	50
Impingement Prevention	**10**	10	100	10	100	10	100	10	100	3	30
Post-Construction Evaluation	**3**	8	24	8	24	8	24	8	24	10	30
Water Supply											
Access to Raw Water	**10**	6	60	6	60	8	80	10	100	5	50
Efficiency of Raw Water Usage	**6**	10	60	10	60	7	42	7	42	10	60
Reliability of Diversion	**10**	7	70	7	70	10	100	10	100	6	60
Flexibility and Redundancy	**10**	5	50	6	60	7	70	7	70	3	30
Sediment, Debris, and Water Quality											
Sediment Intercept and Management	**10**	8	80	9	90	8	80	8	80	1	10
Turbidity Reduction	**5**	1	5	1	5	8	40	8	40	1	5
Debris Management	**5**	6	30	8	40	7	35	7	35	6	30
Operations and Maintenance											
Operating Demands	**6**	7	42	7	42	6	36	6	36	9	54
Maintenance Demands	**8**	7	56	8	64	5	40	3	24	4	32
Functional Lifespan of Facilities	**4**	7	28	7	28	6	24	6	24	4	16
Design and Construction											
Design Certainty	**10**	7	70	8	80	6	60	6	60	10	100
Construction Complexities	**6**	5	30	3	18	5	30	3	18	10	60
Environmental and Permitting											
Environmental Impacts	**7**	8	56	7	49	6	42	7	49	10	70
Permitting	**5**	6	30	6	30	4	20	4	20	10	50
Normalized Overall Score		**95**		**100**		**99**		**99**		**80**	
Normalized Water Supply/Sediment Score		**76**		**82**		**96**		**100**		**52**	
Implementation Costs		**$3.06 mil**		**$3.40 mil**		**$6.5 mil**		**$15.05 mil**		**N/A**	

Implementation Costs

Estimates of probable implementation costs are provided in Appendix C. Since project cost is a basic element of alternative comparison, but the value of cost is entirely subjective to the parties financing the project, the cost factor is not scored as a characteristic within the comparison matrix. Values are simply provided in this report for informational purposes.

Alternative No. 1 – Intake Retrofit	**$3.06 mil**
Alternative No. 2 – New Intake	**$3.40 mil**
Alternative No. 3 – Intake Retrofit and River Wells	**$6.5 mil**
Alternative No. 4 – Intake Retrofit and Collector Wells	**$15.05 mil**
Alternative No. 5 – No Action:	**$0**

The budgeting-level cost estimates developed for each alternative include engineering and design, geotechnical investigation and laboratory testing, environmental compliance and permitting, bidding and contract award, surveying and staking, construction management, and materials testing. Additionally, all anticipated construction costs are accounted for including materials, labor and services, contract administration, mobilization and demobilization, sureties and insurance premiums, overhead and profit, and a 30 percent contingency to account for budgeting at a preliminary design level.

In general, the cost estimates are developed based on the concept level design information consistent with the alternatives presented in this report. The basis for estimating construction costs is data from cost indexes, vendors, and bid summaries from similar past projects. Generic construction activities and materials are based on either actual construction bids from similar past projects or unit pricing from RS Means 2006 Construction Cost Data. No attempt has been made to predict competitive bidding influence, bidding climate, future labor market conditions, or value engineering possibilities.

The dynamic nature of material escalation, market conditions, and bidding climate are difficult to predict. These items are subject to many variables including natural disasters, demand by foreign markets, energy shortages, competitive bidding influence, contractor availability, etc. To some degree these uncertainties are covered by the 30 percent construction cost contingency. However, the contingency is primarily included to cover the cost of successive detail and unknowns regarding final project geometry, complexion, and potential conflicts with existing structures, to name a few. The estimates do not account for significant conflicts with existing structures or radically unusual or unforeseen site conditions.

Several cost adjustment factors are added to provide a margin of safety in the estimates. Construction costs will be based on index pricing from Sacramento-based projects. Due to inflated construction market conditions reported within the Bay area, a 10 percent city location multiplier has been added to the construction subtotal to capture this cost factor (See RS Means City Cost Index/Location Factor relationship between Sacramento and San Francisco).

To account for annual price escalation, barring major unforeseen shifts in the construction market, two annual adjustment factors are included in the estimates to enable the City to budget for the effects of time relative to when the project is let out to bid. Accordingly, a 4 percent annual inflation rate is applied to construction and engineering/construction management services. Minor professional services such as surveying and mapping, geotechnical, and environmental services are assumed to remain constant.

The second annual adjustment factor consists of a 15 percent material escalation multiplier. Due to the volatility of building materials pricing in recent years, it is difficult to predict project outlay. Upon review of market trend data, material and heavy construction costs appear to have steadily increased since mid-2004 but were fairly constant before that time. A greater confidence level can be gained for budgeting purposes by applying this escalation factor. The material escalation factor is based on trend data from the Federal Highway Administration index of federal-aid highway construction for the following construction types; earthwork, surfacing, and reinforced concrete structures. The data can be reviewed over a period of record from 1987 to the fourth quarter of 2005 at the following website:

http://www.fhwa.dot.gov/programadmin/pt2005q4.cfm

Detailed cost estimates are presented in Appendix C to convey the detail of costs considered. The costs for design and construction management services are directly tied to the construction cost of the project. Industry standard percentages are applied to account for such services. Uniform allowances are applied for the following services; surveying and mapping, geotechnical services, environmental compliance, and permitting.

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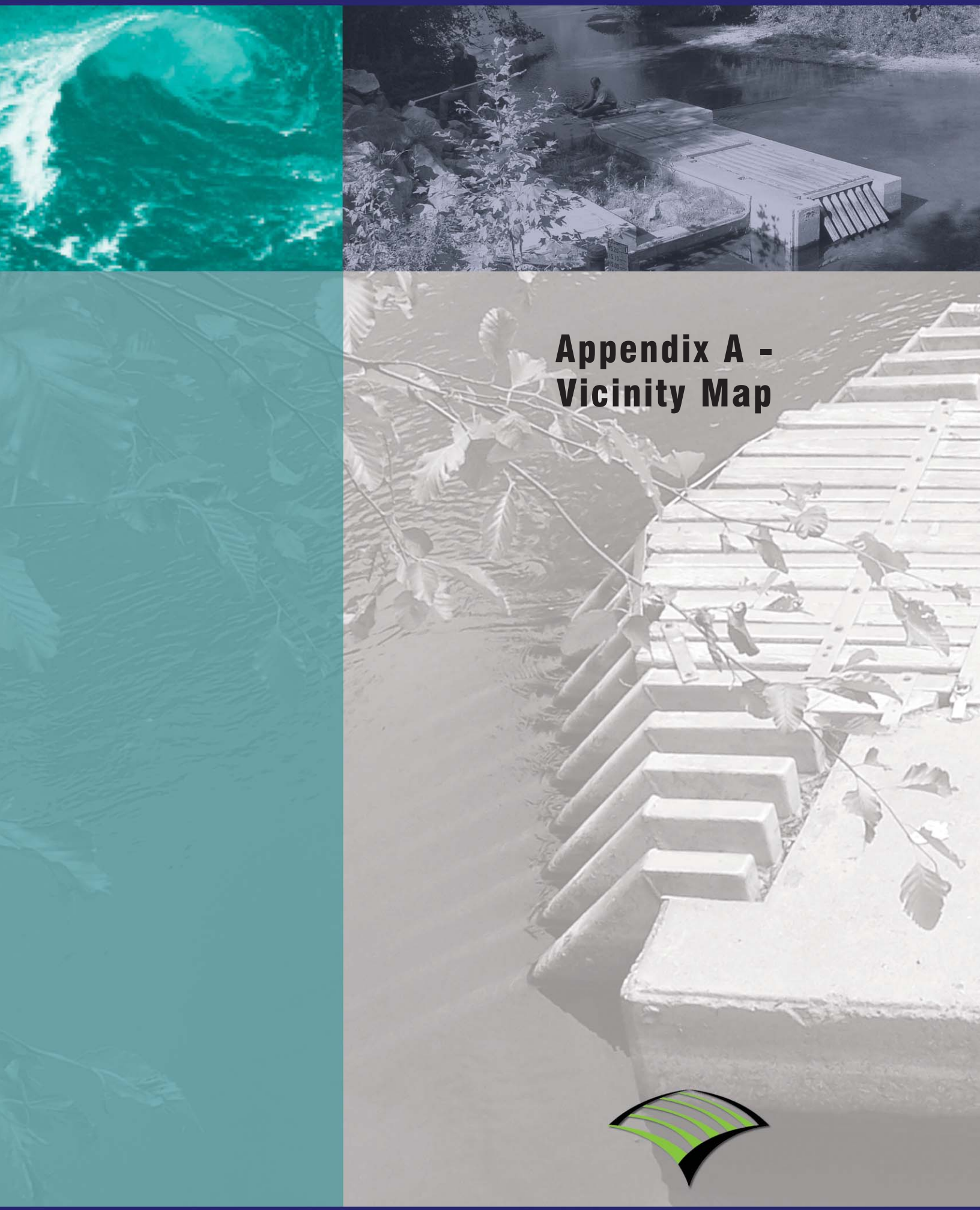
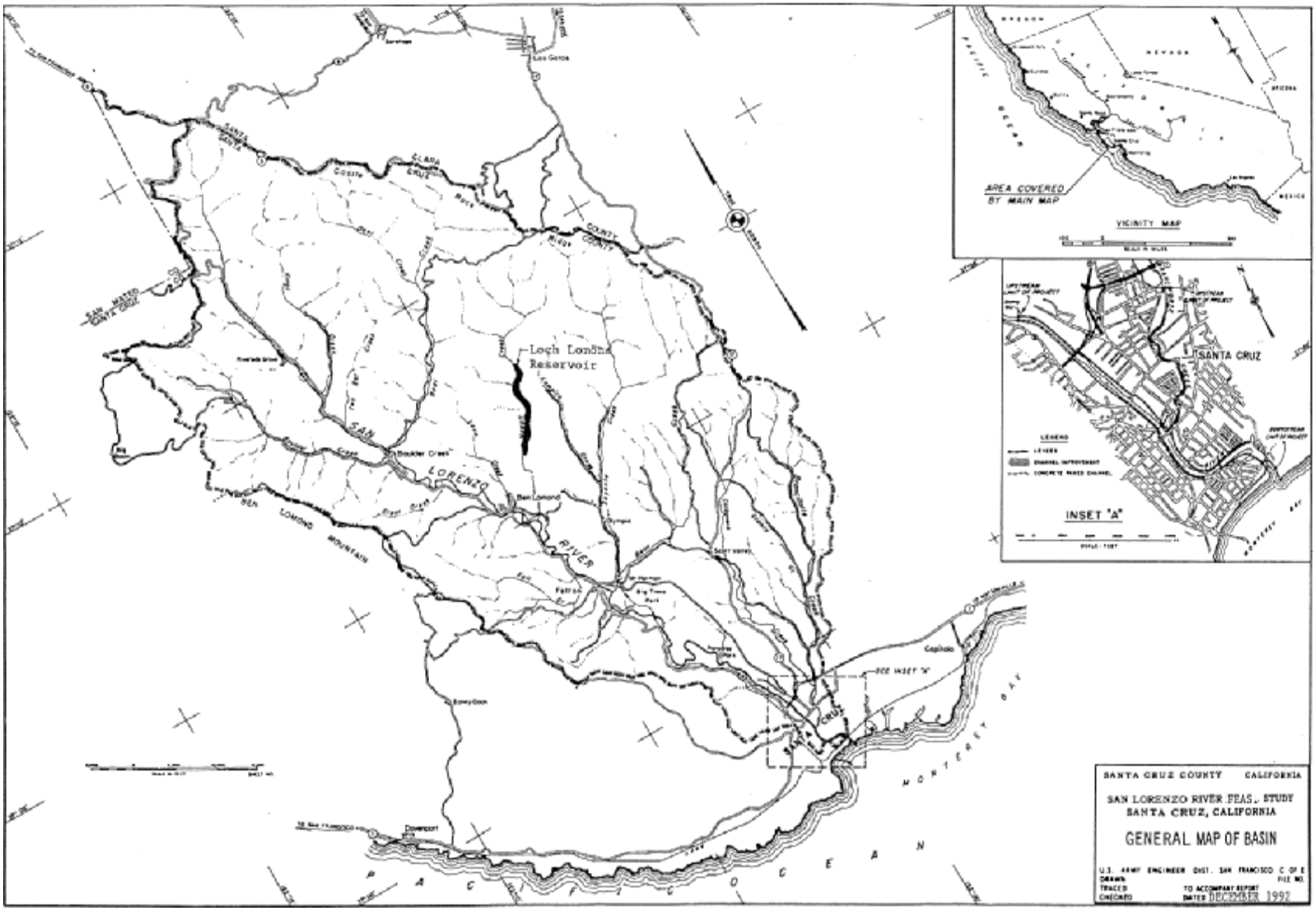
Appendices

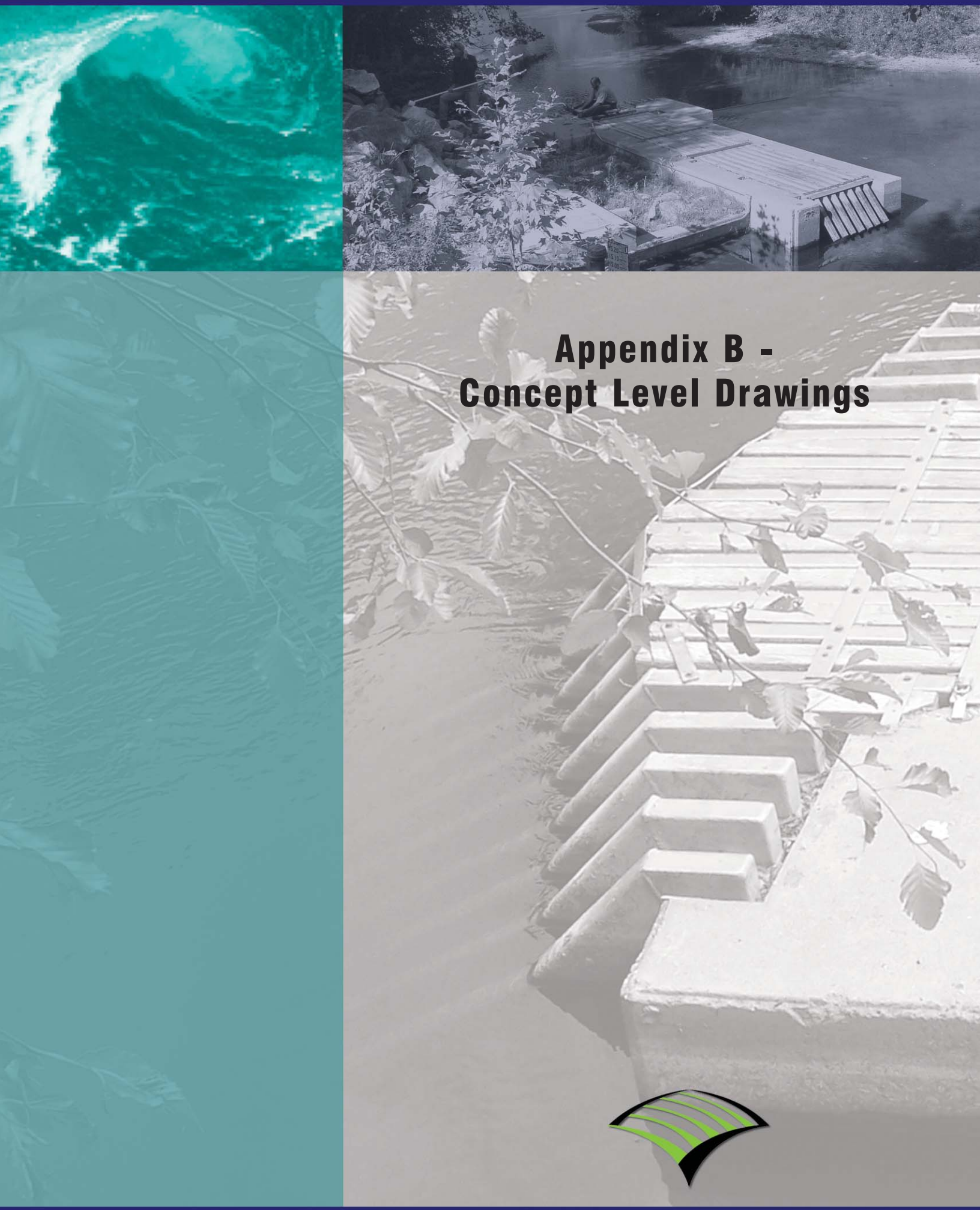
Appendices



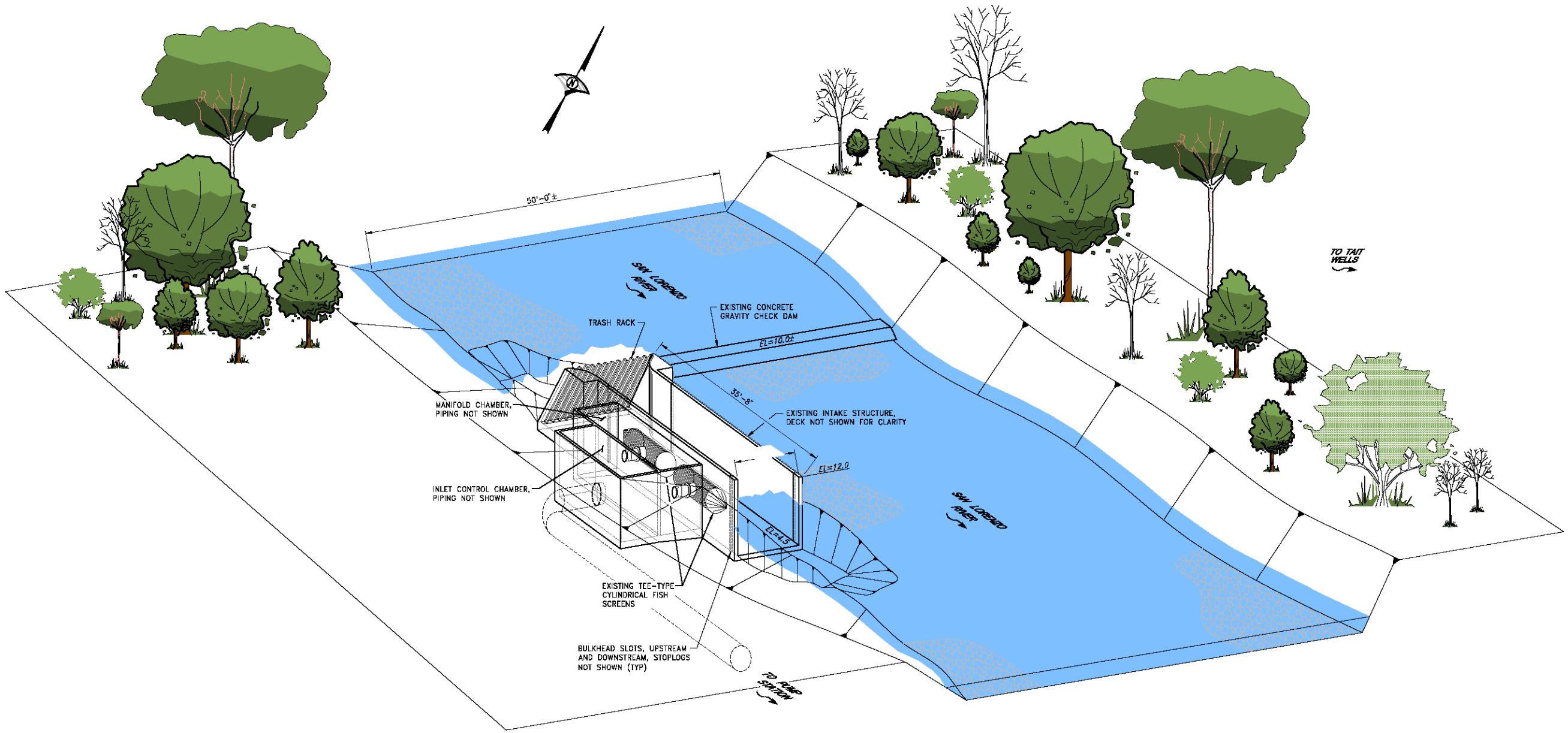
Appendix A - Vicinity Map

Figure A-1. San Lorenzo River Watershed and Vicinity Map





Appendix B - Concept Level Drawings



NOTES:

1. REPRESENTATION OF EXISTING FACILITIES AND RIVER GEOMETRY APPROXIMATE BASED ON RECORD DRAWINGS FOR SAN LORENZO RIVER INTAKE REPLACEMENT PROJECT, DATED OCTOBER 8, 1984, AS PROVIDED BY SCWD.
2. SUGGESTED IMPROVEMENTS SUBJECT TO CHANGE PENDING FURTHER DEFINITION OF DESIGN CRITERIA AND EXISTING FACILITIES. CONFLICTS AND COMPATIBILITY WITH ELEMENTS OF EXISTING FACILITIES TO BE VERIFIED.
3. DIVERSION, DESANDING, AND FISH SCREEN IMPROVEMENTS TO BE BASED ON 12.2 CFS DESIGN CAPACITY, SEDIMENT GRADATION PER ASTM D422 FOR COARSE SAND, AND CURRENT CDFG & NOAA FISH SCREENING CRITERIA, RESPECTIVELY.

