APPENDIX B

Basis of Design Report

Brown AND Caldwell

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Technical Memorandum

FINAL

Prepared for: North Coast County Water District

Project Title: Sheila Tank Replacement

Project No.: 155221

Technical Memorandum

Subject: Basis of Design

Date: September 25, 2020

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Limitations:

This document was prepared solely for North Coast County Water District in accordance with professional standards at the time the services were performed and in accordance with the contract between North Coast County Water District and Brown and Caldwell dated May 15, 2020. This document is governed by the specific scope of work authorized by North Coast County Water District; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by North Coast County Water District and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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List of Abbreviations

AACEI	AACE International (formerly Association for the Advancement of Cost Estimating International)
ACI	American Concrete Institute
ADD	average day demand
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
BC	Brown and Caldwell
CBC	California Building Code
District	North Coast County Water District
ft	foot/feet
ft^2	square foot/feet
GFCI	ground fault circuit interrupter
gpm	gallons per minute
GRS	galvanized rigid steel
MDD	maximum day demand
mgd	million gallons per day
NEMA	National Electrical Manufacturers Association
NPV	net present value
O&M	Operations and Maintenance
OIT	operator interface terminal
PHD	peak hour demand
psig	pounds per square inch gage
SCADA	supervisory control and data acquisition
SST	stainless steel
Stetson	Stetson Engineers, Inc.
TM	technical memorandum
UPS	uninterruptible power supply
XHHW	cross-linked polyethylene high heat resistant water resistant (electrical wire)
yd^3	cubic yard(s)

Executive Summary

This Technical Memorandum (TM) describes the basis of design for the North Coast County Water District (District) Sheila Tank Replacement Project. The proposed project includes the replacement tank -- partially buried, prestressed concrete with a capacity of 0.6 million gallons (MG) – and associated valves, vault, piping, power, supervisory control and data acquisition (SCADA) system and site improvements. The AACE International Class 4/order-of-magnitude estimated construction cost is $3.67 million, with a likely cost range of $2.57 to $5.51 million. Brown and Caldwell (BC) projects a total project duration of about twenty-four months, with nine months required for design and permitting, three months for bidding and award and an expected construction duration of twelve months.

Section 1: Introduction

The District water system serves about 39,000 customers through 12,000 service connections over an area of approximately 11.3 square miles in northwestern San Mateo County. The distribution system has three major service areas and many smaller pressure zones supplied through approximately 120 miles of pipe, four booster pumping stations, and 11 storage tanks. Continued maintenance of these assets is essential so that the District can supply water reliably to its customers. One older District asset, the Sheila Tank, has reached the end of its useful life and currently is out of service. The original Sheila Tank, constructed of redwood, has a volume of about 100,000 gallons. Based on direction from the District, this project will replace the Sheila Tank with a partially buried, prestressed concrete tank, with a volume of 600,000 gallons.