HALF-SIZE

NO.	DESCRIPTION	ENGR INIT	BY	DATE
			COUNTY APPROVED	

DATE: 12/22/06
SCALE: NO SCALE
DRAWN BY: T. BULLER
DESIGNED BY: T. BULLER
CHECKED BY: T. BULLER

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CONCEPTUAL EXHIBITS FOR
SANTA CRUZ WATER DEPARTMENT
TAIT STREET DIVERSION FACILITIES
EXISTING DIVERSION FACILITY - ISOMETRIC
CITY OF SANTA CRUZ CALIFORNIA

PROJECT NO. 8262.002
DRAWING B-1
SHEET 1 OF 4

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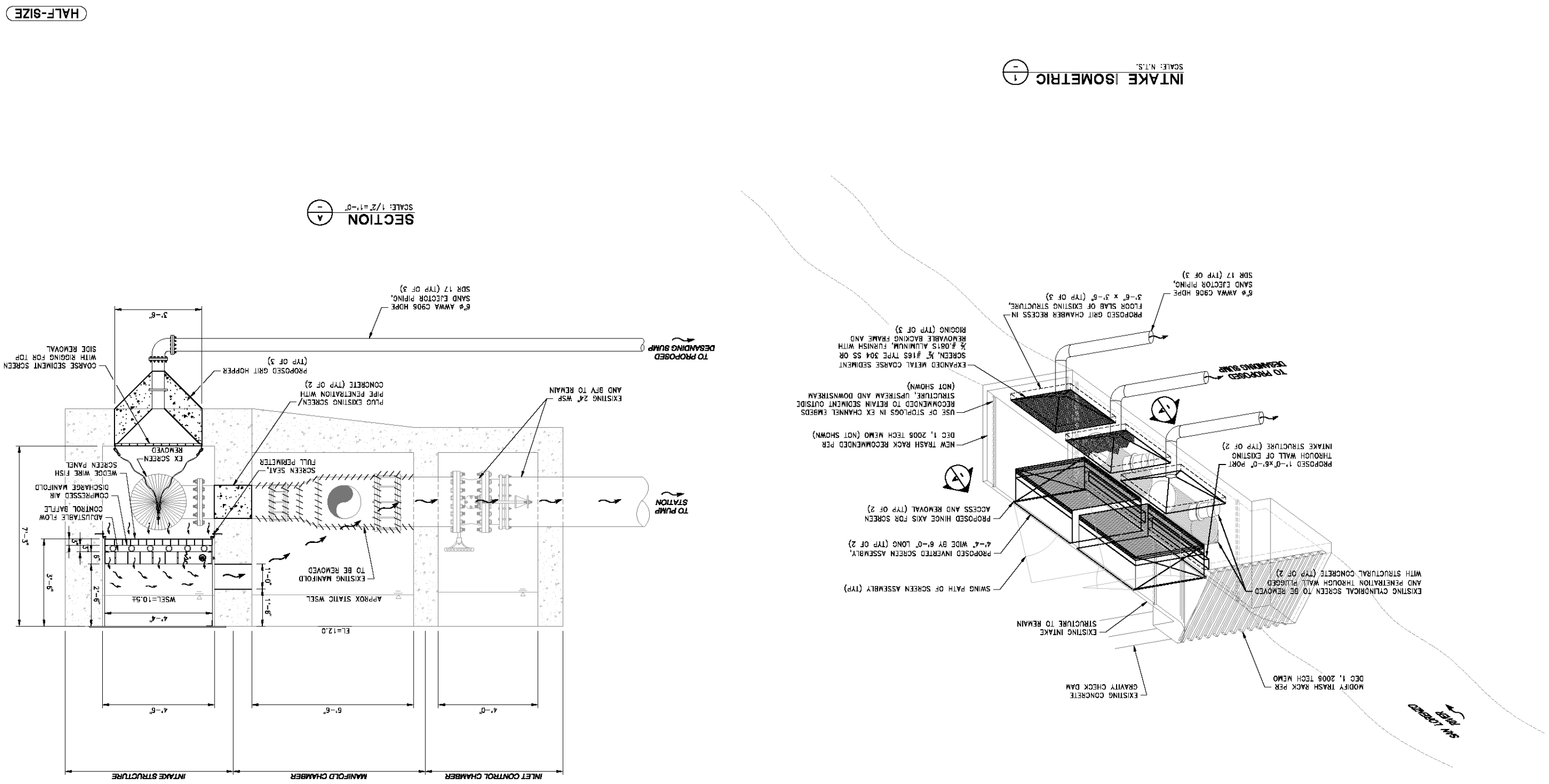

PROJECT NO. 8262.002

DRAWING B-2

SHEET 2 OF 4

CONCEPTUAL EXHIBITS FOR

SANTA CRUZ WATER DEPARTMENT
TAIT STREET DIVERSION FACILITIES
INTAKE AND FISH SCREEN IMPROVEMENTS

CITY OF SANTA CRUZ CALIFORNIA

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NO.	DESCRIPTION	ENGR INIT	BY	DATE
			COUNTY APPROVED	

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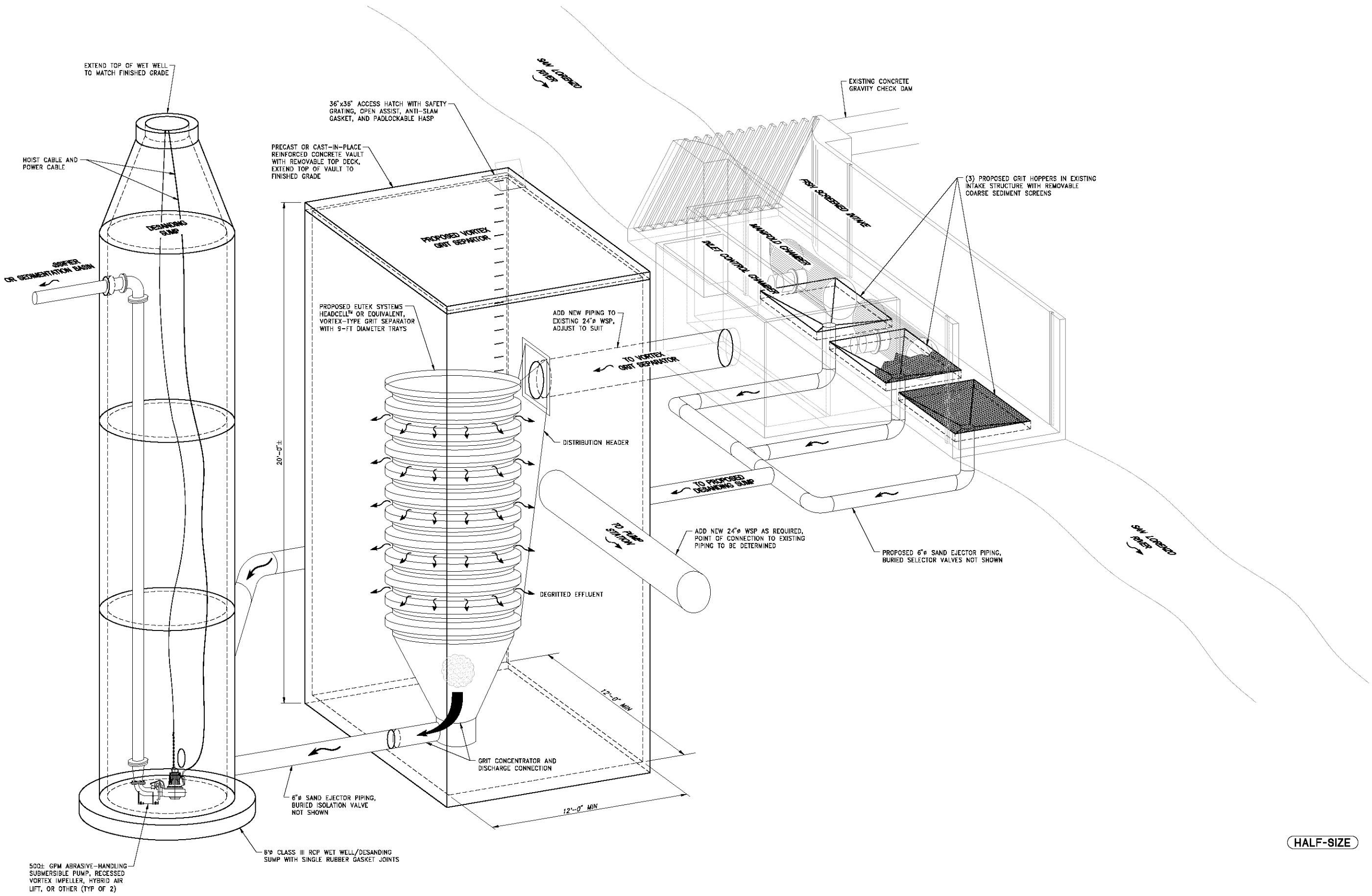

NO.	DESCRIPTION	ENGR INIT	BY	DATE

COUNTY APPROVED

DATE: 12/23/05
SCALE: NO SCALE
DRAWN BY: T. BULLER
DESIGNED BY: T. BULLER
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CONCEPTUAL EXHIBITS FOR
SANTA CRUZ WATER DEPARTMENT
TAIT STREET DIVERSION FACILITIES
SOURCE & IN-LINE GRIT REMOVAL CONCEPTS
CITY OF SANTA CRUZ CALIFORNIA

PROJECT NO. 8262.002
DRAWING B-3
SHEET 3 OF 4

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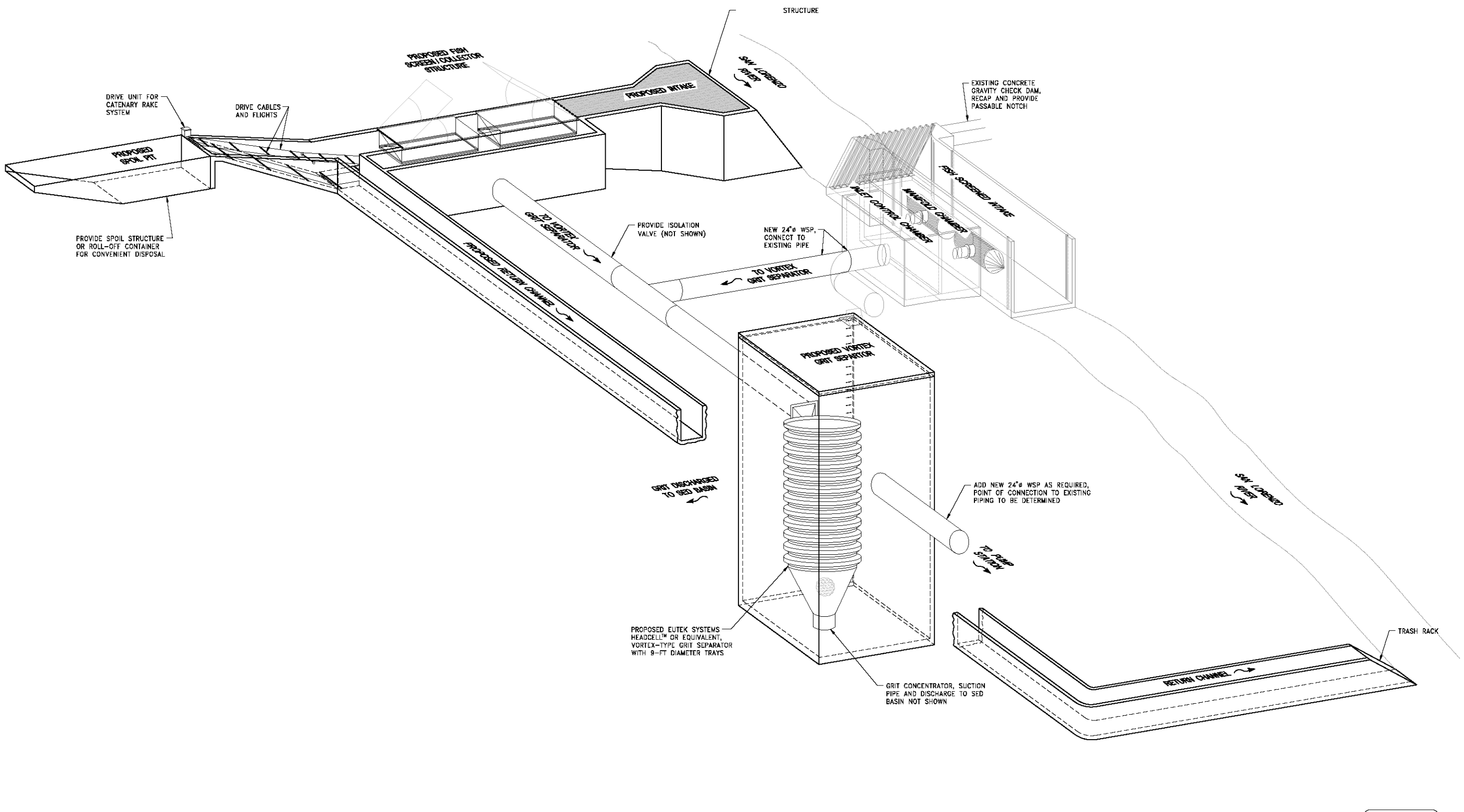

NO.	DESCRIPTION	ENGR/ AHT	BY	DATE
			COUNTY APPROVED	

DATE: 12/22/05
SCALE: NO SCALE
DRAWN BY: T. BULLER
DESIGNED BY: T. BULLER
CHECKED BY: T. BULLER

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CONCEPTUAL EXHIBITS FOR
SANTA CRUZ WATER DEPARTMENT
TAIT STREET DIVERSION FACILITIES
NEW INTAKE CONCEPT

CITY OF SANTA CRUZ CALIFORNIA

PROJECT NO. 8262.002
DRAWING B-4
SHEET 4 OF 4

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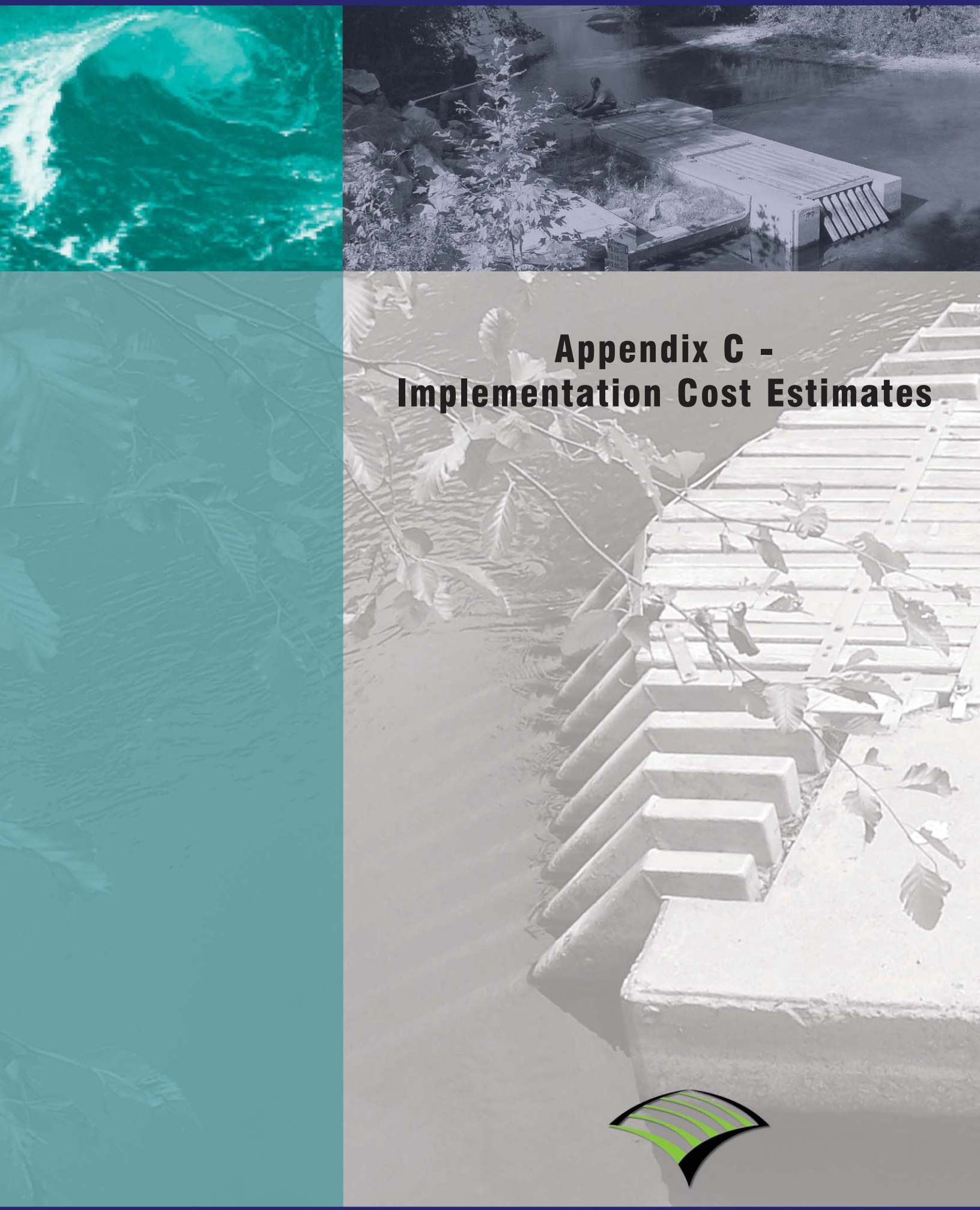


Appendix C - Implementation Cost Estimates

Santa Cruz Water Department
Tait Street Diversion Sanding Study - Surface Water Intake Retrofit Alternative No. 1
Opinion of Probable Implementation Costs
Project No. 8262.002

Updated: **1-Jul-08**

ITEM NO	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	A. General				
1	Mobilization & Demobilization (3%)	1	LS	n/a	$50,000.00
2	Contract Admin/Submittals/RFI's/Schedules/Coordination (3%)	1	LS	n/a	$50,000.00
3	Liability Insurance (1%)	1	LS	n/a	$17,000.00
4	Performance and Payment Bonds (2%)	1	LS	n/a	$34,000.00
5	Temporary Facilities and Utilities	1	LS	n/a	$10,000.00
6	Surveying and Construction Staking	1	LS	n/a	$5,000.00
7	Cal Labor Code Section 6707 Sheeting, Shoring, and Bracing	1	LS	n/a	$10,000.00
8	Overhead and Profit (10%)	1	LS	n/a	$170,000.00
	General Subtotal				**$346,000.00**
	B. Civil Site Work at Intake				
9	Establish Creek Access and Work Space for Tait Intake	1	LS	$20,000.00	$20,000.00
10	Implement Bypass and Dewatering System	1	LS	$40,000.00	$40,000.00
11	Miscellaneous Site Work/Finish Grading/Hydroseeding	1	LS	$15,000.00	$15,000.00
12	Roadway Resurfacing (Agg Base)	1	LS	$10,000.00	$10,000.00
	Sitework Subtotal				**$85,000.00**
	C. Intake and Fish Screen Modifications				
13	Remove and Dispose of Cylindrical Fish Screens and Manifold Piping	1	LS	$5,000.00	$5,000.00
14	Modify Existing Intake Structure and Valve Vault	1	LS	$10,000.00	$10,000.00
15	Modify Compressed Air Piping and Reconnect	1	LS	$5,000.00	$5,000.00
16	Furnish and Install Inverted Fish Screen Modules and Metalwork	2	ea	$60,000.00	$120,000.00
17	Furnish and Install Flow Control Baffles and Air Dist Manifolds	2	ea	$30,000.00	$60,000.00
18	Furnish and Install Traveling Brush System	1	ea	$50,000.00	$50,000.00
19	Saw Cut Intake Slab and Install Grit Chambers and Sand Ejector Piping	3	ea	$35,000.00	$105,000.00
20	Modify Upstream/Furnish New Downstream Trash Racks	1	LS	$15,000.00	$15,000.00
	Intake and Fish Screen Subtotal				**$370,000.00**
	D. Grit Removal Systems				
21	Sheet Pile Shoring, 30-ft Lengths, Rental, Install, Bracing, and Removal	3,000	SF	$35.00	$105,000.00
22	Site Excavation and Stockpile	1,200	CY	$12.50	$15,000.00
23	Excavation Dewatering and Discharge BMP's	1	LS	$20,000.00	$20,000.00
24	Structural Backfill with Processed Native Material	1,000	CY	$25.00	$25,000.00
25	Haul and Dispose Spoils	200	CY	$10.00	$2,000.00
26	Furnish and Install 6"ϕ SDR 17 HDPE Sand Ejector Manifold	1	LS	$20,000.00	$20,000.00
27	Furnish and Install 6"ϕ SDR 17 HDPE Sand Ejector Piping	100	LF	$75.00	$7,500.00
28	Furnish and Install AWWA C509 Gate Valves and Valve Cans	3	ea	$7,500.00	$22,500.00
29	Furnish and Construct 8' Diameter RCP Wet Well, Top Deck, and Hatch	1	LS	$75,000.00	$75,000.00
30	Furnish and Install 5-Hp Submersible Vortex Impeller Pumps and Accessories	2	EA	$25,000.00	$50,000.00
31	Furnish and Install Pump MCC's and Switchgear	1	LS	$50,000.00	$50,000.00
32	Furnish and Install 6"ϕ SDR 17 HDPE Pump Discharge Piping	30	CY	$75.00	$2,250.00
33	Furnish and Install Pump MCC's and Switchgear	1	LS	$100,000.00	$100,000.00
34	Electrical Installation, System Integration, and Testing	1	LS	$30,000.00	$30,000.00
35	Construct Cast-In-Place Grit Separator Vault - Slab on Grade	10	CY	$800.00	$8,000.00
36	Construct Cast-In-Place Grit Separator Vault - Walls	40	CY	$1,500.00	$60,000.00
37	Construct Cast-In-Place Grit Separator Vault - Top Deck	10	CY	$800.00	$8,000.00
38	Furnish and Install Grit Separator Vault Appurtenances	1	LS	$15,000.00	$15,000.00
39	Furnish and Install HeadCell Grit Separator	1	LS	$200,000.00	$200,000.00
40	Furnish and Install 2"/4" Water Service Piping	1	LS	$7,500.00	$7,500.00
41	Construct Cast-In-Place Sed Basin - Slab on Grade	10	CY	$800.00	$8,000.00
42	Construct Cast-In-Place Sed Basin - Walls	10	CY	$1,500.00	$15,000.00
43	Install 8"ϕ SDR 26 HDPE Decant Piping	100	LF	$100.00	$10,000.00
44	Furnish and Install 24"ϕ WSP Raw Water Gravity Piping	100	LF	$200.00	$20,000.00
	Grit Removal System Subtotal				**$875,750.00**
				Construction Subtotal :	**$1,676,800.00**
				City Location Multiplier (10%) :	**$167,700.00**
				Annual Inflation Rate (4%) :	**$67,100.00**
				Annual Material Escalation Factor (15%) :	**$80,200.00**
				Contingency (30%) :	**$503,100.00**
				Construction Total :	**$2,495,000.00**
	F. Professional Services				
45	Engineering/Design/Construction Administration (20%)	1	LS	$499,000.00	$499,000.00
46	Environmental Compliance and Permitting	1	LS	$50,000.00	$50,000.00
47	Surveying and Mapping	1	LS	$10,000.00	$10,000.00
48	Geotechnical	1	LS	$10,000.00	$10,000.00
	Professional Services Subtotal				**$569,000.00**
				Total Estimated Implementation Cost (Bid Late 2009):	**$3,064,000.00**

Note: The Opinion of Probable Cost above is based on Concept Level Drawings prepared by Wood Rodgers for SCWD. Neither Wood Rodgers nor the Client has any control over the cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from engineer's estimate due to bidding climate, competition, and materials escalation at time of receiving bids. The above cost estimate represents preliminary amounts that are subject to change pending confirmation of existing utilities, improvements, and existing structure conflicts with proposed project. Wood Rodgers, Inc. does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

WOOD RODGERS

Santa Cruz Water Department
Tait Street Diversion Sanding Study - New Surface Water Intake Alternative No. 2
Opinion of Probable Implementation Costs
Project No. 8262.002

Updated: 1-Jul-08

ITEM NO	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	A. General				
1	Mobilization & Demobilization (3%)	1	LS	n/a	$57,000.00
2	Contract Admin/Submittals/RFI's/Schedules/Coordination (3%)	1	LS	n/a	$57,000.00
3	Liability Insurance (1%)	1	LS	n/a	$20,000.00
4	Performance and Payment Bonds (2%)	1	LS	n/a	$40,000.00
5	Temporary Facilities and Utilities	1	LS	n/a	$10,000.00
6	Surveying and Construction Staking	1	LS	n/a	$15,000.00
7	Cal Labor Code Section 6707 Sheeting, Shoring, and Bracing	1	LS	n/a	$10,000.00
8	Overhead and Profit (10%)	1	LS	n/a	$190,000.00
	General Subtotal				**$399,000.00**
	B. Civil Site Work at Intake				
9	Establish Creek Access and Work Space for Tait Intake	1	LS	$20,000.00	$20,000.00
10	Implement Bypass and Dewatering System	1	LS	$80,000.00	$80,000.00
11	Miscellaneous Site Work/Finish Grading/Hydroseeding	1	LS	$15,000.00	$15,000.00
12	Roadway Resurfacing (Agg Base)	1	LS	$10,000.00	$10,000.00
	Sitework Subtotal				**$125,000.00**
	C. New Intake and Fish Screen Facilities				
13	Construct New Cast-in-Place Trash Rack Structure - Slab on Grade	15	CY	$800.00	$12,000.00
14	Construct New Cast-in-Place Trash Rack Structure - Walls	15	CY	$1,500.00	$22,500.00
15	Furnish and Install Galv Steel Trash Rack and Support Metalwork	1	LS	$15,000.00	$15,000.00
16	Furnish and Install Galv Steel Grating and Support Metalwork	300	SF	$50.00	$15,000.00
17	Construct New Cast-in-Place Fish Screen Structure - Slab on Grade	25	CY	$800.00	$20,000.00
18	Construct New Cast-in-Place Fish Screen Structure - Walls	40	CY	$1,500.00	$60,000.00
19	Furnish and Install Inverted Fish Screen Modules and Metalwork	2	ea	$60,000.00	$120,000.00
20	Furnish and Install Flow Control Baffles and Air Dist Manifolds	2	ea	$30,000.00	$60,000.00
21	Modify Compressed Air Piping and Reconnect	1	LS	$10,000.00	$10,000.00
22	Furnish and Install Traveling Brush System	1	ea	$50,000.00	$50,000.00
23	Furnish and Install 24"ϕ WSP Raw Water Gravity Piping	100	LF	$200.00	$20,000.00
24	Construct New Cast-in-Place Bypass Channel - Slab on Grade	20	CY	$800.00	$16,000.00
25	Construct New Cast-in-Place Bypass Channel - Walls	35	CY	$1,500.00	$52,500.00
26	Furnish and Install Galv Steel Grating and Support Metalwork Over Channel	200	SF	$50.00	$10,000.00
	New Intake and Fish Screen Subtotal				**$483,000.00**
	D. Grit Removal Systems				
27	Sheet Pile Shoring, 30-ft Lengths, Rental, Install, Bracing, and Removal	5,000	SF	$35.00	$175,000.00
28	Site Excavation and Stockpile	2,000	CY	$12.50	$25,000.00
29	Excavation Dewatering and Discharge BMP's	1	LS	$20,000.00	$20,000.00
30	Structural Backfill with Processed Native Material	1,700	CY	$25.00	$42,500.00
31	Haul and Dispose Spoils	300	CY	$10.00	$3,000.00
32	Furnish and Install Catenary Rake System	1	LS	$200,000.00	$200,000.00
33	Electrical Installation, System Integration, and Testing	1	LS	$25,000.00	$25,000.00
34	Construct Cast-In-Place Grit Separator Vault - Slab on Grade	10	CY	$800.00	$8,000.00
35	Construct Cast-In-Place Grit Separator Vault - Walls	40	CY	$1,500.00	$60,000.00
36	Construct Cast-In-Place Grit Separator Vault - Top Deck	10	CY	$800.00	$8,000.00
37	Furnish and Install Grit Separator Vault Appurtenances	1	LS	$15,000.00	$15,000.00
38	Furnish and Install HeadCell Grit Separator	1	LS	$200,000.00	$200,000.00
39	Furnish and Install 2"/4" Water Service Piping	1	LS	$7,500.00	$7,500.00
40	Construct Cast-In-Place Spoil Basin - Slab on Grade	10	CY	$800.00	$8,000.00
41	Construct Cast-In-Place Spoil Basin - Walls	10	CY	$1,500.00	$15,000.00
42	Install 6"ϕ SDR 26 HDPE Decant Piping	100	LF	$75.00	$7,500.00
43	Furnish and Install 24"ϕ WSP Raw Water Gravity Piping	200	LF	$200.00	$40,000.00
	Grit Removal System Subtotal				**$859,500.00**
				Construction Subtotal :	**$1,866,500.00**
				City Location Multiplier (10%) :	**$186,700.00**
				Annual Inflation Rate (4%) :	**$74,700.00**
				Annual Material Escalation Factor (15%) :	**$81,600.00**
				Contingency (30%) :	**$560,000.00**
				Construction Total :	**$2,770,000.00**
	F. Professional Services				
44	Engineering/Design/Construction Administration (20%)	1	LS	$554,000.00	$554,000.00
45	Environmental Compliance and Permitting	1	LS	$50,000.00	$50,000.00
46	Surveying and Mapping	1	LS	$10,000.00	$10,000.00
47	Geotechnical	1	LS	$10,000.00	$10,000.00
	Professional Services Subtotal				**$624,000.00**
				Total Estimated Implementation Cost (Bid Late 2009):	**$3,394,000.00**

Note: The Opinion of Probable Cost above is based on Concept Level Drawings prepared by Wood Rodgers for SCWD. Neither Wood Rodgers nor the Client has any control over the cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from engineer's estimate due to bidding climate, competition, and materials escalation at time of receiving bids. The above cost estimate represents preliminary amounts that are subject to change pending confirmation of existing utilities, improvements, and existing structure conflicts with proposed project. Wood Rodgers, Inc. does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

Santa Cruz Water Department
Tait Street Diversion Sanding Study - Intake Retrofit and Vertical Wells Alternative No. 3
Opinion of Probable Implementation Costs
Project No. 8262.002

Updated: **1-Jul-08**

ITEM NO	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	A. General				
1	Mobilization & Demobilization (3%)	1	LS	n/a	$165,000.00
2	Contract Admin/Submittals/RFI's/Schedules/Coordination (3%)	1	LS	n/a	$165,000.00
3	Liability Insurance (1%)	1	LS	n/a	$55,000.00
4	Performance and Payment Bonds (2%)	1	LS	n/a	$110,000.00
5	Temporary Facilities and Utilities	1	LS	n/a	$20,000.00
6	Surveying and Construction Staking	1	LS	n/a	$25,000.00
7	Cal Labor Code Section 6707 Sheeting, Shoring, and Bracing	1	LS	n/a	$10,000.00
8	Overhead and Profit (10%)	1	LS	n/a	$550,000.00
	General Subtotal				**$1,100,000.00**
	B. Civil Site Work at Intake				
9	Establish Creek Access and Work Space for Tait Intake	1	LS	$20,000.00	$20,000.00
10	Implement Bypass and Dewatering System	1	LS	$40,000.00	$40,000.00
11	Miscellaneous Site Work/Finish Grading/Hydroseeding	1	LS	$15,000.00	$15,000.00
12	Roadway Resurfacing (Agg Base)	1	LS	$10,000.00	$10,000.00
	Sitework Subtotal				**$85,000.00**
	C. Intake and Fish Screen Modifications				
13	Remove and Dispose of Cylindrical Fish Screens and Manifold Piping	1	LS	$5,000.00	$5,000.00
14	Modify Existing Intake Structure and Valve Vault	1	LS	$10,000.00	$10,000.00
15	Modify Compressed Air Piping and Reconnect	1	LS	$5,000.00	$5,000.00
16	Furnish and Install Inverted Fish Screen Modules and Metalwork	2	ea	$60,000.00	$120,000.00
17	Furnish and Install Flow Control Baffles and Air Dist Manifolds	2	ea	$30,000.00	$60,000.00
18	Furnish and Install Traveling Brush System	1	ea	$50,000.00	$50,000.00
19	Saw Cut Intake Slab and Install Grit Chambers and Sand Ejector Piping	3	ea	$35,000.00	$105,000.00
20	Modify Upstream/Furnish New Downstream Trash Racks	1	LS	$15,000.00	$15,000.00
	Intake and Fish Screen Subtotal				**$370,000.00**
	D. Grit Removal Systems				
21	Sheet Pile Shoring, 30-ft Lengths, Rental, Install, Bracing, and Removal	3,000	SF	$35.00	$105,000.00
22	Site Excavation and Stockpile	1,200	CY	$12.50	$15,000.00
23	Excavation Dewatering and Discharge BMP's	1	LS	$20,000.00	$20,000.00
24	Structural Backfill with Processed Native Material	1,000	CY	$25.00	$25,000.00
25	Haul and Dispose Spoils	200	CY	$10.00	$2,000.00
26	Furnish and Install 6"ϕ SDR 17 HDPE Sand Ejector Manifold	1	LS	$20,000.00	$20,000.00
27	Furnish and Install 6"ϕ SDR 17 HDPE Sand Ejector Piping	100	LF	$75.00	$7,500.00
28	Furnish and Install AWWA C509 Gate Valves and Valve Cans	3	ea	$7,500.00	$22,500.00
29	Furnish and Construct 8' Diameter RCP Wet Well, Top Deck, and Hatch	1	LS	$75,000.00	$75,000.00
30	Furnish and Install 5-Hp Submersible Vortex Impeller Pumps and Accessories	2	EA	$25,000.00	$50,000.00
31	Furnish and Install Pump MCC's and Switchgear	1	LS	$50,000.00	$50,000.00
32	Furnish and Install 6"ϕ SDR 17 HDPE Pump Discharge Piping	30	CY	$75.00	$2,250.00
33	Furnish and Install Pump MCC's and Switchgear	1	LS	$100,000.00	$100,000.00
34	Electrical Installation, System Integration, and Testing	1	LS	$30,000.00	$30,000.00
35	Construct Cast-In-Place Grit Separator Vault - Slab on Grade	10	CY	$800.00	$8,000.00
36	Construct Cast-In-Place Grit Separator Vault - Walls	40	CY	$1,500.00	$60,000.00
37	Construct Cast-In-Place Grit Separator Vault - Top Deck	10	CY	$800.00	$8,000.00
38	Furnish and Install Grit Separator Vault Appurtenances	1	LS	$15,000.00	$15,000.00
39	Furnish and Install HeadCell Grit Separator	1	LS	$200,000.00	$200,000.00
40	Furnish and Install 2"/4" Water Service Piping	1	LS	$7,500.00	$7,500.00
41	Construct Cast-In-Place Sed Basin - Slab on Grade	10	CY	$800.00	$8,000.00
42	Construct Cast-In-Place Sed Basin - Walls	10	CY	$1,500.00	$15,000.00
43	Install 8"ϕ SDR 26 HDPE Decant Piping	100	LF	$100.00	$10,000.00
44	Furnish and Install 24"ϕ WSP Raw Water Gravity Piping	100	LF	$200.00	$20,000.00
	Grit Removal System Subtotal				**$875,750.00**
	E. Vertical Wells and Pump Stations				
45	**Tait Street Well - 20" Casing Path Well, 60 ft Deep**	1	LS	$63,000.00	$63,000.00
46	Perform Well Flushing and Testing	1	LS	$10,000.00	$10,000.00
47	Furnish and Install Multi-Stage Submersible Turbine Pump, 120' TDH, 800 gpm	1	ea	$15,000.00	$15,000.00
48	Furnish and Install Submersible Motor, 40-Hp	1	ea	$7,500.00	$7,500.00
49	Furnish and Install Discharge Piping, Valving, and Appurtenances	1	ea	$40,000.00	$40,000.00
50	Construct Elevated Structural Steel Electrical Platform	1	ea	$80,000.00	$80,000.00
51	Furnish and Install Switchboard & MCC Panel with VFD	1	ea	$50,000.00	$50,000.00
52	Furnish and Install RTU Panel	1	ea	$60,000.00	$60,000.00
53	Provide New Metered Electrical Service	1	LS	$20,000.00	$20,000.00
54	System Integration/Programming, Start-Up, Testing, Training	1	LS	$10,000.00	$10,000.00
55	Balance of Electrical Materials, Equipment, & Labor	1	LS	$30,000.00	$30,000.00
56	Civil Site Improvements	1	LS	$20,000.00	$20,000.00
57	**Ocean Street Well - 20" Casing Path Well, 70 ft Deep**	1	LS	$70,000.00	$70,000.00
58	Perform Well Flushing and Testing	1	LS	$20,000.00	$20,000.00
59	Furnish and Install Multi-Stage Submersible Turbine Pump, 350' TDH, 700 gpm	1	ea	$20,000.00	$20,000.00
60	Furnish and Install Submersible Motor, 100-Hp	1	ea	$15,000.00	$15,000.00
61	Furnish and Install Discharge Piping, Valving, and Appurtenances	2	ea	$30,000.00	$60,000.00
62	Construct 8"ϕ AWWA C151 Class 250 DIP Pipeline	2,200	LF	$75.00	$165,000.00
63	Construct Elevated Structural Steel Electrical Platform	1	ea	$80,000.00	$80,000.00
64	Furnish and Install Switchboard & MCC Panel with VFD	1	ea	$60,000.00	$60,000.00
65	Furnish and Install RTU Panel	1	ea	$60,000.00	$60,000.00
66	Provide New Metered Electrical Service	1	LS	$20,000.00	$20,000.00
67	Extend 3-Phase Overhead Electrical Utility Lines	2,200	LF	$30.00	$66,000.00
68	System Integration/Programming, Start-Up, Testing, Training	1	LS	$10,000.00	$10,000.00
69	Balance of Electrical Materials, Equipment, & Labor	1	LS	$30,000.00	$30,000.00
70	Civil Site Improvements	1	LS	$40,000.00	$40,000.00
	Vertical Well and Pump Station Subtotal				**$1,121,500.00**
				Construction Subtotal :	**$3,552,300.00**
				City Location Multiplier (10%) :	**$355,300.00**
				Annual Inflation Rate (4%) :	**$142,100.00**
				Annual Material Escalation Factor (15%) :	**$136,600.00**
				Contingency (30%) :	**$1,065,700.00**
				Construction Total :	**$5,252,000.00**
	F. Professional Services				
45	Engineering/Design/Construction Administration (20%)	1	LS	$1,050,000.00	$1,050,000.00
46	Environmental Compliance and Permitting	1	LS	$150,000.00	$150,000.00
47	Surveying and Mapping	1	LS	$30,000.00	$30,000.00
48	Geotechnical	1	LS	$30,000.00	$30,000.00
	Professional Services Subtotal				**$1,260,000.00**
				Total Estimated Implementation Cost (Bid Late 2009):	**$6,512,000.00**

Note: The Opinion of Probable Cost above is based on Concept Level Drawings prepared by Wood Rodgers for SCWD. Neither Wood Rodgers nor the Client has any control over the cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from engineer's estimate due to bidding climate, competition, and materials escalation at time of receiving bids. The above cost estimate represents preliminary amounts that are subject to change pending confirmation of existing utilities, improvements, and existing structure conflicts with proposed project. Wood Rodgers, Inc. does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

WOOD RODGERS

Santa Cruz Water Department
Tait Street Diversion Sanding Study - Intake Retrofit and Collector Wells Alternative No. 4
Opinion of Probable Implementation Costs
Project No. 8262.002

Updated: 1-Jul-08

ITEM NO	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
	A. General				
1	Mobilization & Demobilization (3%)	1	LS	n/a	$255,000.00
2	Contract Admin/Submittals/RFI's/Schedules/Coordination (3%)	1	LS	n/a	$255,000.00
3	Liability Insurance (1%)	1	LS	n/a	$85,000.00
4	Performance and Payment Bonds (2%)	1	LS	n/a	$170,000.00
5	Temporary Facilities and Utilities	1	LS	n/a	$20,000.00
6	Surveying and Construction Staking	1	LS	n/a	$25,000.00
7	Cal Labor Code Section 6707 Sheeting, Shoring, and Bracing	1	LS	n/a	$10,000.00
8	Overhead and Profit (10%)	1	LS	n/a	$850,000.00
	General Subtotal				**$1,670,000.00**
	B. Civil Site Work at Intake				
9	Establish Creek Access and Work Space for Tait Intake	1	LS	$20,000.00	$20,000.00
10	Implement Bypass and Dewatering System	1	LS	$40,000.00	$40,000.00
11	Miscellaneous Site Work/Finish Grading/Hydroseeding	1	LS	$15,000.00	$15,000.00
12	Roadway Resurfacing (Agg Base)	1	LS	$10,000.00	$10,000.00
	Sitework Subtotal				**$85,000.00**
	C. Intake and Fish Screen Modifications				
13	Remove and Dispose of Cylindrical Fish Screens and Manifold Piping	1	LS	$5,000.00	$5,000.00
14	Modify Existing Intake Structure and Valve Vault	1	LS	$10,000.00	$10,000.00
15	Modify Compressed Air Piping and Reconnect	1	LS	$5,000.00	$5,000.00
16	Furnish and Install Inverted Fish Screen Modules and Metalwork	2	ea	$60,000.00	$120,000.00
17	Furnish and Install Flow Control Baffles and Air Dist Manifolds	2	ea	$30,000.00	$60,000.00
18	Furnish and Install Traveling Brush System	1	ea	$50,000.00	$50,000.00
19	Saw Cut Intake Slab and Install Grit Chambers and Sand Ejector Piping	3	ea	$35,000.00	$105,000.00
20	Modify Upstream/Furnish New Downstream Trash Racks	1	LS	$15,000.00	$15,000.00
	Intake and Fish Screen Subtotal				**$370,000.00**
	D. Grit Removal Systems				
21	Sheet Pile Shoring, 30-ft Lengths, Rental, Install, Bracing, and Removal	3,000	SF	$35.00	$105,000.00
22	Site Excavation and Stockpile	1,200	CY	$12.50	$15,000.00
23	Excavation Dewatering and Discharge BMP's	1	LS	$20,000.00	$20,000.00
24	Structural Backfill with Processed Native Material	1,000	CY	$25.00	$25,000.00
25	Haul and Dispose Spoils	200	CY	$10.00	$2,000.00
26	Furnish and Install 6"ϕ SDR 17 HDPE Sand Ejector Manifold	1	LS	$20,000.00	$20,000.00
27	Furnish and Install 6"ϕ SDR 17 HDPE Sand Ejector Piping	100	LF	$75.00	$7,500.00
28	Furnish and Install AWWA C509 Gate Valves and Valve Cans	3	ea	$7,500.00	$22,500.00
29	Furnish and Construct 8' Diameter RCP Wet Well, Top Deck, and Hatch	1	LS	$75,000.00	$75,000.00
30	Furnish and Install 5-Hp Submersible Vortex Impeller Pumps and Accessories	2	EA	$25,000.00	$50,000.00
31	Furnish and Install Pump MCC's and Switchgear	1	LS	$50,000.00	$50,000.00
32	Furnish and Install 6"ϕ SDR 17 HDPE Pump Discharge Piping	30	CY	$75.00	$2,250.00
33	Furnish and Install Pump MCC's and Switchgear	1	LS	$100,000.00	$100,000.00
34	Electrical Installation, System Integration, and Testing	1	LS	$30,000.00	$30,000.00
35	Construct Cast-In-Place Grit Separator Vault - Slab on Grade	10	CY	$800.00	$8,000.00
36	Construct Cast-In-Place Grit Separator Vault - Walls	40	CY	$1,500.00	$60,000.00
37	Construct Cast-In-Place Grit Separator Vault - Top Deck	10	CY	$800.00	$8,000.00
38	Furnish and Install Grit Separator Vault Appurtenances	1	LS	$15,000.00	$15,000.00
39	Furnish and Install HeadCell Grit Separator	1	LS	$200,000.00	$200,000.00
40	Furnish and Install 2"/4" Water Service Piping	1	LS	$7,500.00	$7,500.00
41	Construct Cast-In-Place Sed Basin - Slab on Grade	10	CY	$800.00	$8,000.00
42	Construct Cast-In-Place Sed Basin - Walls	10	CY	$1,500.00	$15,000.00
43	Install 8"ϕ SDR 26 HDPE Decant Piping	100	LF	$100.00	$10,000.00
44	Furnish and Install 24"ϕ WSP Raw Water Gravity Piping	100	LF	$200.00	$20,000.00
	Grit Removal System Subtotal				**$875,750.00**
	E. Ranney Collector Wells and Pump Stations				
45	**Tait Street Ranney Collector - Construct Caisson, Screened Laterals, etc.**	1	LS	$2,250,000.00	$2,250,000.00
46	Perform Well Flushing and Testing	1	LS	$20,000.00	$20,000.00
47	Furnish and Install Multi-Stage Vertical Turbine Column Pump, 120' TDH, 1,000 gpm	2	ea	$20,000.00	$40,000.00
48	Furnish and Install Vertical Lineshaft Motor, Inverter Duty, 50-Hp	2	ea	$7,500.00	$15,000.00
49	Furnish and Install Discharge Piping, Valving, and Appurtenances	2	ea	$30,000.00	$60,000.00
50	Construct Structural Steel Pump Station Building on Top of Caisson	1	ea	$80,000.00	$80,000.00
51	Furnish and Install Switchboard & MCC Panels with VFD's	1	ea	$80,000.00	$80,000.00
52	Furnish and Install RTU Panel	1	ea	$60,000.00	$60,000.00
53	Provide New Metered Electrical Service	1	LS	$20,000.00	$20,000.00
54	System Integration/Programming, Start-Up, Testing, Training	1	LS	$15,000.00	$15,000.00
55	Balance of Electrical Materials, Equipment, & Labor	1	LS	$50,000.00	$50,000.00
56	Civil Site Improvements	1	LS	$20,000.00	$20,000.00
57	**Ocean Street Ranney Collector - Construct Caisson, Screened Laterals, etc.**	1	LS	$2,000,000.00	$2,000,000.00
58	Perform Well Flushing and Testing	1	LS	$20,000.00	$20,000.00
59	Furnish and Install Multi-Stage Vertical Turbine Column Pump, 350' TDH, 500 gpm	2	ea	$30,000.00	$60,000.00
60	Furnish and Install Vertical Lineshaft Motor, Inverter Duty, 75-Hp	2	ea	$10,000.00	$20,000.00
61	Furnish and Install Discharge Piping, Valving, and Appurtenances	2	ea	$20,000.00	$40,000.00
62	Construct 12"ϕ AWWA C151 Class 250 DIP Pipeline	2,200	LF	$100.00	$220,000.00
63	Construct Structural Steel Pump Station Building on Top of Caisson	1	ea	$80,000.00	$80,000.00
64	Furnish and Install Switchboard & MCC Panels with VFD's	1	ea	$80,000.00	$80,000.00
65	Furnish and Install RTU Panel	1	ea	$60,000.00	$60,000.00
66	Provide New Metered Electrical Service	1	LS	$20,000.00	$20,000.00
67	Extend 3-Phase Overhead Electrical Utility Lines	2,200	LF	$30.00	$66,000.00
68	System Integration/Programming, Start-Up, Testing, Training	1	LS	$15,000.00	$15,000.00
69	Balance of Electrical Materials, Equipment, & Labor	1	LS	$50,000.00	$50,000.00
70	Civil Site Improvements	1	LS	$40,000.00	$40,000.00
	Collector Well and Pump Station Subtotal				**$5,481,000.00**
				Construction Subtotal :	**$8,481,800.00**
				City Location Multiplier (10%) :	**$848,200.00**
				Annual Inflation Rate (4%) :	**$339,300.00**
				Annual Material Escalation Factor (15%) :	**$150,300.00**
				Contingency (30%) :	**$2,544,600.00**
				Construction Total :	**$12,365,000.00**
	F. Professional Services				
45	Engineering/Design/Construction Administration (20%)	1	LS	$2,473,000.00	$2,473,000.00
46	Environmental Compliance and Permitting	1	LS	$150,000.00	$150,000.00
47	Surveying and Mapping	1	LS	$30,000.00	$30,000.00
48	Geotechnical	1	LS	$30,000.00	$30,000.00
	Professional Services Subtotal				**$2,683,000.00**
				Total Estimated Implementation Cost (Bid Late 2009):	**$15,048,000.00**

Note: The Opinion of Probable Cost above is based on Concept Level Drawings prepared by Wood Rodgers for SCWD. Neither Wood Rodgers nor the Client has any control over the cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from engineer's estimate due to bidding climate, competition, and materials escalation at time of receiving bids. The above cost estimate represents preliminary amounts that are subject to change pending confirmation of existing utilities, improvements, and existing structure conflicts with proposed project. Wood Rodgers, Inc. does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

Appendix D - Review Comments and Responses

Wood Rodgers Responses to City of Santa Cruz Comments on
DRAFT TAIT STREET DIVERSION SANDING STUDY
Dated March 7, 2007 by Wood Rodgers

Overall comments:

- The page layout is very nice. The City, however, prefers a more paper conserving layout with fewer blank spaces.

  Margins adjusted and report will be printed out double sided to reduce paper usage.

- Check the use and omission of hyphens throughout.

  Document revised.

- Can we see a section in the body of the report on construction issues, before the rating section, since working next to the river is always a big issue. How and where to install the grit separator or sed basin would be discussed, plus the pipeline to wells and to the Ocean St Ext site. This could also include figures showing the footprint of each alternative, on site or parcel maps.

  Section added explaining construction issues and where facilities are located.

- It seems that comparison of alternatives can't be complete without conducting the field study of the river wells. The viability of the Ocean St Ext site, the well yield, # wells and well spacing is all necessary to estimate costs and impacts of alts. 3, 4 and 5.

  Correct. Subsurface alternatives have since been updated based on the test well program administered. Since well alternatives alone can not produce the City's water right allotment, the alternatives have been altered.

- The Pugh scoring would benefit from some discussion unless a clear project choice surfaces. The weight and score for each parameter might be scored differently by each of the section within the Water Department. This might be a big issue for each section.

  This is discussed in detail in the Comparison of Alternatives section. The scoring and ranking process requires collaboration amongst various interests and parties to arrive at an objective outcome. A consensus approach toward weighting and scoring of characteristics and alternative performance is important with respect to establishing a fair assessment of alternatives ranking. Final scoring and weighting should be a collaborative effort involving the various City departments prior to publishing the final document.

- Alt 1 is not a viable option if the screening and velocity criteria aren't met; unless it can be proven that this design is equally protective. Similarly, the piece of Alt 5 that includes this is also likely not viable.

  On the contrary, the screening and velocity criteria can be met by Alt 1, although the grit chambers in the intake must receive regulatory agency buy-in. Nonetheless, this alternative can meet screening criteria without the grit chambers, albeit mitigation of sedimentation in the intake may not be improved to the point that it completely eliminates grit ingestion. The same applies for Alt 5.

- It looks like the 2 fps sediment transport criteria (page 28) results in a bypass flow, which is obviously of concern as well if that is planned. Will the 2 fps affect our water right allotment of 12.2 cfs? NOAA/DFG will be asking for a bypass flow at some point in the near future, but we have no idea what that is yet. We probably should keep it in the back of our minds, but not make plans to bypass any sooner than necessary.

  The 2 fps is not a requirement but a suggested hydraulic condition. A 2 fps transport velocity through the intake will keep typical sediments encountered in the San Lorenzo River from falling out in the intake. In addition, regulatory agencies generally require a sweeping velocity (two times the approach velocity or 0.66 fps) to minimize fish exposure to new or modified screened diversions. Sweeping velocity is typically produced by capitalizing on minimum downstream bypass flow requirements. If a bypass flow is required by the regulatory agencies, the above transport and sweeping velocities can be produced. Bypass flows would reduce water available in the river for diversion.

- How do you keep water moving through the intake to move sand and don't have a bypass of some kind? An alternative with a bypass would score big points, environmentally speaking, if not in terms of water supply; but we would also have to be careful that an alternative with a bypass flow does not compromise our allotment of 12.2 cfs; would we have to sacrifice one for the other?

  Transport of sediment through the structure requires a bypass flow. When water is available in the river to do so, it should be encouraged. Otherwise, a grit chamber or rake system is needed to prevent sedimentation within the intake. Bypass flows would reduce water available in the river for diversion.

- Are any of the flow requirements for equipment (Grit Removal system, HEADCELL, and bypassflow) in addition to the 12.2 cfs allotment? Or, are these requirements covered as part of the 12.2 cfs going through the intake?

  Bypass flow is separate and additional, but equipment flows if recirculated within the diversion system would not require additional water once connectivity is established. This is further explained in responses to questions below regarding the waste streams for the HEADCELL and desanding pump arrangement.

- There are several references throughout that our NTU Standard is "25 to 30", or roughly 30; these should all be deleted and restated as 25 NTU. (Page 29, 30,36)

  Text revised.

- When will we get to see the well workplan (App. F)?

  The work plan has since been transmitted, reviewed by the City, and executed. It is provided, along with the test well results, as an appendix to this report. The results and recommendations have been added to the report.

1) Introduction page 1
   a) 3rd paragraph replace "(supplied by the City's Felton Diversion)" with "on Newell Creek".

      Text revised.

   b) 4th Par. The City's Water Right license allotment of 12.2 cfs was received under two licenses; the first license (No. 001553) granted in 1928 allotted the City 6.2 cfs, and the second license (No. 007200) granted in 1963 allotted the City 6.0 cfs.

      Text revised.

   c) 4th par. 3rd sentence. This sentence is confusing. Replace "In contrast with an approximate" with "The 30-year period …. indicates that surface water is available in the river …….".

      Text revised.

   d) 4th par. 3rd sentence. The above statement about availability of water for diversion at the river is confusing/misleading since the gage is downstream of the diversion. The percentage, 75%, should probably be revised.

      Text revised to read as follows, "The 30-year period of record available from USGS hydrologic data (USGS Gage 11161000 San Lorenzo River at Santa Cruz, 1952-1960 and 1987-2006), indicates surface water in the river is available above 12.2 cfs for 75% of the time. According to the data, flows are less than 12.2 cfs mainly between July and December. Because the gauge is located downstream of the City's diversion, the influence of the diversion is not accounted for, and the percentage of time flow exceeds 12.2 cfs is actually greater than 75%. Regardless, the ability to continue to tap this resource is critical."

   e) 4th par. Last sentence. Amend with a generalization about the other % of the time surface water is not available- is it in certain summer months?

      Text revised as stated in response to item d. above.

2) Page 3
   a) Cite date of this figure since it is out of date with respect to Beltz and Tait wells. This figure was created in 4/94 and was last updated in 1/01.

      Source and date referenced.

3) Page 4
   a) 3rd Sentence, Remove the word "demands". It should read as follows: "Because the Tait Diversion is the dominant contributor toward SCWD's overall domestic water supply, the City is ……."

      Text revised.

   b) The primary purpose of this study is threefold: the first and third bullets (combined since they are about the same), the second bullet, and thirdly to consider the condition and function of the check dam and recommend solutions to maximize diversions. The check dam was not emphasized in the RFP but Jim Bentley has made his concerns clear regarding this in our project meetings.

Text revised. A dam improvements section is added to the report.

c) Bullet 4, turbidity minimization is not a goal, but would be a side benefit if it happened.

Text revised.

d) Bullet 5 is an alternate solution so I would not list it here.

Item omitted.

4) Page 6.
   a) 1st par. You probably don't mean "City's Water Treatment Rule". You probably mean water supply protocols or something like that.

      Text revised.

   b) 3rd par. Reference Fig A-1 in App B here.

      Reference added.

   c) 3rd par., last sentence. There are no down stream bulkhead slots per. se., just a notch the slide gate fits in.

      Text revised.

   d) 4th par. "former" 36-inch CMP sounds awkward. Maybe "existing" or omit the word "former".

      Text revised.

5) Page 7
   a) Par 1. For clarity, we call it the San Lorenzo River Pump Station, not the Tait Pump Station

      Text revised throughout.

6) Page 8
   a) Par 1. Tait well 2 was "destroyed" not "abandoned". This distinction is important.

      Text revised.

   b) Par 2. Although you say this later, note that the high iron and manganese often exceeds Secondary MCLs.

      Text added.

7) Page 9
   a) 3rd par., second sentence. Sediment does and has compromised the capacity of the diversion. When we said it hasn't we meant that we have been able to mitigate the affects but not with out some cost or extra effort and in fact we recently had a situation where we were unable to mitigate the problem.

      Text revised.

   b) Does 10 NTU value refer to color? If yes, units are CU.

      This information was provided by SCWD (J. Bentley) and reiterated verbatim. Document was titled, "City of Santa Cruz - SOP Related to the San Lorenzo River Source." No change made.

8) Page 10
   a) 3rd par., first sentence. The City's practice relating to the discharge of sand to the river has changed. We are no longer discharging sand directly into a storm drain inlet, we have straw bales and wattles set up around the storm drain to filter out the sand. Revise this sentence to reflect the City's practice relating to the discharge from the desanding pumps.

      Text revised.

9) Page 11
   a) To bullets add: Diversion Dam Improvements. You will need to add a discussion of this as well.

      Report amended.

10) Page 13
   a) Last sentence. Delete "consist" and add colon between "are" and "slotted".

      Text revised.

11) Page 15.
   a) 1st bullet, reference drawing A-2 in App B.

      Text revised.

   b) Any new screen arrangement should be designed so individual screens are alternately cleaned by compressed air for more effective cleaning.

      Text revised.

12) Page 16.
   a) The City's Water Right license allotment of 12.2 cfs was received under two licenses; the first license (No. 1553) granted in 1928 allotted the City 6.2 cfs, and the second license (No. 7200) granted in 1963 allotted the City 6.0 cfs.

      This information is stated on page 1 of the report per the comment above. Rather than restate, no reference is made to water right licenses on this page.

   b) Are screens going to be design with a maximum flow ***into*** the screen of 12.2 cfs or 12.2 cfs ***through*** them? If ***through*** them, design screens for greater than 12.2 cfs to allow for clogging (25% greater).

      The fish screens, as proposed, feature a 50% contingency in screen area to provide some margin of safety against occlusion and non-uniform approach velocity distribution. Available space in the existing intake structure exists to accommodate this design feature. Fish screen design considers the design flow "into" the screens per regulatory agency screening criteria. The screen area contingency is above and beyond the minimum required for continuously cleaned screens and will aid in maintaining capacity if a portion of the screen area becomes blocked.

13) Page 17
   a) Adjustable height screens to accommodate the changing height of the river bed is a good idea but what about the rest of the dam structure. Not much discussion about how the

fixed structure would fair. Begs the question….why wasn't a rubber dam considered? We have had very little if any river bed sediment load issues with Felton Diversion so it is a proven technique.

It was our understanding the City did not want to undertake implementing an artificial barrier in the river channel. Implementing an inflatable dam or equivalent mechanism will require a fish ladder for upstream fish passage. Bear in mind, the Felton Diversion involves an 8-foot tall inflatable dam and considerable bypass flows through the intake and ladder. To address this issue, the dam improvements section has been added per the above comment. Dam improvements are not added to the alternatives since they are universal for all alternatives and therefore do not provide any discriminating effects in the comparisons. Instead, information about the technology, benefits and liabilities, and costs are explained in this new section added.

14) Page 19

a) 3rd par. Insert "Figs A-3 and A-4 in" between "(See" and "Appendix B)". It should read as follows: (See Figured A-3 and A-4 in Appendix B).

Text revised.

b) Since returning decanted water back to the river may require regulatory agency approval, why not just return decant water to wet well and forget about returning water to the river.

Both options are identified. The downsides of returning decanted water to the wet well is it may contain residual sediment, especially if the grit basin is not monitored, and would require cost of additional piping as opposed to free discharging into a drainage swale back to the river. Since the City currently discharges its desanding stream back to the river, it may not be an issue at all for regulatory approval. With that said, recirculating decanted waste stream water seems to make the most sense.

15) Page 21

a) 1st par. "…raked to a spoil area in the dry." Dry what? There is something missing here.

Text revised.

b) 1st par. Last sentence start with "Figure A-4 in." before "Appendix B…"

Text revised.

c) What would the new rake system be made of, how durable is it?

The rake system would consist of mild steel drive chain links and drive system components and fiber reinforced plastic flights. These systems are used in wastewater sludge collectors, a corrosive and demanding environment for mechanical equipment. Suggest visiting websites of vendors listed to become familiar with commonly manufactured systems.

d) How would the new intake be protected from flooding?

It would be embedded in the existing embankment outside the primary channel flush with existing ground and tied in with an apron of slope protection. See Exhibit A-4 in Appendix B. The top surface of the intake would be enclosed with grating, concrete, and screen panels.

e) How well has the Cascade Pipeline on Deer Creek worked?

In subsequent conversations with the former Chief Engineer for the District, no sedimentation problems have occurred.

16) Page 24

a) The grit removal system requires 1 cfs (450gpm) to operate; is this in addition to the 12.2 cfs we will be taking per our water right allotment? If so, how do we manage this so it doesn't adversely affect our water right?

If the waste stream is returned to the wet well, the general service pumps would need to have speed reduced until connectivity is established. Once accomplished recirculating water through the decanting system and back to the wet well would not affect the diversion rate. A step-logic ramping routine could be programmed in the PLC to reduce general service pump output by 1 cfs for a few seconds until the recirculation process is established.

17) Page 27.

a) 1st par. Why is a grit classifier needed in addition to a grit separator or sed basin? You recommend a sed basin over a grit separator. I think you also say you are trying to be redundant for good measure but I would like to see some more explanation regarding why 2 systems are needed. What if only a rake system is used?

On the contrary, a sed basin is suggested for dealing with collected sediment. The alternate technology of a grit classifier is only identified for informational purposes and is a sister component to a grit separator in confined space areas, typically used at water treatment plants. There is no redundancy, the grit separator requires either a sed basin or classifier to manage sediment. The rake system simply drags collected sediment to an accessible spoil structure.

18) Page 28

a) 1st par, last sentence. Can you state here what the current trash rack clearance is?

Text added.

b) Shrinking the trash rack openings to 1" may lead to more plugging due to leaf matter and liter which now passes through and gets blown off the intakes. It is a good idea to close down the screens but there will be a maintenance/operational impact and possibly the need to automate cleaning the racks.

Fish passable trash racks must feature a clear spacing between vertical members of 9-inches. Otherwise it is a barrier and should have 1-inch spacing. The current trash rack is not consistent with regulatory agency guidelines if fish were to swim through the intake. If bypass/sediment transport flows were to be concentrated through the intake (or a new in-line fish ladder if an inflatable dam were to be used) The existing trash rack would have to be "opened up", thereby allowing larger material to enter the intake structure. Otherwise, to prohibit adult entry into the intake a 1-inch spacing applies. Text added to identify increased maintenance.

c) 2nd par. refers to the existing intake only right? This section is a bit hard to follow and might be clearer if it was separated into alternatives, although I know you already have it

separated by technologies. Maybe just make it more clear what alternative you are speaking about in this section.

Text revised to clarify.

d) 3rd par. Will the 2 fps requirement affect our water rights? You mention that in either case a bypass will be needed for fish; is there a way to just divert what we need into the structure and screen the fish out at the river?

The 2 fps is not a requirement but a suggested hydraulic condition. A 2 fps transport velocity through the intake will keep typical sediments encountered in the San Lorenzo River from falling out in the intake. In addition, regulatory agencies generally require a sweeping velocity (two times the approach velocity or 0.66 fps) to minimize fish exposure to new or modified screened diversions. Sweeping velocity is typically produced by capitalizing on minimum downstream bypass flow requirements. If a bypass flow is required by the regulatory agencies, the above transport and sweeping velocities can be produced. Bypass flows would reduce water available in the river for diversion. You can divert without bypassing. Although not ideal from a fisheries perspective, it is sometimes allowed at small diversions.

19) Page 29

a) 2nd large par. Gary B and/or Jim B to provide cost numbers for maintenance.

Cost data not received. Spaceholders left unchanged.

b) Last par. Modify; after "treating raw water with a turbidity level" add "up to 25 NTU".

Text revised.

20) Page 30.

a) 1st par, first sentence. NTU has been measured to exceed 2,000 NTU

Text revised.

b) 1st par, last sentence. Here is where the "SOP" mentioned in the next paragraph is really first mentioned so it should be called out here first. Therefore I suggest you move "(SOP related to the San Lorenzo River Source …" from the second to first paragraphs. Actually I think you are trying to mention this on page 6 par. 1.

Unclear, the SOP is mentioned in the first paragraph and not in the next paragraph. No change made.

c) 2nd par. Starting the par. off with "In large" sounds awkward.

Text revised.

21) Page 31

a) 1st par. Insert "that" between "It is acknowledged" and "upcoming". It should read as follows: "It is acknowledged that upcoming ……."

Text revised.

b) 1st par.This paragraph mentions a MCL limit of 5 NTU being mitigated by new membranes at plant. This statement is incorrect. At present, elevated NTU is a problem in that it reduces the availability (or extends the duration of turnout) of the SLR because

of the GHTP's current treatment process. However, this NTU issue will be largely eliminated by the installation of either microfiltration or ultrafiltration membranes in the sedimentation basins. The membranes are not intended to reduce turbidity of influent water. Rather, influent water turbidity will be reduced by chemical coagulation and flocculation prior to membrane filtration. Since we will be using membranes at the plant we can tolerate higher raw water NTU but there is no MCL for this (raw water), and if we are talking effluent MCL, then that would be .3 NTU. The 5 NTU secondary MCL applies to water served to the public (in the distribution system), not source water that receives full treatment. The only case where a 5 NTU standard applies to untreated source water is for approval to avoid filtration.

Text revised.

c) 2nd par. Here again you mention that for the existing intake alternative, two grit separation technologies are recommended for redundancy, the grit chambers and a grit separator or sed basin. Is this necessary?

The grit chambers are suggested in the intake structure to mitigate coarse grain sedimentation that can occlude screens and impair diversion capacity. The in-line grit separator is suggested as a secondary treatment aimed at intercepting fine grained sediments before they reach the pump station. A sed basin is a completely separate feature and is required to receive/manage collected sediments routed from both locations. At this level of evaluation it is prudent to consider both technologies in an effective intake retrofit alternative.

d) 2nd par. You may explain this somewhere, but I assume we want to keep the old intake if we build a new one in case it is down for repairs or something. Will DHS allow this?

I don't believe the intake arrangements would not fall under the jurisdiction of DPH, but rather the State Water Resources Control Board. Protecting the existing intake in place is mentioned for the new intake alternative on Pages 49 and 54 and shown on Dwg A-4 of Appendix B. It makes sense to keep the existing intake as a backup for emergency conditions as mentioned.

e) After heading "Design Criteria" add "For Grit Separators" for clarity.

Text revised.

22) Page 32

a) Headcell requires 150 gpm for grit removal; would water be recovered to offset loss of water from our right (allotment)?

Yes, if decanted water from the sed basin is plumbed back to the Headcell or wet well. Recirculated water would not reduce the City's water right or diversion allotment.

~~b)~~ 3rd par. You say the carrier stream of grit from the Headcell would go into the pump station wet well but don't you mean the new wet well?

Actually the carrier stream would be routed to the sed basin and then the decanted water would be plumbed back to the HEADCELL or pump station wet well. Correction/clarification made.

c) Last par. are elevations from Mean Sea Level? What is "wsel"? water surface elevation?

Datum from as-builts used referencing NGVD 29. WSEL acronym deleted and water surface elevation spelled out.

d) Elevations are based on as-built datum.

Yes, NGVD 1929.

e) Bottom of page discussion of our San Lorenzo Pumps makes optimistic assumptions that may not be accurate. First of all, the affective level of our dam is the downstream partition of the intake structure which has an elevation of 9.0'. This only leaves us 3' of pump submergence to compensate for any headloss through the intake works. This information should be verified in the field under operating conditions before we use this to justify giving up head for system improvements.

Agreed. Information presented is based on data shown on the as-builts and comparable pump characteristic curves. It is not known what the actual manufacturer submergence requirements are or whether the pumps are installed as shown on the as-builts. The City should verify as indicated.

23) Page 34

a) End of 1st par. After "Grit would be separated from the carrier stream" add "and sent to the new pump station wet well ~~or back to river with regulatory approval~~".

Text revised.

b) 2nd par. You say the PISTA system would require installation with a top elev. above max high water level. Isn't this a major problem since the flood plain is at a level above the pavement at the pump station?

Not a problem, just costly. The reason for elevating is to keep electromechanical components above flood stage. This makes the HEADCELL technology more attractive, since it is a static device and features no sensitive equipment.

24) Page 36.

a) 1st par. What size sed basin is expected?

Size is stated on Page 27. Text added to reiterate.

b) After item d (turbidity Reduction)might be a good place to summarize the general engineering recommendations for the two alternatives, build new and rehab old intake. It might help to show a flow diagram for each.

This section discusses the sediment removal concepts and it doesn't seem to be an appropriate place to discuss alternatives here. Alternatives are later described in the Alternatives Comparison section.

25) Page 37

a) 2nd par. replace "in some cases exceed" with "in well 3 (now a monitoring well) has exceeded".

Text revised.

b) Footnote 1. This footnote indicates the WQ data came from DHS. Is this true? Shouldn't the data come from the City? Can a date range be given for the data? This reference needs to be more specific.

Yes, the WQ data came from the DHS. The DHS database is a readily available resource, which contains the City's water quality data. Footnote revised to include data date range.

26) Page 39

a) I would change the heading "Corrective Measures" to "Recommendations" or something like that.

Text revised.

b) 1st bullet. Why measure spec cond when the EC was the same for all the wells?

It is important to monitor changes in the well water quality and to compare to water quality changes in the San Lorenzo River to monitor for river influences.

c) 3rd bullet. I would state the site is on Ocean Street Extension and also cite the parcel number.

Text revised

27) Page 40.

a) Bullet at top of page. It is the City's understanding that Kim Vester and Jenn Hyman have done all they could to track down boring logs around the river and provided you with previous hydrogeo studies by the City.

It is still important for the City to maintain internal records for the beneficial use for future studies.

b) 2nd par. I was expecting to see a test well workplan in this report, which I believe is going in App F. Will this been transmitted to the City separately?

The work plan has since been transmitted, reviewed by the City, and executed. It is provided, along with the test well results, as an appendix to this report.

28) Page 41

a) Throughout this section I would like "Infiltration Gallery" changed to "River Wells". To me an infiltration gallery is something horizontal.

Text revised.

b) Last par. Add "Extension" after "Ocean Street".

Text revised.

c) Will the intake be demolished if the well alts. can supply all the water right? or would it be left in place in case of emergency?

The riverbank infiltration alternatives are not capable of supplying the full water right, only a portion (yield will only be able to be determined after river wells are constructed and tested). The intake, or modification thereof, will need to remain and the alternatives have been revised in the report accordingly. Neither the infiltration gallery or radial collector are viable stand alone options.

d) If the well alternative can supply all the water right allotment of 12.2 cfs and we no longer use an intake, will this be considered a new point of diversion?

The well alternatives will not supply the full water right. However, the wells will draw on river influenced groundwater, and the Ocean Street site is a significant distance (roughly 1-mile) from the current point of diversion. A petition to change point of diversion will need to submitted to the State Water Resources Control Board.

29) Page 42

a) Alt No. 5 is a combination of Alts 1 and 3 not 4.

Alternatives revised.

b) Explain the No Action alt. here.

Text revised.

c) Was another weight decision matrix or process considered? How about a pair-wise method?

No other matrix or process was considered.

30) Page 43, bottom.

a) You should probably add that a score of 10 means the alternative is the best and zero is the worst or something like that.

Text added to clarify.

b) How was the scoring of each parameter and alternative done? The weight and score for each parameter might be scored differently by each of the sections within the Water Department. I think this might be a big issue for each section.

The scoring and ranking process requires collaboration amongst various interests and parties to arrive at an objective outcome. A consensus approach toward weighting and scoring of characteristics and alternative performance is important with respect to establishing a fair assessment of alternatives ranking. Final scoring and weighting should be a collaborative effort involving the various City departments prior to publishing the final document. The weighting and scoring was conducted by WR staff and reviewed with the City. Collective input was requested, but none received, with the exception of the below.

31) Page 44

a) Entrainment Prevention. I would score Alt 5 a 9 as an average of 1 and 3.

Agreed. Scoring revised. Note changes in alternatives.

b) Pugh comparisons seem to place Alt. 1 ahead of Alt. 2 for use in Alt. 5. Why? Wasn't Alt. 1 have a score of 8 and Alt. 2 a score of 10?

A variety of alternative combinations exist. The combination of Alt 1 and Alt 3 (Alt 5) was formulated before the City requested Alt 2 be developed. Adding a new alternative combining Alt 2 with river or collector wells will provide little additional information that cannot already be determined from brief review of the scoring comparisons. If Alt 2 scores higher than Alt 1, then a combination of Alt 2 with river or collector wells would score higher than a combination of Alt 1 and river or collector well alternatives.

32) Page 45

a) Post-Construction Evaluation. There is a difference in opinion within our department about this.

Noted.

b) Alt. 5 is cored an 8, while Alt. No. 1 is scored an 8 and Alt. No. 3 is scored a 10? Should this be an average of the two alternatives?

No, because post-construction testing applies to fish screen testing only. There is no testing requirement for wells with respect to fish impingement/entrainment prevention.

33) Page 46

a) Access to raw Water. Could the river wells operate if they were flooded? If not, this would limit availability of water. You cannot score river wells until # of wells and well yield is known.

Using submersible turbine pumps with elevated platforms allows the wells to remain functional regardless of flooding conditions. Accordingly to findings from the test well program, one river or collector well is recommended for each site. The river wells are anticipated to produce ~800 gpm and ~700 gpm at the Tait Street and Ocean Street sites, respectively. The collector wells are anticipated to produce ~2,000 gpm and ~1,000 gpm at the Tait Street and Ocean Street sites, respectively.

b) Again, the analysis that says we only have water available in the river to supply our full right 75% of the time may not be correct. True or false; this would seem to affect the Pugh rating.

Text revised. True, the scoring of surface water alternatives is a function of water availability in the river.

c) Efficiency of Raw Water Usage. I think what you really mean is “Energy Usage”. Does the sed basin require a pump? If so both 1 and 2 have a new pump. Also alt 2 has the added power for the rake system. Can you explain the piping improvements for the well alts somewhere, like on page 41? Didn’t really understand what you were saying about the reduction in friction/minor losses here. I would score alt 5 a 9 not 10 since it is a combination of the two alts.

I suppose they are synonymous. The sed basin is static but the desanding systems require energy to circulate the waste streams. Alt 2 has a traveling rake whereas Alt 1 has a desanding pump. Piping explained on page 41. Text revised to clarify reduction in friction/minor losses.

d) In Alt. No. 5, how would the efficiency be improved if we are connecting directly to the transmission main? Wouldn't the new pumps have to overcome the head required to go uphill toward the treatment plant, along with the pressures already seen from the booster pumps at the wet well.

Efficiency would be improved by virtue of introducing additional flow at a point further downstream in the transmission main. Basically, water would have to be pumped almost roughly a half-mile less from the Ocean Street site than the Tait Street site. In addition, static lift is roughly 30-feet less at the Ocean Street site versus the Tait Street site.

34) Page 47 Reliability of Diversion

a) Should the score for river wells and collector wells be higher? Since wells can be replaced if they fail, it is just a matter of $. Also, they should be a higher score than the collector well in this category.

Don't think so. Infiltration wells have opportunity for media bed to clog. Intakes have access for cleaning. Both river wells and radial wells can be rehabilitated.

b) Alt 3 2nd par. I would replace "known sources" with "river well projects" if this is what you mean. Also change galleries to river wells.

Text revised.

35) Page 48 Sediment Intercept and Management 1st par. "A key objective…" should say "The main objective…".

Text revised.

36) Page 49 Turbidity Reduction. Should this category be included since it is not a primary objective, just a side benefit?

Sure, the weighting or importance is just reduced. Lowered from 7 to 5 based on comment.

37) Page 50.

a) Alt 5 from Debris Management says it should have a better score than alt 1 but they have the same score.

Scores would be the same since they have the same intake and wells not susceptible to debris. Text revised.

b) Shrinking the trash rack openings to 1" may lead to more plugging due to leaf matter and liter which now passes through and gets blown off the intakes. It is a good idea to close down the screens but there will be a maintenance/operational impact and possibly the need to automate cleaning the racks (also see Page 28).

Scoring revised to account for trash rack modifications.

38) Page 51

a) 1st par. Delete discussion of energy usage since this was already its own criteria.

Text omitted.

b) Maintenance Demands. Alt 1 says maintenance will be similar to that already done at Tait but what about the additional maintenance due to the addition of the grit chambers and sed basin. Alt 2 I don't think you mean "in contrast to rake system", probably "with the addition of the rake system". If alt 3 will require less maintenance than the Tait diversion then it should score less than alt 1.

Text revised.

c) Functional Lifespan of Facilities should be combined with Maintenance since they may be related.

They are related but entirely different. For example, the service life of a well may be short-lived regardless of typical maintenance performed. No change.

39) Page 52 Design Certainty

a) Alt 1 Any discussion of NOAA or CDFG should be moved to permitting criterion.

Sentence deleted.

b) Alt 2 – are you sure this design will work? Is it possible the new intake geometry would prevent it from collecting as much water as the current intake?

Design will work, off-channel intakes are proven. Geometry will not affect hydraulics or diversion capacity.

c) Alt 3, 4 and 5, wait to score until after field effort.
Scores revised.

40) Page 53 Construction complexities

a) Alt 1 and 2 should score less than 7 due to installation of grit separator. I cannot envision where the sed basin would go; maybe this is less complicated to construct.

Separator structure would be roughly 20-ft deep, not excessive. Sewer wet wells constructed much deeper. Excavation may require sheeting to stabilize. Sed basin relatively small and shallow.

b) In Alt 1 CDFG SAA limit work to starting July 1. Perhaps discuss in new construction section, taking into consideration that there is generally a prohibition on work during the rainy season, and a preference for work in the low-flow season (July, August/Sept/Oct).

Mentioned in new section, nonetheless, a contractor's opportunity to schedule and conduct the work is a constructability issue.

c) In the Pugh evaluation, the difficulty of constructing Alt. 2 is under rated because of the size of the excavation and the limited access. If true, this would make this Alt. rate lower.

Score reduced from 5 to 3. However, alternative is some distance away from existing intake so conflicts would be avoided.

d) Alt 3 Pipeline down Ocean St Ext could be tricky.

Secondary access route is supposedly available. Difficulty understood and scoring reduced.

e) Alt 4 Potential for conflicts would be low (delete “the” before “low”). Dewatering the river would not apply but dewatering the excavation for the caisson would. Change “Construction type is highly…” to “Construction contractors are highly…”.

Text revised.

41) Page 54

a) 1st par. What does “Construction would be well controlled.” mean?

Sentence deleted.

b) 2nd par Alt 5. This should be scored the same as the lowest of alts 1 and 3 in this case.

Scoring revised.

c) Environmental Impacts

i) Does this section consider both construction impacts and operational impacts?

No, only impacts to the environment and public.

ii) Alt 1 sounds like you are assuming the grit separator will not be installed since it would require deep shoring. Clarify how diversion system will work somewhere in the report. Is there a potential for take with the grit chambers? If so this should be counted here.

No, grit separator is a part of Alt No. 1. The diversion system will draw water through the screens as the pump station is operated. The water will pass through the grit separator and flow into the influent conduit to the pump station wet well. The grit chambers have the potential for take. This is accounted for in the fish entrainment criteria and noted that regulatory agency approval is required.

iii) Alt 2. If the new intake does a better job of passing fish than alt 1 then it should score higher.

Not sure where this is stated. This dynamic is dealt with in the Fish Protection section.

42) Page 55 Environmental Impacts continued

i) Alt 3 and 4 should score higher than 1 and 2 for environmental impacts since there is no fish entrainment and no river construction.

This dynamic is dealt with in the Fish Protection section. Alts have changed and now all involve in river construction except the no-action alternative.

ii) Alt 4 the well caissons “will” extend above grade since most of the site is in the flood plain.

Text added.

iii) Permitting – list expected permits for each alternative

Permits identified.

iv) All alts. will involve CEQA process.

Check, all but the No Action alternative.

v) All well alts. might involve DFG permit since in riparian habitat and flood plain.

1602 Streambed Alteration Agreements will be required for all alternatives except the No Action alternative.

43) Page 56 Alt 3
   a) Do not say DHS only contacted as a courtesy. They might want to pre-approve all well locations even if it is raw. Remove the words “as a courtesy only”.

      Text omitted.

44) Page 57
   a) Move the comparison table out of the appendix and into this section since it is important.

      Matrix relocated.

45) Page 59
   a) Ca we see cost tables before review of this section? Make sure to include pipelines for wells.

      Opinions of cost included.

46) App B
   a) If you are sure you are not recommending the grit separator, which you show in figs A-3 and A-4, add new figures somewhere with the sed basin shown instead.

      No, grit separator is recommended and sed basin is needed to support.

Wood Rodgers Responses to City of Santa Cruz Comments on
DRAFT TAIT STREET DIVERSION SANDING STUDY
Dated July 17, 2008 by Wood Rodgers

Final comments received on January 22, 2009

Cover

- Two spaces btwn "Diversion" and "Sanding"
- **Revised**

Pg i

- pages don't match sections
- **Revised**

Pg 1, 1st paragraph

- Should be "Figure B-4" not "Figure A-4"
- **Revised**

Pg 25, 1st paragraph, last sentence*

- $X,XXX = $3,100 - $6,200
- **Revised**

Pg 25, 2nd paragraph, 3rd sentence*

- $X,XXX = $45,000
- **Revised**

Pg 25, 2nd paragraph, last sentence*

- $X,XXX = $12,000 - $18,000
- **Revised**

Pg 25, 2nd paragraph*

- I don't know if you want to mention that the two sand pumps cost about $7,000 (total) every 2-3 years and intake cleaning costs about $6,200 - $9,300 each year.
- **Revised**

Pg 27, 2nd paragraph, last sentence

- Is "desanding pump" the "grit removal pump"?
- **Yes, they are synonymous**

Pg 27, bottom of page

- Maybe put "b. Smith and Loveless…" on next page?
- **Moved to next page**

Pg 32, 3rd bullet

- Missing word? "...should be__if additional wells…"
- **Added “considered”**

Pg 33, Well Pipelines and Capacities

- Update: Tait #1 is back on-line and producing 370-380 gpm; Tait #4 was down for a failed motor but is back on-line producing 220-245 gpm
- **Deleted comment regarding well failure**

Pg 39, Alternative No. 2

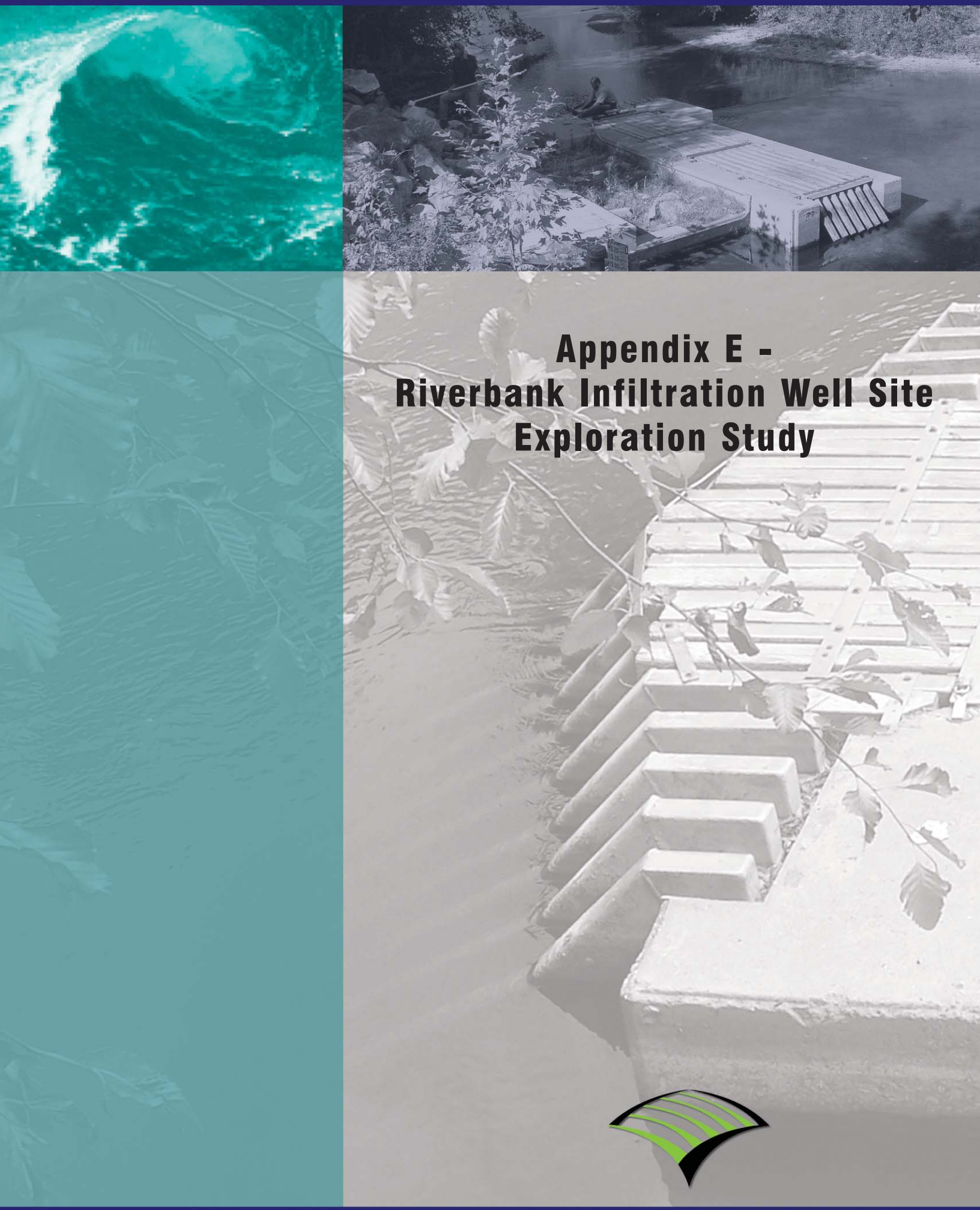
- Would we still make improvements to the existing intake since it would be left for redundancy?
- **Alt 2 does not include improvements to the existing intake. The only modification involves plumbing the existing intake into the proposed grit separator. See Dwg A-4.**

Pg 45, Reliability of Diversion

- Why are Alternatives 1 and 2 lower (7) than Alternatives 3 and 4 if "gravity diversions are considered the most reliable for of water supply" and "Subsurface pumping…is susceptible to…a greater degree of uncertainty"? Are the numeric values mis-assigned? If so, does this change the final results?
- **Alternatives with technologies tapping both surface and subsurface water sources are scored higher for reliability since they have access options to water should the river run dry at the surface and potentially greater opportunity for diverting when turbidity conditions typically force SCWD to cease surface water diversions. The description for Alts No 3 and 4 were not updated to reflect the combination of gravity intake and well technologies for the final draft report. The description will be revised to read, "Although subsurface pumping...than gravity diversions, the combination of both gravity intakes and river wells compliment one another by improving access to usable water in both drought and high turbidity conditions. The sentence, "Once plugged, they are not easily maintained and permeability can be greatly altered," should be deleted.**

Pg 46, Flexibility and Redundancy of Diversion

- Why are Alternatives 3&4 only one point higher than Alternative #2? They seem a lot more flexible and redundant.
- **Alts 3 and 4 are a combination of Alt 1 and river wells. Alt 1 does not have a backup surface water intake. If Alts 3 and 4 featured a combination of Alt 2 and wells, then it is agreed they would receive a higher score, maybe 9 or 10.**



Appendix E - Riverbank Infiltration Well Site Exploration Study

WOOD RODGERS

May 9, 2007
Job No. 8262.002

Mr. Isidro Rivera
City of Santa Cruz Water Department
809 Center Street, Room 102
Santa Cruz, CA 95060

Dear Mr. Rivera:

Subject: City of Santa Cruz, Tait Street Diversion Sanding Study – Riverbank Infiltration Well Site Exploration Work Plan

In accordance with our contract with the City of Santa Cruz (City), Wood Rodgers has prepared this work plan to provide the data needed to assess the potential for increasing the production capacity of the City's Tait Well Field. This work plan was prepared with input from Collector Wells International (CWI), and will allow for assessment of the viability of additional shallow vertical wells or a radial collector well.

This program includes site exploration at the Tait Well Field (near Tait Well 4). If site conditions are favorable for further evaluation, Wood Rodgers will design and construct a large-diameter test well at this location. This test well would be used to perform pumping tests to further determine if additional shallow vertical wells or radial collector wells would be an alternative source of non-turbid, sand-free water.

At the City's request, this site exploration program also includes an exploration borehole and a monitoring well at the Ocean Street Extension parcel (also owned by the City). This parcel is north of the Tait Well Field. The Ocean Street site exploration was not part of our original proposal and is not included in our contract.

Background

A discussion and analysis of the City's Tait Well Field was presented in Wood Rodgers' Tait Street Diversion Sanding Study – Draft Alternatives Evaluation Report (March 7, 2007). Although the City has conducted numerous studies of the Tait and other potential City well fields, efforts to target underflow from the San Lorenzo River have been largely unsuccessful. Testing previously performed at the Tait Well Field has not been able to conclusively determine whether the wells are actually drawing water from the San Lorenzo River.

One problem is that the Tait Wells target aquifer materials that extend well below the San Lorenzo riverbed, and consequently may not be effectively targeting river underflow. Additionally, water quality in the Tait Wells, as presented in the Draft Alternatives Evaluation

Report, is significantly different from the river water, particularly with regard to elevated concentrations of manganese and iron in the Tait Wells. Concentrations of iron and manganese in the Tait Well Field generally increase with distance from the river. Water quality in the Tait Well Field is reportedly not a current problem for the City because well water is always blended with a substantial volume of surface water at the City's Graham Hill Water Treatment Plant prior to distribution. If the City increases production from the Tait wells, however, water quality from the wells may become more significant. For that reason, one objective of this investigation is to determine possible sources of iron and manganese in the Tait wells, and approaches to reducing concentrations of these metals in well water. Four possible sources have been identified:

1. **Groundwater.** Wells may be drawing a mix of surface water and groundwater, and the groundwater quality may be worse than the surface water quality. Wells further from the river may be drawing in a larger proportion of poorer quality groundwater and a lower proportion of river water.

2. **Biogeochemical Processes.** A well-documented potential effect of riverbank infiltration is that biogeochemical processes reduce (remove oxygen from) water that infiltrates from the river, allowing iron and manganese to go into solution and raising concentrations of these metals in water pumped from the wells.

3. **Turbidity.** Water quality samples from the Tait Wells are frequently slightly turbid. Wood Rodgers recently completed an analysis of the relationship between turbidity and iron concentrations in water samples, which showed a pronounced increase in iron concentrations when turbidity was above 1 NTU. Turbidity in well samples is usually a result of well design, incomplete well development, well failure, or inadequate flushing prior to sample collection.

4. **Colloidal Materials.** Because the Tait Wells are screened across intervals that include fine materials (silt and clay), very small colloidal particles may be present in water pumped from the wells. These particles are small enough that they would not show up as turbidity, but would be dissolved by the acids in water sample bottles for metals analysis, raising concentrations of metals in the samples.

Work Plan

The work plan that Wood Rodgers has developed will help identify the potential to specifically target river underflow to maximize production from the Tait Well Field. The work plan will also help determine how to obtain water with lower concentrations of iron and manganese from the Tait Well Field. Finally, the work plan will provide initial data to evaluate the feasibility of developing future riverbank infiltration supply at the Ocean Street Extension site.

Because of additional information obtained during this project, this work plan differs from the approach initially proposed in several aspects: (1) we recommend sonic drilling for site exploration, (2) we recommend the construction of monitoring wells to provide better data, and (3) we recommend that the large-diameter test well be constructed separately from the site exploration and monitoring well construction.

At the beginning of this project, Wood Rodgers proposed to conduct site exploration drilling with a bucket auger drilling rig immediately prior to construction of the large-diameter test well. Subsequent input from CWI suggested that a more detailed analysis of the sediments would be very helpful for the complete characterization of the shallow aquifer system. CWI recommended that the sonic drilling method be used for site exploration. The sonic drilling method is well suited for the soil types near the river, and sonic drilling provides continuous cores of the sediments. These continuous cores of sediments will identify if and where thin clay layers exist. Clay layers could prohibit or reduce the downward migration of underflow from the river, and could also contribute to reduced conditions away from the river.

Wood Rodgers recommends that two sonic boreholes be drilled at the Tait Well Field, and one at the Ocean Street Extension site. These boreholes would then be converted into monitoring wells at minimal additional expense. Initially, the monitoring wells would be used to obtain water quality samples. At the Tait Well Field, the monitoring wells would also be used as observation points to evaluate the performance of the large-diameter test well.

The proposed location of the monitoring wells at the Tait Well Field is shown in Figure 1; the location of the monitoring well at the Ocean Street Extension site would be determined by the drill rig's ability to access that site. The preliminary design for the monitoring wells is shown in Figure 2. The cost to construct the three monitoring wells using the sonic drilling method is estimated to be $27,000. Water quality sampling and engineering services associated with the site exploration are estimated at an additional $8,000. These costs for site exploration were not included in our original proposal. However, some tasks that were included in our original proposal, such as the fish screen testing, will not be conducted. In addition Wood Rodgers has been efficient on some of the tasks that have been substantially completed. These costs will roughly offset each other therefore the overall project cost will likely not increase.

The locations of the monitoring wells at the Tait Well Field were selected to provide site-specific data for test well design, a monitoring point to evaluate the test well's effectiveness at drawing river water, and a monitoring point to evaluate distance-drawdown to determine spacing for future wells. At least one of the existing Tait Wells would also be monitored during test pumping of the test well. During the testing the existing Tait Wells will need to remain idle. Data gathered during site exploration and testing will be very helpful in determining the viability of additional riverbank infiltration wells.

Based on the geology from previous studies of the Tait Well Field, Wood Rodgers has developed a preliminary test well design as shown in Figure 3; this design would be refined after site-specific data is obtained. The cost for the construction of the test well was estimated in our original proposal to be $67,000. The attached preliminary test well design includes 20-inch diameter well screen from 18 to 43 feet below ground surface to target underflow from the river. The diameter of the well casing was selected to allow for the installation of a second well casing. The second well casing would be used to reduce entrained air generated by cascading water as the upper well screens are dewatered during pumping. Unlike conventional "casing path" well designs, the second casing could be removed to provide more effective access to the well screen during well rehabilitation. As with other wells, shallow river infiltration wells are anticipated to require periodic rehabilitation to maintain well yields. The final test well design will utilize materials suitable for conversion into a production well if the well yield and water quality meet the City's objectives. Because of its shallow depth, the test well will not have a DHS-approved 50-foot annular seal and thus is anticipated to be viewed as a surface water supply, like the existing Tait Wells.

We are prepared to start on the site exploration as soon as we receive your notice to proceed with this work plan; however drilling contractors normally have a back log of work. We will get on a driller's schedule as soon as possible after we receive your approval of this work plan. The site exploration is expected to last one week. We will have recommendations about the viability of proceeding with the test well within three weeks after the monitoring wells have been sampled.

If you have any questions or require additional information, please call me at (916) 341-7447 (office) or (916) 417-7687 (cell).

Sincerely,

Lawrence H. Ernst

PROFESSIONAL GEOLOGIST
LAWRENCE H. ERNST
No. 390
CERTIFIED
HYDROGEOLOGIST
STATE OF CALIFORNIA

Lawrence H. Ernst, PG, CEG, CHG
Senior Hydrogeologist

Enclosures

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0 Feet 50 Feet

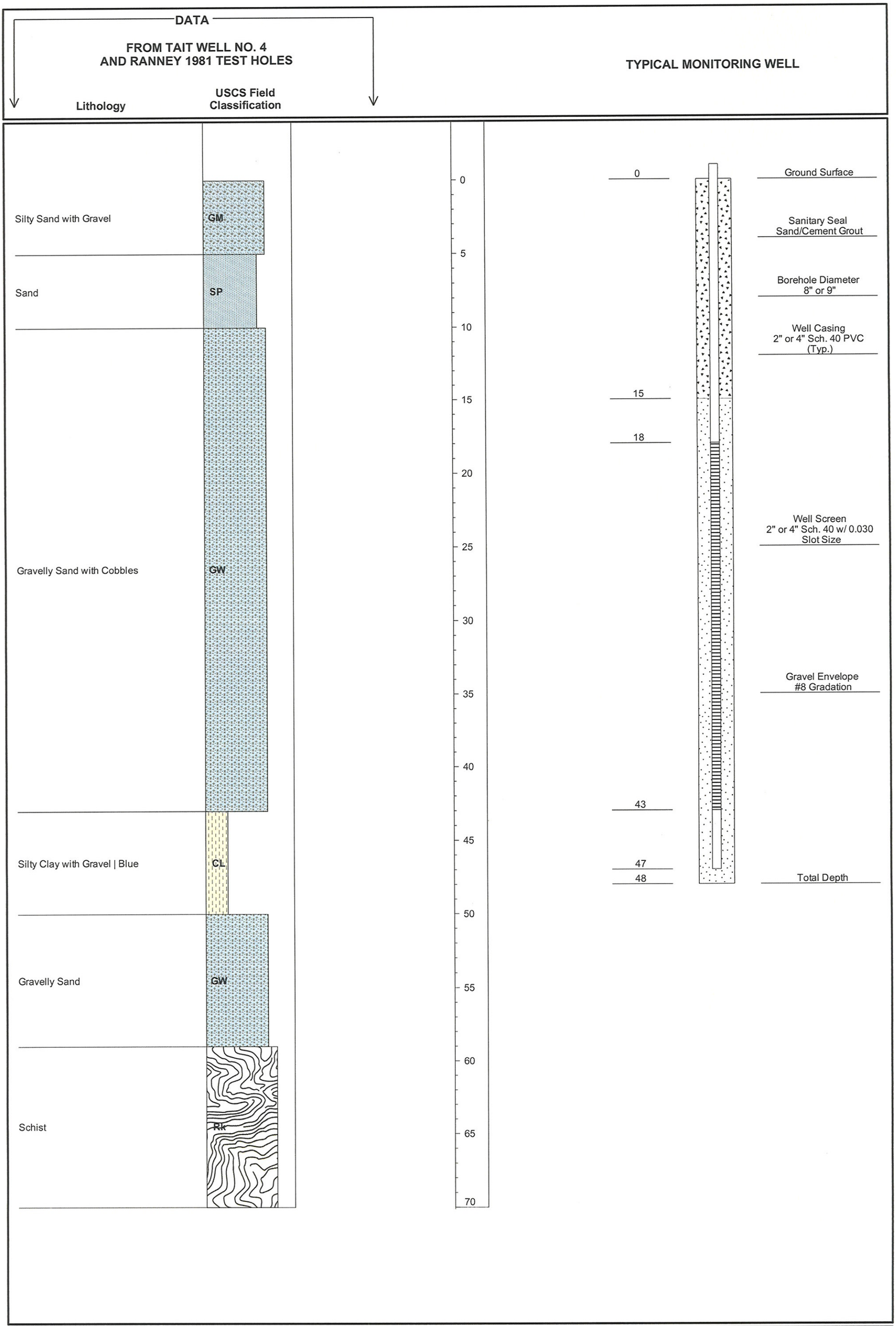
Proposed Test Well Location

New Monitoring Well Location

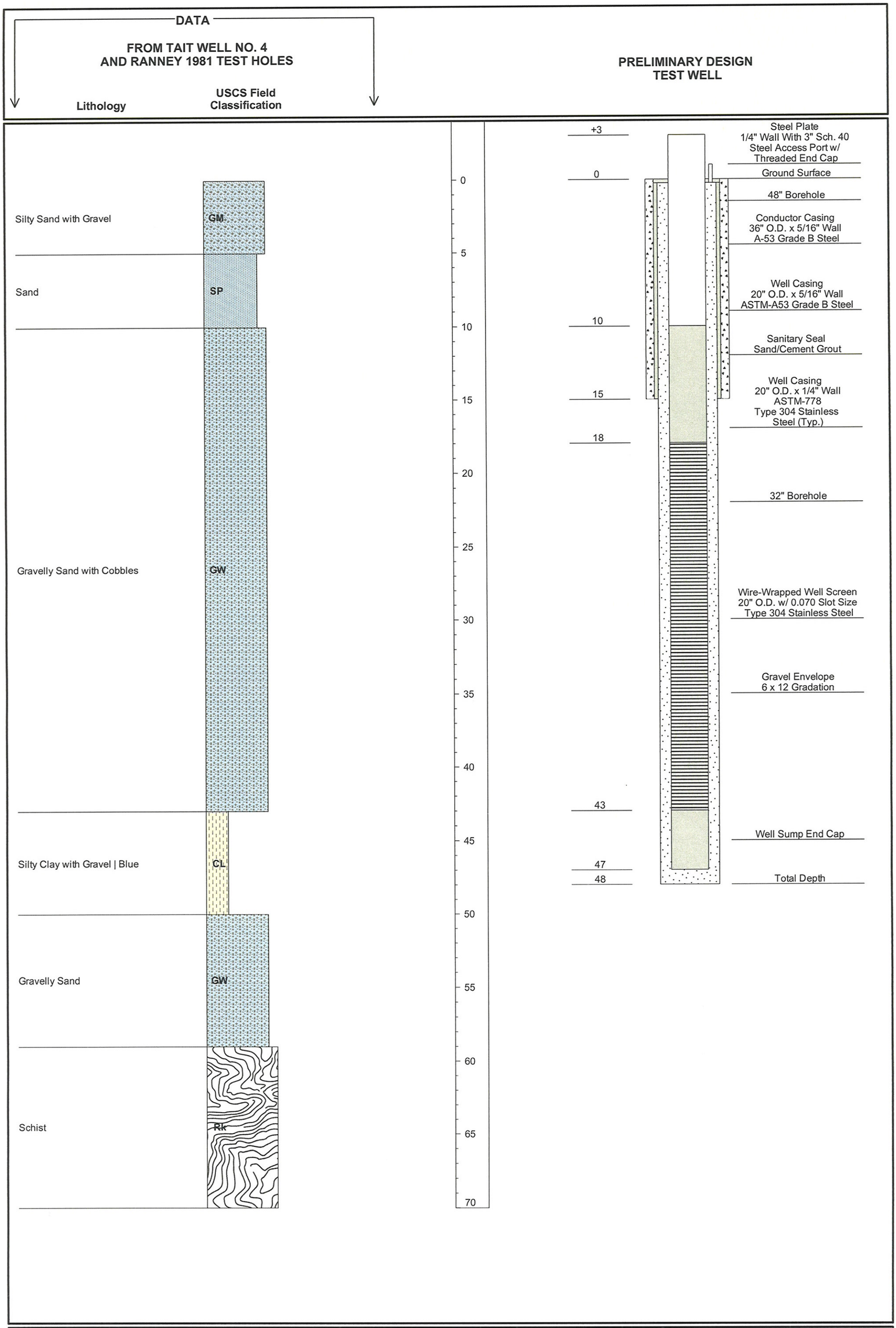
Source: Aerial Image, Google Maps

Figure 1
Santa Cruz Water Department
Tait Street Diversion
Well Location Map

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS



PROJECT NO. 8262.002	MONITORING WELL	WOOD RODGERS	DATE: 5/1/07 10:19	J:\Jobs\8262-Santa Cruz Water Dept\8262.002 Tait Sanding Study\Groundwater\Records
FIGURE 2	**SANTA CRUZ TAIT STUDY**	DEVELOPING INNOVATIVE DESIGN SOLUTIONS	SCALE: V: 1" = 3'	
	SANTA CRUZ, CA	3301 C Street, Bldg. 100-B Tel: 916.341.7760 Sacramento, CA 95816 Fax: 916.341.7767	DRAWN BY: S. SPAETH	
			DESIGNED BY: L. ERNST	
			CHECKED BY: L. ERNST	NO. DESCRIPTION ENGR. INIT BY APPROVED DATE



PROJECT NO. 8262.002	TEST WELL	WOOD RODGERS	DATE: 5/1/07 10:16
FIGURE 3	SANTA CRUZ TAIT STUDY	DEVELOPING INNOVATIVE DESIGN SOLUTIONS	SCALE: V: 1" = 3'
	SANTA CRUZ, CA	3301 C Street, Bldg. 100-B Sacramento, CA 95816 Tel: 916.341.7760 Fax: 916.341.7767	DRAWN BY: S. SPAETH
			DESIGNED BY: L. ERNST
			CHECKED BY: K. VENTON

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NO.	DESCRIPTION	ENGR. INIT	BY	DATE
			APPROVED	

WOOD RODGERS

October 9, 2007
Job No. 8262.002

Ms. Dawn Smithson
City of Santa Cruz Water Department
809 Center Street, Room 102
Santa Cruz, CA 95060

Dear Ms. Smithson:

Subject: City of Santa Cruz – Riverbank Infiltration Well Site Exploration, Findings and Recommendations

In accordance with our contract addendum with the City of Santa Cruz (City), Wood Rodgers, Inc. is pleased to submit this letter report detailing the site exploration for riverbank infiltration wells. Wood Rodgers has completed the exploratory drilling program, which included two of the three planned monitoring wells described in the July 5, 2007 revised work plan. The third, Tait-2007B, was attempted; however, significant debris was encountered eight feet below ground surface (bgs), and drilling could not proceed at that site. The result of the exploratory drilling program is described below and includes a description of the lithology, monitoring well construction summaries, and water quality results. At the conclusion of the monitoring well construction, water levels were monitored for approximately 19 days to observe if pumping of nearby wells influenced the water levels.

Site Exploration

WDC Exploration and Wells of Woodland, California conducted the sonic exploratory drilling and coring. Drilling commenced on August 17, 2007, at the Tait Street well site. The first exploration borehole was Tait MW-2007A as shown in Figure 1. The test hole encountered mostly sand and gravel from the ground surface to a depth of 45 feet bgs, with the exception of a 2-foot brown clay layer from 18 to 20 feet bgs, and a 6-foot blue clayey silt layer from 35 to 41 feet bgs as shown in Figure 2. On August 18, a 2-inch diameter PVC monitoring well was installed in the test hole, with a perforated interval from 18.7 to 33.7 feet bgs, also shown in Figure 2.

On August 18, the drilling rig was moved to the Tait MW-2007B site, on the southwest corner of the Tait Street well site. The test hole was terminated at 8 feet bgs when steel plating was cored. The City did not have records of the underground facilities in this area. Therefore, the Tait MW-2007B site exploration was canceled and the drilling rig proceeded to the Ocean Street MW site.

The exploratory borehole at the Ocean Street site was drilled to a total depth of 73 feet bgs. Bedrock was encountered at a depth of 70 feet bgs. A 4-inch diameter PVC monitoring well was installed to a depth of 65.4 feet bgs, with perforated intervals from 20 to 40 feet and 50 to 65 feet bgs as shown in Figure 3.

Monitoring Well Development and Water Quality

The Tait MW-2007A and the Ocean Street MW were developed and sampled on August 21, 2007. Table 1 contains the results of the laboratory water quality analysis. The results indicate that the water from the Tait MW-2007A and the Ocean Street MW meet the Title 22 general mineral and inorganic primary and secondary drinking water standards, with the exception of manganese, which was over the maximum contaminant level (MCL) at the Ocean Street site. The wells were also sampled for volatile organic compounds by EPA method 524.2. Chloroform and toluene were detected at levels under the MCL. These constituents were likely trace amounts introduced during the well drilling or sampling. Chloroform trace amounts are probably the result of adding water during the well construction process. Toluene can likely be attributed to lubricants used on the tool joints on the drill pipe or pump column pipe.

Water Level Data

At the conclusion of the monitoring well sampling, pressure transducers were installed in Tait MW-2007A and the Ocean Street MW to monitor water levels. Data was collected from August 23, 2007 to September 10, 2007. The water levels for Tait MW-2007A and the Ocean Street MW are shown in Figures 4 and 5, respectively. Tait Wells 1 and 4 were pumping when the transducers were installed. The water level in Tait MW-2007A remained between 15.6 and 15.8 feet bgs, with Tait Wells 1 and 4 pumping. On August 31, 2007, Tait Wells 1 and 4 were turned off for a period of 12 hours. During the 12-hour shut down, the water level in Tait MW-2007A recovered by approximately 1.2 feet. On September 4, 2007, the pump motor for Well 1 failed and pumping from Well 1 did not resume for the remainder of the test period. When the pump motor failed in Well 1, the water level recovered approximately one foot over a period of six days. This data suggests that there is a small amount of hydraulic connection between Wells 1 and 4 and the Tait MW-2007A; however, there is likely less than three feet of pumping influence from the pumping of Tait Wells 1 and 4 on the shallow aquifer as monitored at Tait MW-2007A.

At the Ocean Street MW, the water levels remained between 15.6 to 15.9 feet bgs for the duration of the 19-day test. A very slight amount (0.1 feet) of water level increase was observed over the test duration. There did not appear to be any other wells in this area influencing the water levels in the Ocean Street MW during the test period.

Test Well Development

At the Tait Street well site, a test well could be constructed with a perforated interval from 20 to 35 feet bgs, which would likely be able to produce between 200 and 350 gallons per minute (gpm). This capacity takes into consideration the mutual pumping interference from Wells 1 and 4, and the limited available drawdown for this very shallow well. The recommended test well design is shown in Figure 6.

At the Ocean Street well site, there appears to be the potential to construct a well that could produce 400 to 700 gpm. Figure 7 illustrates a preliminary production well design.

The well designs represented in Figures 6 and 7 are riverbank infiltration wells, not groundwater supply wells, due to the lack of the required 50-foot sanitary seals. The water produced from either of these structures would require treatment at the City's surface water treatment plant prior to meeting potability standards.

During production well development at either site, it will be necessary to dispose of turbid water. It is anticipated that a small amount of very turbid water, greater than 100 nephelometric turbidity units (NTU), could be disposed of at either site; however, for the 200,000 to 300,000 gallons of slightly turbid water, less than 100 NTU, produced during well development, pumping to a sanitary sewer is a preferred method. A second option would be treating to lower turbidity prior to discharge to the San Lorenzo River (River). It is possible that if the wells were drilled in winter when the turbidity levels in the River are high, treatment would not be necessary. At the Tait Street well site, it may be possible to pump the clean testing water across the river to the wet wells if permission can be obtained from the California Department of Public Health.

Conclusions

At the Tait well site, a shallow riverbank infiltration well could likely be constructed to produce 200 to 350 gpm with only slight impact to the existing Tait Wells 1 and 4. Water produced from the test well would focus on the shallow water under the San Lorenzo River, which may not be in direct connection with the River due to a 2-foot thick clay layer 20 feet bgs.

At the Ocean Street well site, a shallow riverbank infiltration well could likely be constructed to a depth of approximately 70 feet bgs that should be able to produce 400 to 700 gpm. There do not appear to be any other wells in this shallow aquifer in the vicinity of the Ocean Street MW.

Water produced from either site would likely meet all Title 22 water quality requirements, with the exception of manganese. This water would be considered surface water and would require treatment at the City's surface water treatment plant prior to distribution.

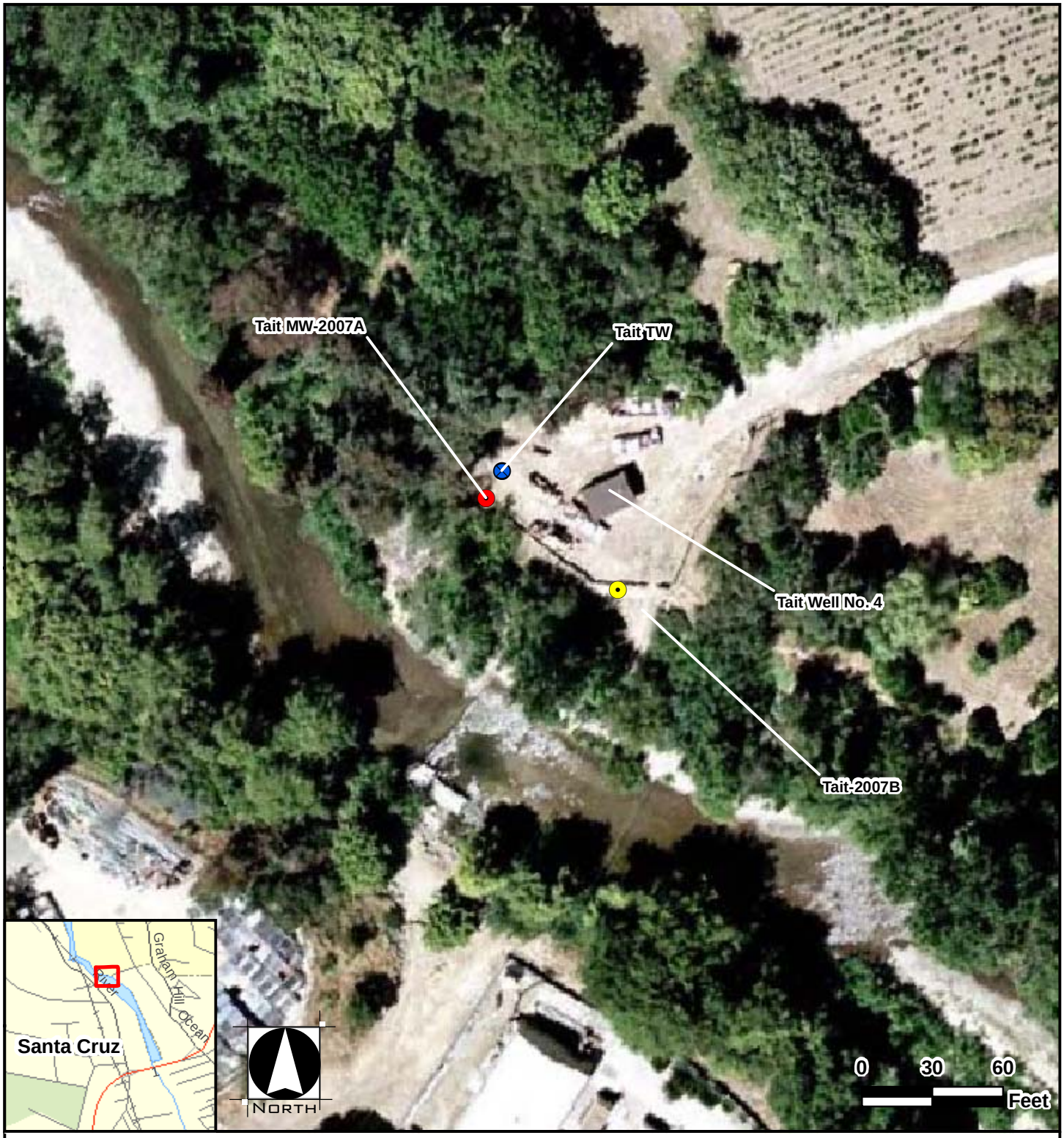
We look forward to moving forward with the test well if the City wishes to pursue it at this time and the water discharge issues can be resolved. If not, Wood Rodgers will proceed with final report preparation for the Tait Street Diversion Sanding Study.

Sincerely,

Lawrence H. Ernst

Lawrence H. Ernst, PG, CEG, CHG
Senior Hydrogeologist

PROFESSIONAL GEOLOGIST
LAWRENCE H. ERNST
No. 390
CERTIFIED
HYDROGEOLOGIST
STATE OF CALIFORNIA



Legend

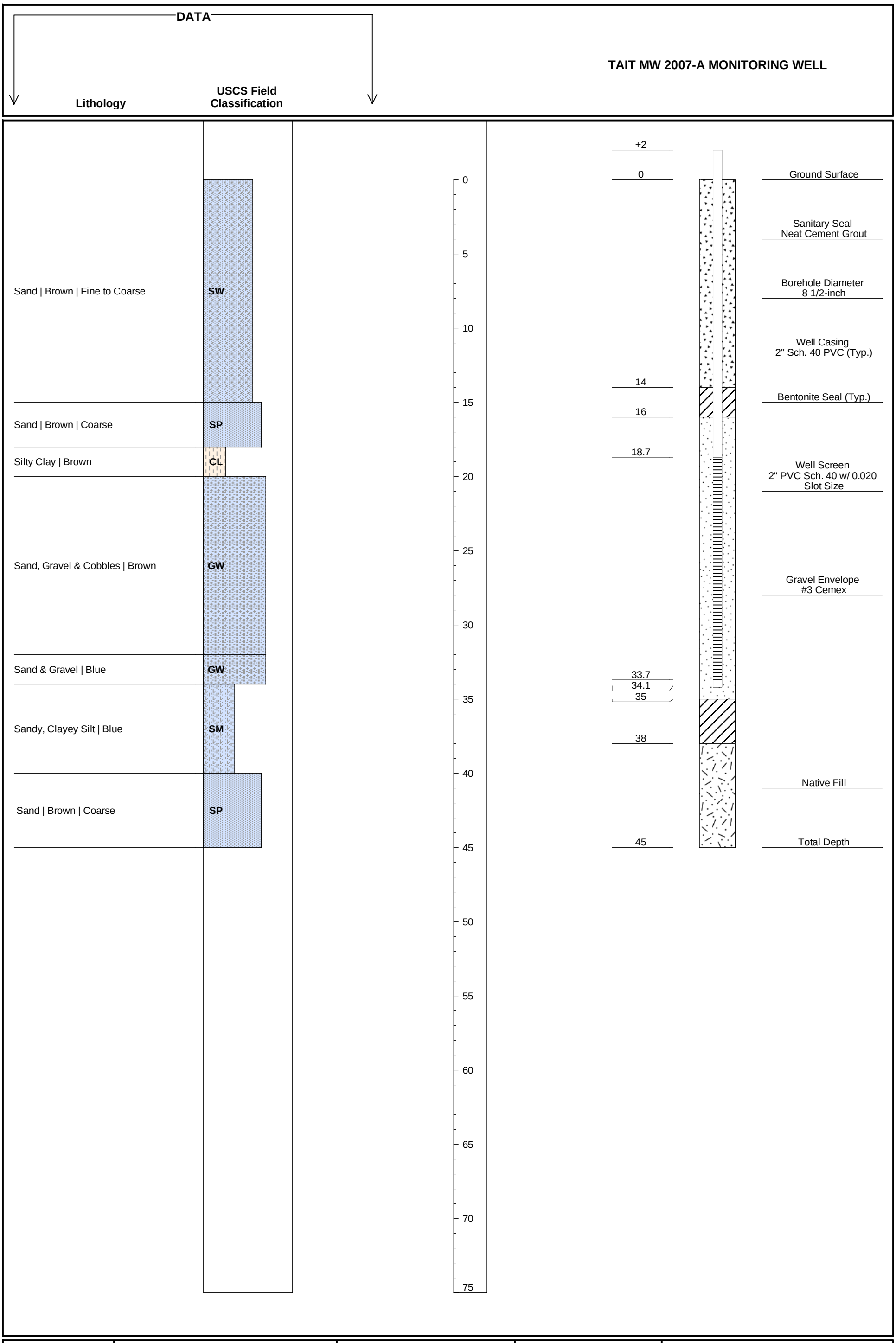
- Abandoned Test Hole Tait-2007B
- Monitoring Well Tait MW-2007A
- Proposed Test Well

Figure 1
Santa Cruz Water Department
Tait Well Location Map

Source: Google Earth, StreetMap USA

3301 C St, Bldg. 100-B
Sacramento, CA 95816
Tel 916.341.7760
Fax 916.341.7767
WOOD RODGERS

J:\Jobs\8262-Santa Cruz Water Dept\8262.002 Tait Sanding Study\Groundwater\GIS\Figure 1 Well Location Map.mxd



PROJECT NO. 8262.002	MONITORING WELL PROFILE	WOOD RODGERS DEVELOPING INNOVATIVE DESIGN SOLUTIONS 3301 C Street, Bldg. 100-B Sacramento, CA 95816 Tel: 916.341.7760 Fax: 916.341.7767	DATE: 10/4/07 12:49	J:\Jobs\8262-Santa Cruz Water Dept\8262.002 Tait Sanding Study\Groundwater\Records
FIGURE 2	**CITY OF SANTA CRUZ**		SCALE: V: 1" = 3'	
	SANTA CRUZ, CA		DRAWN BY: B.DEMUCHA	
			DESIGNED BY: L. ERNST	
			CHECKED BY: L.ERNST	NO. DESCRIPTION ENGR. INIT BY APPROVED DATE

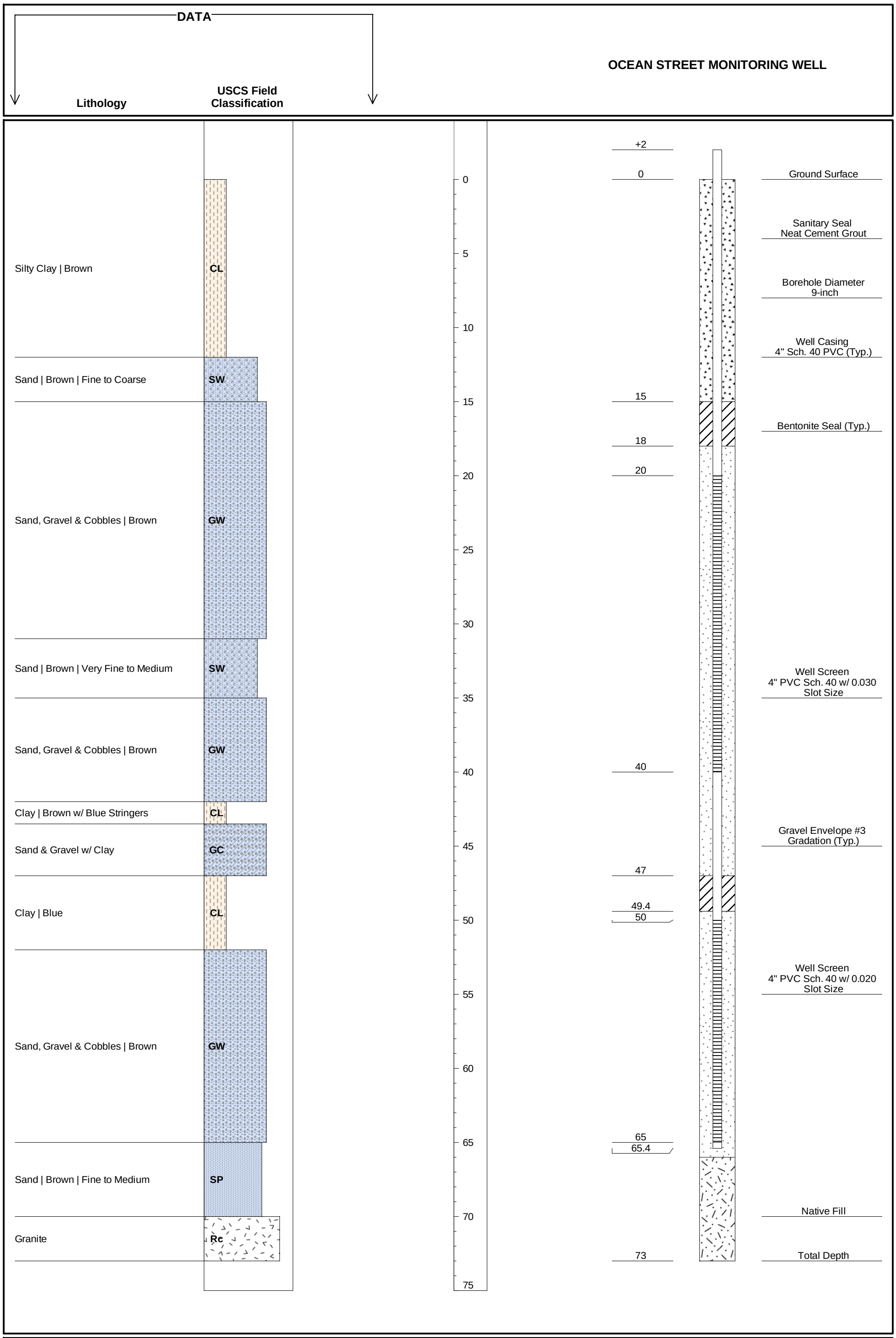


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FIGURE 3	**CITY OF SANTA CRUZ**	DEVELOPING INNOVATIVE DESIGN SOLUTIONS	SCALE: V: 1" = 3'	NO. / DESCRIPTION / ENGR. INIT / BY / DATE / APPROVED
	SANTA CRUZ, CA	3301 C Street, Bldg. 100-B Sacramento, CA 95816 Tel: 916.341.7760 Fax: 916.341.7767	DRAWN BY: B.DEMUCHA	
			DESIGNED BY: L. ERNST	
			CHECKED BY: L.ERNST	

Figure 4
Depth to Groundwater
City of Santa Cruz Tait Monitoring Well 2007-A

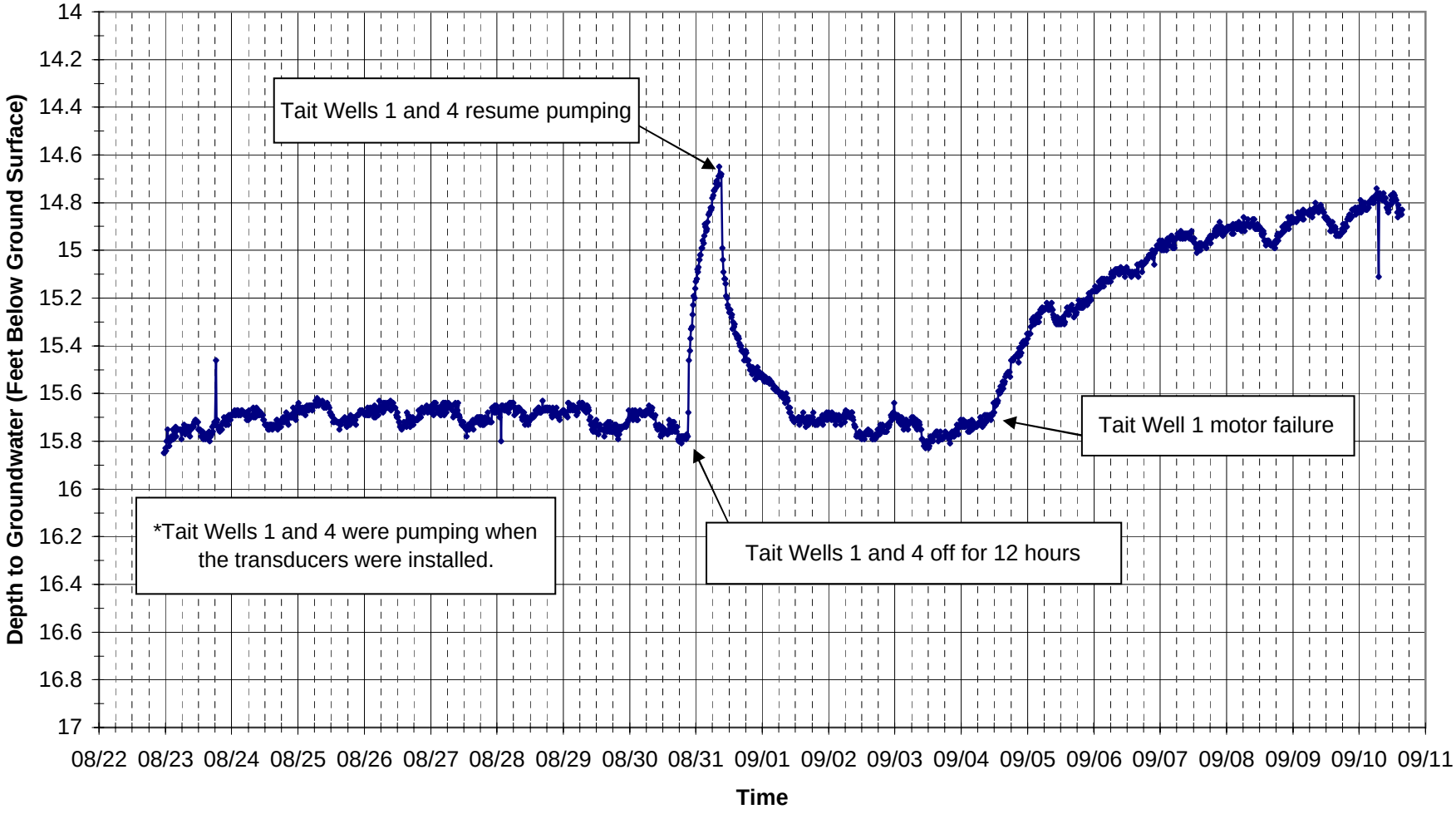
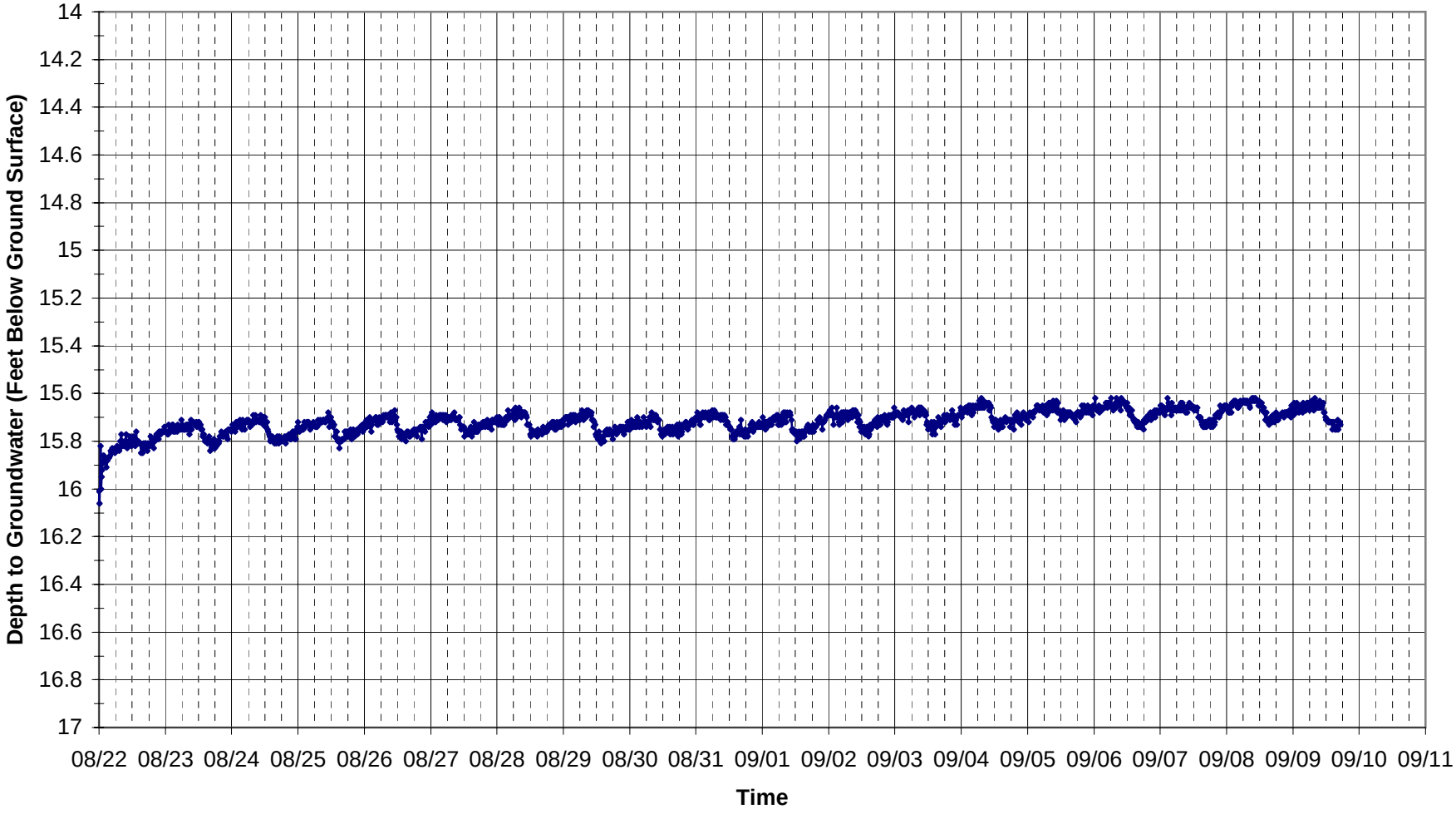
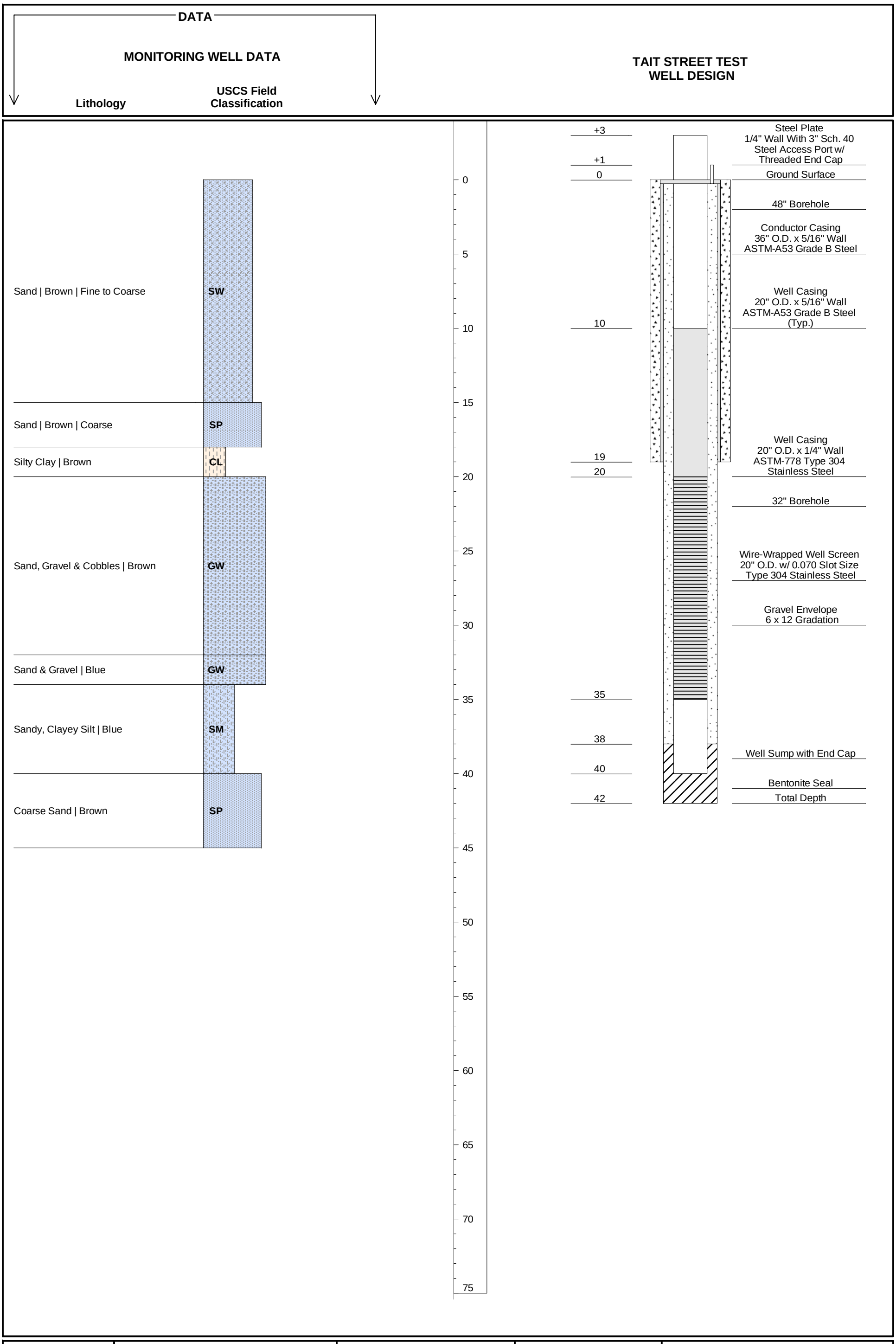


Figure 5
Depth to Groundwater
City of Santa Cruz Ocean Street Monitoring Well





PROJECT NO. **8262.002**	TEST WELL DESIGN	WOOD RODGERS	DATE: **10/4/07 10:02**
FIGURE 6	**SANTA CRUZ TAIT STUDY**	DEVELOPING INNOVATIVE DESIGN SOLUTIONS	SCALE: V: **1" = 3'**
	SANTA CRUZ, CA	3301 C Street, Bldg. 100-B Sacramento, CA 95816 Tel: 916.341.7760 Fax: 916.341.7767	DRAWN BY: **S. SPAETH**
			DESIGNED BY: **L. ERNST**
			CHECKED BY: **K. VENTON**

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NO.	DESCRIPTION	ENGR. INIT	BY	DATE
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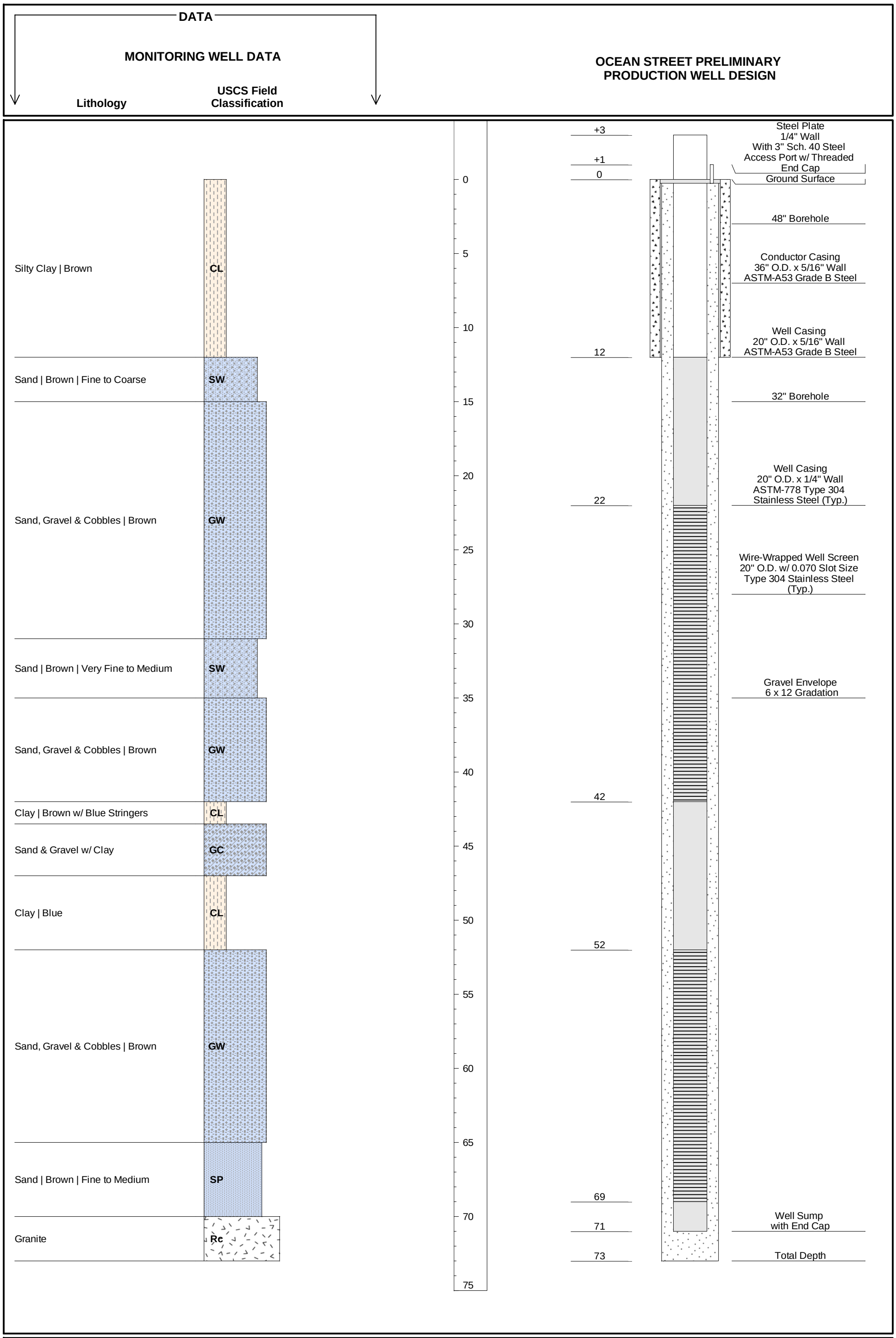

PROJECT NO. 8262.002	PRELIMINARY PRODUCTION WELL DESIGN	WOOD RODGERS DEVELOPING INNOVATIVE DESIGN SOLUTIONS 3301 C Street, Bldg. 100-B Sacramento, CA 95816 Tel: 916.341.7760 Fax: 916.341.7767	DATE: 10/4/07 12:57	J:\Jobs\8262-Santa Cruz Water Dept\8262.002 Tait Sanding Study\Groundwater\Records
FIGURE 7	**SANTA CRUZ TAIT STUDY**		SCALE: V: 1" = 3'	
	SANTA CRUZ, CA		DRAWN BY: S. SPAETH	
			DESIGNED BY: L. ERNST	
			CHECKED BY: K. VENTON	NO. / DESCRIPTION / ENGR. INIT / BY / DATE / APPROVED

TABLE 1
SUMMARY OF WATER QUALITY RESULTS

City of Santa Cruz Ocean St. MW-2007-D Sample Date: 8/22/2007	Notification Level	Primary MCL	Regulatory Action Level	Secondary MCL	Units	Result	Exceeds MCL
GENERAL MINERAL							
Bicarbonate Alkalinity (as CaCO3)					mg/l	150	☐
Calcium					mg/l	56	☐
Carbonate Alkalinity (as CaCO3)					mg/l	<5	☐
Chloride				250/500/600	mg/l	36	☐
Fluoride		2.0			mg/l	0.14	☐
Foaming Agents (MBAs)				0.5	mg/l	<0.1	☐
Hardness (as CaCO3)					mg/l	180	☐
Hydroxide Alkalinity (as CaCO3)					mg/l	<5	☐
Magnesium					mg/l	10	☐
Nitrate (as NO3)		45			mg/l	<2	☐
Potassium					mg/l	3.3	☐
Sodium					mg/l	33	☐
Sulfate				250/500/600	mg/l	42	☐
Total Alkalinity (as CaCO3)					mg/l	150	☐
GENERAL PHYSICAL							
Color				15	color units	<1	☐
Odor - Threshold				3	TON	<1	☐
pH					pH units	6.39	☐
Specific Conductance				900/1600/2200	umhos/cm	450	☐
Total Dissolved Solids				500/1000/1500	mg/l	280	☐
Turbidity				5	NTU	0.79	☐
INORGANICS							
Aluminum		1000		200	ug/l	<50	☐
Antimony		6			ug/l	<6	☐
Arsenic		10			ug/l	<2	☐
Barium		1000			ug/l	<100	☐
Beryllium		4			ug/l	<1	☐
Boron	1000				ug/l	<100	☐
Cadmium		5			ug/l	<1	☐
Chromium		50			ug/l	<10	☐
Copper			1300	1000	ug/l	<50	☐
Iron				300	ug/l	150	☐
Iron (Filtered)					ug/l	140	☐
Lead			15		ug/l	<5	☐
Manganese	500			50	ug/l	160	☑
Manganese (Filtered)	500			50	ug/l	160	☑
Mercury		2			ug/l	<1	☐
Nickel		100			ug/l	<10	☐

Note: " MCL" is the Maximum Contaminant Level established by the California Department of Health Services. Multiple values for MCL represent trigger levels or recommended/upper ranges.

TABLE 1
SUMMARY OF WATER QUALITY RESULTS (Continued)

City of Santa Cruz Ocean St. MW-2007-D Sample Date: 8/22/2007	Notification Level	Primary MCL	Regulatory Action Level	Secondary MCL	Units	Result	Exceeds MCL
INORGANICS							
Selenium		50			ug/l	<5	☐
Silver				100	ug/l	<10	☐
Thallium		2			ug/l	<1	☐
Vanadium	50				ug/l	<3	☐
Zinc				5000	ug/l	<50	☐
VOLATILE ORGANIC CHEMICALS							
Chloroform					ug/l	0.74	☐
Toluene		150			ug/l	0.86	☐

Note: " MCL" is the Maximum Contaminant Level established by the California Department of Health Services. Multiple values for MCL represent trigger levels or recommended/upper ranges.

TABLE 1
SUMMARY OF WATER QUALITY RESULTS (Continued)

City of Santa Cruz Ocean St. MW-2007-S Sample Date: 8/22/2007	Notification Level	Primary MCL	Regulatory Action Level	Secondary MCL	Units	Result	Exceeds MCL
GENERAL MINERAL							
Bicarbonate Alkalinity (as CaCO3)					mg/l	140	☐
Calcium					mg/l	57	☐
Carbonate Alkalinity (as CaCO3)					mg/l	<5	☐
Chloride				250/500/600	mg/l	37	☐
Fluoride		2.0			mg/l	0.14	☐
Foaming Agents (MBAs)				0.5	mg/l	<0.1	☐
Hardness (as CaCO3)					mg/l	180	☐
Hydroxide Alkalinity (as CaCO3)					mg/l	<5	☐
Magnesium					mg/l	10	☐
Nitrate (as NO3)		45			mg/l	<2	☐
Potassium					mg/l	3.2	☐
Sodium					mg/l	33	☐
Sulfate				250/500/600	mg/l	43	☐
Total Alkalinity (as CaCO3)					mg/l	140	☐
GENERAL PHYSICAL							
Color				15	color units	<1	☐
Odor - Threshold				3	TON	<1	☐
pH					pH units	6.4	☐
Specific Conductance				900/1600/2200	umhos/cm	470	☐
Total Dissolved Solids				500/1000/1500	mg/l	290	☐
Turbidity				5	NTU	0.55	☐
INORGANICS							
Aluminum		1000		200	ug/l	<50	☐
Antimony		6			ug/l	<6	☐
Arsenic		10			ug/l	<2	☐
Barium		1000			ug/l	<100	☐
Beryllium		4			ug/l	<1	☐
Boron	1000				ug/l	<100	☐
Cadmium		5			ug/l	<1	☐
Chromium		50			ug/l	<10	☐
Copper			1300	1000	ug/l	<50	☐
Iron				300	ug/l	<100	☐
Iron (Filtered)					ug/l	<100	☐
Lead			15		ug/l	<5	☐
Manganese	500			50	ug/l	100	☑
Manganese (Filtered)	500			50	ug/l	99	☑
Mercury		2			ug/l	<1	☐
Nickel		100			ug/l	<10	☐

Note: " MCL" is the Maximum Contaminant Level established by the California Department of Health Services. Multiple values for MCL represent trigger levels or recommended/upper ranges.

TABLE 1
SUMMARY OF WATER QUALITY RESULTS (Continued)

City of Santa Cruz Ocean St. MW-2007-S Sample Date: 8/22/2007	Notification Level	Primary MCL	Regulatory Action Level	Secondary MCL	Units	Result	Exceeds MCL
INORGANICS							
Selenium		50			ug/l	<5	☐
Silver				100	ug/l	<10	☐
Thallium		2			ug/l	<1	☐
Vanadium	50				ug/l	<3	☐
Zinc				5000	ug/l	<50	☐
VOLATILE ORGANIC CHEMICALS							
Chloroform					ug/l	0.5	☐

Note: " MCL" is the Maximum Contaminant Level established by the California Department of Health Services. Multiple values for MCL represent trigger levels or recommended/upper ranges.

TABLE 1
SUMMARY OF WATER QUALITY RESULTS (Continued)

City of Santa Cruz Tait MW-2007A Sample Date: 8/22/2007	Notification Level	Primary MCL	Regulatory Action Level	Secondary MCL	Units	Result	Exceeds MCL
GENERAL MINERAL							
Bicarbonate Alkalinity (as CaCO3)					mg/l	120	☐
Calcium					mg/l	48	☐
Carbonate Alkalinity (as CaCO3)					mg/l	<5	☐
Chloride				250/500/600	mg/l	27	☐
Fluoride		2.0			mg/l	0.24	☐
Foaming Agents (MBAs)				0.5	mg/l	<0.1	☐
Hardness (as CaCO3)					mg/l	160	☐
Hydroxide Alkalinity (as CaCO3)					mg/l	<5	☐
Magnesium					mg/l	8.5	☐
Nitrate (as NO3)		45			mg/l	<2	☐
Potassium					mg/l	3.3	☐
Sodium					mg/l	27	☐
Sulfate				250/500/600	mg/l	42	☐
Total Alkalinity (as CaCO3)					mg/l	120	☐
GENERAL PHYSICAL							
Color				15	color units	<1	☐
Odor - Threshold				3	TON	<1	☐
pH					pH units	7.12	☐
Specific Conductance				900/1600/2200	umhos/cm	400	☐
Total Dissolved Solids				500/1000/1500	mg/l	230	☐
Turbidity				5	NTU	<0.5	☐
INORGANICS							
Aluminum		1000		200	ug/l	<50	☐
Antimony		6			ug/l	<6	☐
Arsenic		10			ug/l	<2	☐
Barium		1000			ug/l	<100	☐
Beryllium		4			ug/l	<1	☐
Boron	1000				ug/l	100	☐
Cadmium		5			ug/l	<1	☐
Chromium		50			ug/l	<10	☐
Copper			1300	1000	ug/l	<50	☐
Iron				300	ug/l	<100	☐
Iron (Filtered)					ug/l	<100	☐
Lead			15		ug/l	<5	☐
Manganese	500			50	ug/l	24	☐
Manganese (Filtered)	500			50	ug/l	20	☐
Mercury		2			ug/l	<1	☐
Nickel		100			ug/l	<10	☐

Note: " MCL" is the Maximum Contaminant Level established by the California Department of Health Services. Multiple values for MCL represent trigger levels or recommended/upper ranges.

TABLE 1
SUMMARY OF WATER QUALITY RESULTS (Continued)

City of Santa Cruz Tait MW-2007A Sample Date: 8/22/2007	Notification Level	Primary MCL	Regulatory Action Level	Secondary MCL	Units	Result	Exceeds MCL
INORGANICS							
Selenium		50			ug/l	<5	☐
Silver				100	ug/l	<10	☐
Thallium		2			ug/l	<1	☐
Vanadium	50				ug/l	<3	☐
Zinc				5000	ug/l	<50	☐

Note: " MCL" is the Maximum Contaminant Level established by the California Department of Health Services. Multiple values for MCL represent trigger levels or recommended/upper ranges.

Preliminary Project Summary Report
Beltz Well 12-Phase 1
CWO 2010-004

Introduction: Beltz Well 12-Phase 1 consists of the drilling of an approximately 700-foot deep, 16-inch diameter drinking water supply well, with a target production rate of 210 GPM (0.3 MGD). The well head treatment facilities and system connections will be constructed in Phase 2.

Statement of the Problem: The City currently operates 3 wells, Beltz Well No. 8, 9, and 10, in the Live Oak Area, producing approximately 1 MGD, during peak pumping. In 2009, the City commissioned a study to investigate declining coastal groundwater levels in the vicinity of the existing wells. When groundwater levels drop below sea level, as a result of a localized pumping depression, or basin-wide groundwater level reduction, salt water intrusion can occur, contaminating the aquifer, and rendering it unusable.

A Study (Hopkins Groundwater Consultants, Inc, 2009b) recommended developing a new inland well, to shift pumping away from the coastal areas, to protect the Purisama Aquifer from further saltwater intrusion, and to improve the Live Oak Well system reliability and flexibility. By developing Beltz 12, the City could reduce pumping at Beltz 8, 9 and 10, to maintain protective groundwater levels. The redistributed pumping scheme allows the City to continue extracting volumes close to historic levels (520 acre-ft/year, non-critically dry year, and 645 acre-ft/year, critically dry year), while reducing the threat of salt water intrusion, and increasing system reliability and flexibility with a second treatment plant.

Background: The City's primary water supplies are surface water diversions from a collection of streams located northwest of Santa Cruz, the San Lorenzo River, and Newell Creek, also known as Loch Lomond Reservoir. The Live Oak Well Field pumps water from the Purisma aquifer, and provides approximately 5% (a long term average of approximately 520 Acre-ft per year) of the City's annual supply. Although the well field provides a relatively small portion of the overall volume supplied, it is a critical supply component because the source (groundwater) is available during the dry season, when surface water sources are less abundant. During the dry season, the Live Oak Well Field can supply between 8% to 12% of daily demand and is an increasingly important source of water to augment the City's water supply during peak demands, and drought periods.

Declining water levels in portions of the Purisma and elevated chloride levels in coastal monitoring wells indicate localized areas of salt water intrusion. Since 2005, the City has been working with SqCWD to cooperatively manage pumping in the western portions of the Purisma aquifer in an effort to reduce the threat of salt water intrusion. The City and SqCWD have installed a network of monitoring wells to characterize the

influence of pumping on groundwater levels, and to track chloride levels in the various zones of the Purisma aquifer.

Existing Facilities: Beltz Wells 8, 9, and 10 are clustered around 30th avenue between Brommer and Portola Dr. The most inland well is Well No. 10, and is approximately 4,000-feet from the coast. Each well discharges into a raw water line which feeds into a central water treatment plant (Beltz treatment plant). The plant is located adjacent to Well No 8. The treatment plant removes iron and manganese, by aeration and filtration processes, then treated water is chlorinated and injected directly into the drinking water system. The original Beltz Groundwater Treatment Plant (TP) was constructed in the early 1970's and was upgraded and expanded in the mid 1980's to its current configuration (for improved iron and manganese removal).

Deficiencies and Justification: Declining water levels in portions of the Purisma and elevated chloride levels in coastal monitoring wells indicate localized areas of salt water intrusion. Since 2005, the City has been working with SqCWD to cooperatively manage pumping in the western portions of the Purisma aquifer in an effort to reduce the threat of salt water intrusion. One goal of this management effort is to maintain groundwater levels approximately 6-feet above sea level and meeting this goal is challenging given the coastal proximity, and pump configuration of the existing wells. Each agency is constructing an inland well towards the northern terminus of 41st Ave. Constructing wells farther inland, provides for more even distribution of pumping and drawdown over the basin, reducing the occurrence of localized, and severe pumping depressions, which increase the risk of further sea water intrusion.

Beltz Wells 8, 9, and 10 pump to Beltz treatment plant. The plant and wells are operated steadily at approximately 750 GPM for the entire pumping season (approximately March to October). The wells cannot be shutdown during low demand periods to allow the aquifer to recover. If there is a mechanical issue at Beltz treatment all three wells have to be taken offline, taking the entire source out of service.

Constructing a new inland well allows the City to shift pumping inland, reduce pumping at wells in closer proximity to the coast, and maintain historic ground production rates. Unlike the existing wells, the new well will be served by it's own treatment plant which will allow for more operational flexibility (12 hour pumping cycles) and provide overall system redundancy (a second treatment system).

Proposed Project Description: An extensive siting study (Hopkins 2009) evaluated over 30 different well sites and ranked them based on 1) hydrogeological suitability, construction suitability, environmental suitability, site acquisition potential. The City selected one of the top-ranked sites (Research Park Way/Cory St) for further investigation. A preliminary drinking water source assessment, completed in 2010 determined the site was suitable for drinking water production. An EIR (Chambers Group 2011) analyzed 3 project alternatives: no project, a 700 GPM well, and a 210 GPM well. The no-project alternative was not selected because it did not achieve the project objective of shifting pumping inland. The 700-GPM well was not selected

because aquifer modeling (Hopkin's 2011) indicated there may be a reduction in base flow of Soquel Creek, when operated in tandem with the nearby O'Neil Ranch Well. The 210 GPM, 700-foot deep project alternative well was determined to be the environmentally superior alternative as a less than significant change in base flows of Soquel Creek is expected. Because it would be cost prohibitive to connect to the existing Beltz treatment plant, a new well-head treatment facility will be constructed adjacent to the well. The proposed 210 GPM well is expected to produce approximately 125 Acre-Feet or 40 million gallons annually. The anticipated pumping season is expected to be approximately 130 days per year, and would commence in April. Certification of the EIR occurred in December 2011, and the site was acquired in January 2012.

Also included in the project to meet other Water Department needs will be construction of a bulk water station.

Major Issues: Prior to Beltz 12 becoming fully operational, the following tasks must be completed or in progress

- Additional monitoring well: the Cory St Monitoring well is located immediately south of the Beltz 12 site. The deepest Corey St monitoring well is approximately 330-feet deep, and Beltz 12 is anticipated to be approximately 700 feet deep. To monitor pumping affects on the "Tu" Unit of the aquifer, therefore a new monitoring well may be necessary.
- In addition to several private wells, the O'Neil Ranch Well is located in close proximity to the Beltz 12 well. A voluntary private well monitoring program must be implemented, to determine the extent of draw down affects in nearby by wells.
- Although the EIR analyzed several impacts, no mitigation measures were identified. The City will partner with SqCWD to monitor Soquel Creek, to determine what affects, if any, the new wells have on creek base flows.
- A final drinking water sources assessment will be completed and approved by California Department of Public Health prior to connecting the Beltz 12 treatment plant to the City system.

Project Costs:

Preliminary design and investigation costs:	$90,000
Design costs (consultant contract?)	$60,000
Property acquisition	$850,000
Environmental work	$13,000
Construction contract costs	$2,000,000
Construction management contract costs	$20,000
Inspection costs	$30,000
Utility Fees	$30,000
Total	**$3,100,000**

Schedule Milestones:

- Complete Design of Well: 06/2012
- Construct Well: 11/2012
- Complete Design of Well Treatment Facilities: 05/2013
- Construction Well Treatment Facilities: 12/2013

Project Summary Report
Beltz Well 12-Phase 2
CWO 2010-004

Introduction: The Beltz Well 12-Phase 2 project consists of design and construction of a well-head treatment plant and other site improvements necessary to deliver approximately 125 Acre-Feet of treated water over a four month pumping season. A 640-foot deep, 16-inch diameter drinking water supply well, was designed and constructed in Phase 1.

Statement of the Problem: The City currently operates 3 wells, Beltz Well No. 8, 9, and 10, in the Live Oak Area, producing approximately 1 MGD, during peak pumping. In 2009, the City commissioned a study to investigate declining coastal groundwater levels in the vicinity of the existing wells. When groundwater levels drop below sea level, as a result of a localized pumping depression, or basin-wide groundwater level reduction, salt water intrusion can occur, contaminating the aquifer, and rendering it unusable.

A Study (Hopkins Groundwater Consultants, Inc, 2009b) recommended developing a new inland well, to shift pumping away from the coastal areas, to protect the Purisama Aquifer from further saltwater intrusion, and to improve the Live Oak Well system reliability and flexibility. By developing Beltz 12, the City may reduce pumping at Beltz 8, 9 and 10, to maintain protective groundwater levels. The redistributed pumping scheme allows the City to continue extracting volumes close to historic levels (520 acre-ft/year, non-critically dry year, and 645 acre-ft/year, critically dry year), while reducing the threat of salt water intrusion, and increasing system reliability and flexibility with a second treatment plant.

Background: The City's primary water supplies are surface water diversions from a collection of streams located northwest of Santa Cruz, the San Lorenzo River, and Newell Creek, also known as Loch Lomond Reservoir. The Live Oak Well Field pumps water from the Purisma aquifer, and provides approximately 5% (a long term average of approximately 520 Acre-ft per year) of the City's annual supply. Although the well field provides a relatively small portion of the overall volume supplied, it is a critical supply component because the source (groundwater) is available during the dry season, when surface water sources are less abundant. During the dry season, the Live Oak Well Field can supply between 8% to 12% of daily demand and is an increasingly important source of water to augment the City's water supply during peak demands, and drought periods. Additionally, the wells maintain

Declining water levels in portions of the Purisma and elevated chloride levels in coastal monitoring wells indicate localized areas of salt water intrusion. Since 2005, the City has been working with Soquel Creek Water District (SqCWD) to cooperatively manage pumping in the western portions of the Purisma aquifer in an effort to reduce the threat of salt water intrusion. The City and SqCWD have installed a network of monitoring

wells to characterize the influence of pumping on groundwater levels, and to track chloride levels in the various zones of the Purisma aquifer.

Existing Facilities: Beltz Wells 8, 9, and 10 are clustered around 30th avenue between Brommer and Portola Dr. The most inland well is Well No. 10, and is approximately 4,000-feet from the coast. Each well discharges into a raw water line which feeds into a central water treatment plant (Beltz treatment plant). The plant is located adjacent to Well No 8. The treatment plant removes iron and manganese, by aeration and filtration processes, then treated water is chlorinated and injected directly into the drinking water system. The original Beltz Groundwater Treatment Plant (TP) was constructed in the early 1970's and was upgraded and expanded in the mid 1980's to its current configuration (for improved iron and manganese removal).

Deficiencies and Justification: Declining water levels in portions of the Purisma and elevated chloride levels in coastal monitoring wells indicate localized areas of salt water intrusion. Since 2005, the City has been working with SqCWD to cooperatively manage pumping in the western portions of the Purisma aquifer in an effort to reduce the threat of salt water intrusion. One goal of this management effort is to maintain groundwater levels approximately 6-feet above sea level and meeting this goal is challenging given the coastal proximity, and pump configuration of the existing wells. Each agency is constructing an inland well towards the northern terminus of 41st Ave. Constructing wells farther inland, provides for more even distribution of pumping and drawdown over the basin, reducing the occurrence of localized, and severe pumping depressions, which increase the risk of further sea water intrusion.

Beltz Wells 8, 9, and 10 pump to Beltz treatment plant. The plant and wells are operated steadily at approximately 750 GPM for the entire pumping season (approximately March to October). The wells cannot be shutdown during low demand periods to allow the aquifer to recover. If there is a mechanical issue at Beltz treatment all three wells have to be taken offline, taking the entire source out of service.

Constructing a new inland well allows the City to shift pumping inland, reduce pumping at wells in closer proximity to the coast, and maintain historic ground production rates. Unlike the existing wells, the new well will be served by it's own treatment plant which will allow for more operational flexibility (such as 12 hour pumping cycles) and provide overall system redundancy (a second treatment system).

Proposed Project Description: An extensive siting study (Hopkins 2009) evaluated over 30 different well sites and ranked them based on 1) hydrogeological suitability, construction suitability, environmental suitability, site acquisition potential. The City selected one of the top-ranked sites (Research Park Way/Cory St) for further investigation. A preliminary drinking water source assessment, completed in 2010 determined the site was suitable for drinking water production. An EIR (Chambers Group 2011) analyzed 3 project alternatives: no project, a 700 GPM well, and a 210 GPM well. The no-project alternative was not selected because it did not achieve the project objective of shifting pumping inland. The 700-GPM well was not selected

because aquifer modeling (Hopkin's 2011) indicated there may be a reduction in base flow of Soquel Creek, when operated in tandem with the nearby O'Neill Ranch Well. The 210 GPM, 700-foot deep "project alternative" well was determined to be the environmentally superior alternative as a less than significant change in base flows of Soquel Creek was predicted in the modeling. Certification of the EIR occurred in December 2011, and the ¾ acre site at 2750 Reasearch Park Dr. ,Soquel, CA was acquired in January 2012.

Because it would be cost prohibitive to connect to the existing Beltz treatment plant, a new well-head treatment facility will be constructed adjacent to the well. The proposed well is expected to produce approximately 125 Acre-Feet or 40 million gallons annually. The anticipated pumping season is expected to be approximately 135 days per year, corresponding with May to September.

Phase 1: **Design and Construct Well**

Pueblo Water Resources, Ventura CA, was selected to provide hydrogeological consulting services to finalize the design of well, casing, filter pack, and drilling method. The well design was finalized in June, and bids were solicited to construct the well in July. Bids were received in August, and a contract to drill the well was awarded to Maggiora Brothers Drilling Inc, of Watsonville, CA in the amount of $500,000. Construction of well started mid-September was completed mid-October. The Beltz Well 12, as completed is approximately 640-feet deep, and screened over the Pursima, A, AA and Santa Margarita (SM or Tu) zones. Water production rates are anticipated to be very similar to the O'Neill Ranch Well, which produced approximately 800 GPM without dropping water levels below the top screen. During pump testing, water samples will be collected to determine the physical and chemical characteristics of the water for purposes of selecting and sizing the appropriate iron and manganese removal system, and to confirm the absence of any inorganic constituents such a arsenic, chromium, or any radionuclides. After completion of the pump testing, the test pump will be removed, and the well head will be secured, until construction of the Phase 2 site improvements commences.

Phase 2: Design and Construction of Well-head Treatment Plant

Design: (8-Months) The second phase of the project includes the following design tasks: additional survey and geotechnical investigation, evaluation of various treatment methods, and preparation of design documents to provide a fully operational well head treatment facility. An RFP for consultant design services was issued in August, 2012. Luhdorf and Scalmanini Consulting Engineers (LSCE) of Woodland, CA was selected out of seven proposing firms. LSCE will prepare a basis of design, design drawings and specifications, assist with bidding and construction, system inspection and startup, and preparation of a technical report to be submitted to CDPH upon completion of construction, and prior to bringing the facility online.

System Sizing and Operational Considerations: There are several parameters and constraints which will influence design and operation of the Beltz Well 12, and must be considered as part of the Phase 2 design process.

The well will only be operated in dry and critically dry years, for a maximum of 135-days from approximately May to September. The well will be in-active for the remainder of the time, however it will require regular flushing and maintenance to prevent accumulation of biological growth in the well, and seizing/locking of pumps, valves and controllers. Provisions for flushing, disinfection, and exercising will be included in the design.

The Stream flow and Impact analysis prepared by Hopkin's for the EIR analyzed a 210 GPM pumping rate 24 hour per day, 7 days a week, for 135 days, equating to 125 Acre feet of production, and concluded at a pumping rate of 210 GPM, there was a *less than significant impact* on Soquel Creek. Sizing the well pump and treatment plant for 210 GPM capacity would be a mistake because future operational preferences or production needs may require the treatment plant to operate closer to what the well is capable of producing (est. 800 GPM). The City currently operates wells 24/7 during the pumping season. If Beltz 12 were operated 24/7, then the well would need to produce a maximum of 210 GPM, however, agencies commonly operate wells on a 12 hours-on 12 hours-off cycle to allow for groundwater level recovery. If Beltz 12 were operated on a 12/12 basis over a 135 day pumping season, the well and treatment plant would need to be sized for 420 GPM.

The stream flow modeling prepared by Hopkins will be supplemented by the Soquel Creek Stream flow monitoring program, to understand how pumping by both O'Neill and Beltz 12 affect base flows. If the impacts observed are less than those modeled, the City may be able increase or further redistribute some of its coastal groundwater production to Beltz 12, which would result in a production rate greater than 210 GPM. The well pump and treatment system will be sized for the peak sustainable yield (est. 800 GPM). The incremental extra costs of over-sizing the treatment system initially are justified by the added operational flexibility, and the ability to increase production in the future.

Construction Narrative: (1-year) The scope of construction includes demolition and removal of the existing chain link fence surrounding the property, rough grading to provide proper drainage in the vicinity of the well head and site of the treatment plant facilities. Utility connections will be made to Santa Cruz County Sewer and Storm, City Water for site domestic and irrigation use, and PG&E for power. A bulk water station will be installed on Research Park Dr, to improve bulk water availability in the North-Eastern extents of the water service area. A new fence and landscaping will be constructed around the perimeter of the property, to provide visual screening and security. Two driveway entrances and gates (one automatic, one manually operated) will be provided for site access. An approximately 20-foot wide road through the site will be provided for facility access, and material delivery.

A submersible or vertical line-shaft pump will be installed on the well, and yard piping will connect the well to the filter vessels. Oxidation and removal of the iron and manganese will be accomplished through chlorine injection, and mixed media filtration. Finished water will either be directly injected into the distribution system or stored in a

clear well and pumped into the distribution system by booster pumps. Other major system components and facilities include the backwash tank, and a block house which will contain the chlorine generation equipment, all system controller cabinets, a small wet-lab for staff to collect and analyze water samples, and a restroom. Hand-holds, pull boxes, and conduit will be provided for future installation of SCADA by the Production group. Connections for a temporary generator will be provided, and a trailer mounted generator will be provided by others.

Major Issues: Prior to Beltz 12 becoming fully operational, the following tasks must be completed or in progress

- Additional monitoring well: the Cory St Monitoring well is located immediately south of the Beltz 12 site. The deepest Corey St monitoring well is approximately 330-feet deep, and Beltz 12 is anticipated to be approximately 700 feet deep. To monitor pumping affects on the "Tu" Unit of the aquifer, therefore a new monitoring well may be necessary, depending on well interference observed after startup of O'Neill Ranch and Beltz Well No. 12.
- In addition to several private wells, the O'Neil Ranch Well is located in close proximity to the Beltz 12 well. A voluntary private well monitoring program for wells within 1,000 meters of Beltz 12 and O'Neill Ranch Well will be implemented, to determine the extent of draw down affects in nearby by wells. Participants in the private well monitoring program are eligible to enroll in both SqCWD, and SCWD programs, however to avoid duplicate efforts, SqCWD will take the lead to install meters, and water level monitors on private wells in the overlapping areas of the respective programs.
- Although the EIR analyzed several impacts, no mitigation measures were identified. The City will partner with SqCWD to monitor Soquel Creek, to determine what affects, if any, the new wells have on creek base flows.
- Low Threat Discharge Permit: When offline, the well will require regular flushing. The groundwater generated during this flushing will be discharged to Rodeo Creek, via a County of Santa Cruz Storm Drain. This discharge is permitted as a "low threat discharge" by the Central Coast Regional Water Quality Control Board. An annual monitoring an compliance report will have to be prepared and submitted to the Board.
- A final drinking water sources assessment will be completed and approved by California Department of Public Health prior to connecting the Beltz 12 treatment plant to the City system.

Project Costs:

Preliminary design and investigation costs	$100,000
Property acquisition	$850,000
Phase 1-Design of Well	$90,000
Phase 1-Construct Well	$500,000
Phase 2-Design Treatment Plant	$340,000
Phase 2-Construct Treatment Plant	$2,500,000
Construction management contract costs	$200,000
Private Well and Stream Flow Monitoring	$30,000
Utility Fees	$30,000
Total	**$4,640,000**

Schedule Milestones:

- Complete Design of Well: 06/2012
- Construct Well: 11/2012
- Complete Design of Well Treatment Facilities: 08/2013
- Construction Well Treatment Facilities: 08/2014