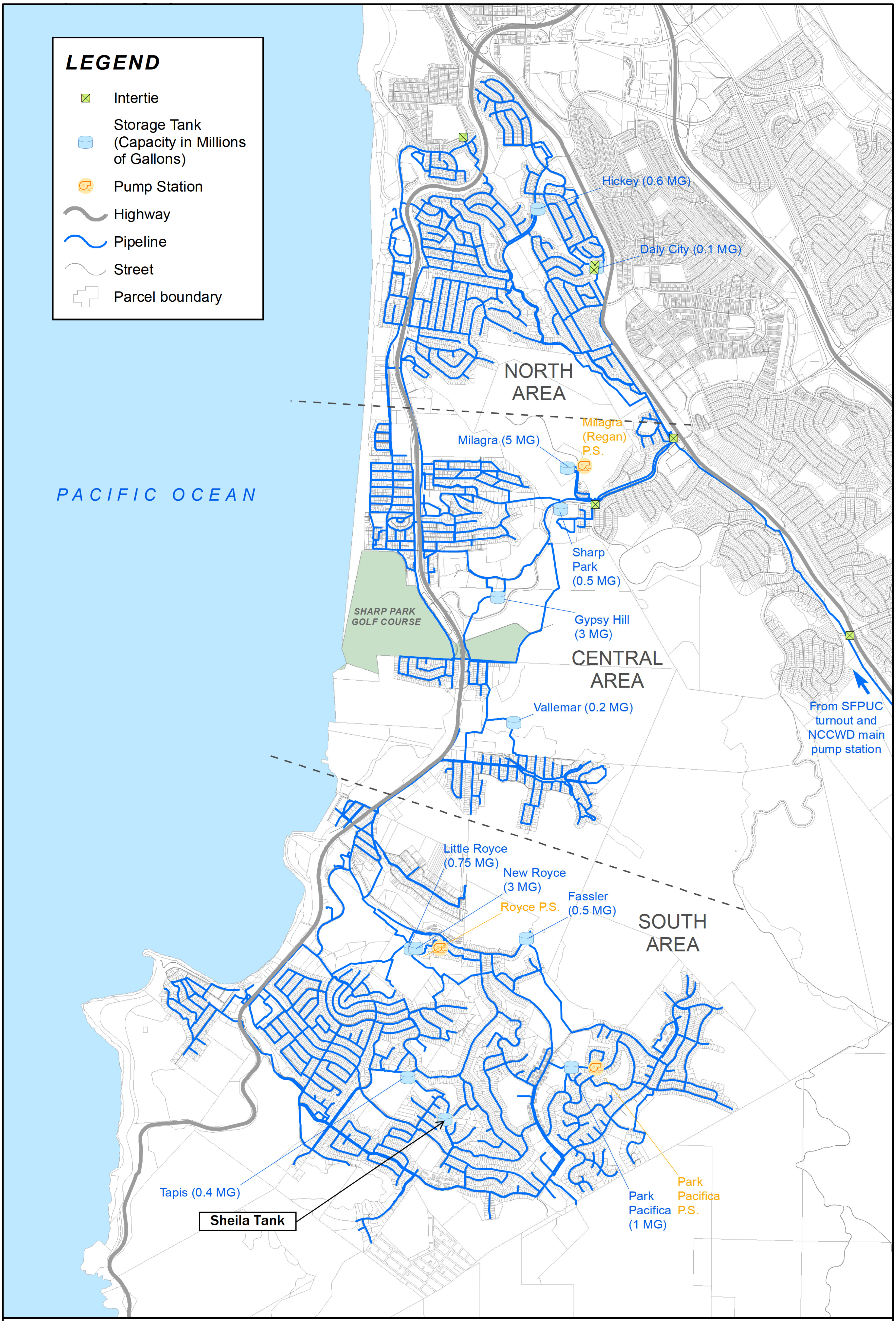
1.1 Summary of Site and Proposed Components

Constructed in 1955, the current Sheila Tank has a base elevation of approximately 280 feet. The District has determined that the tank is no longer viable with its current capacity. It holds inadequate fire protection storage and cannot supply peak demands. Its overall condition is unacceptable, e.g., it is seismically inadequate for project earthquakes.

The site is located at 1141 Sheila Ln. Pacifica, CA within a residential development, an important consideration for the replacement tank's design. The tank site also fronts onto Alvarado Avenue but no sit e access from that side exists nor is new access contemplated owing to the steep terrain. Area residents very likely will prefer a new tank with minimal visual impact; a tank option that obstructs views of surrounding hillsides and the ocean from existing residents is undesirable.

Figure 1-2 presents an aerial image of the current Sheila Tank site, with superimposed contours. The site slopes steeply from North to South with approximately a 90 ft elevation change across the site creating construction and access challenges. The design must consider geotechnical conditions carefully to ensure tank stability on the slope. Careful site layout will minimize use of expensive retaining walls which would complicate tank access and increase the replacement tank construction cost.

The tank site now has existing vaults: one is an emergency connection, one is a PRV station and the last vault has the inlet pipe pressure sustaining valve. The proposed design will demolish the existing vaults and for maintenance ease and operational simplicity will combine multiple functions into one large valve vault adjacent to the tank.



North Coast County Water District

Brown AND Caldwell

FIGURE 1-1. SHEILA TANK SITE LOCATION

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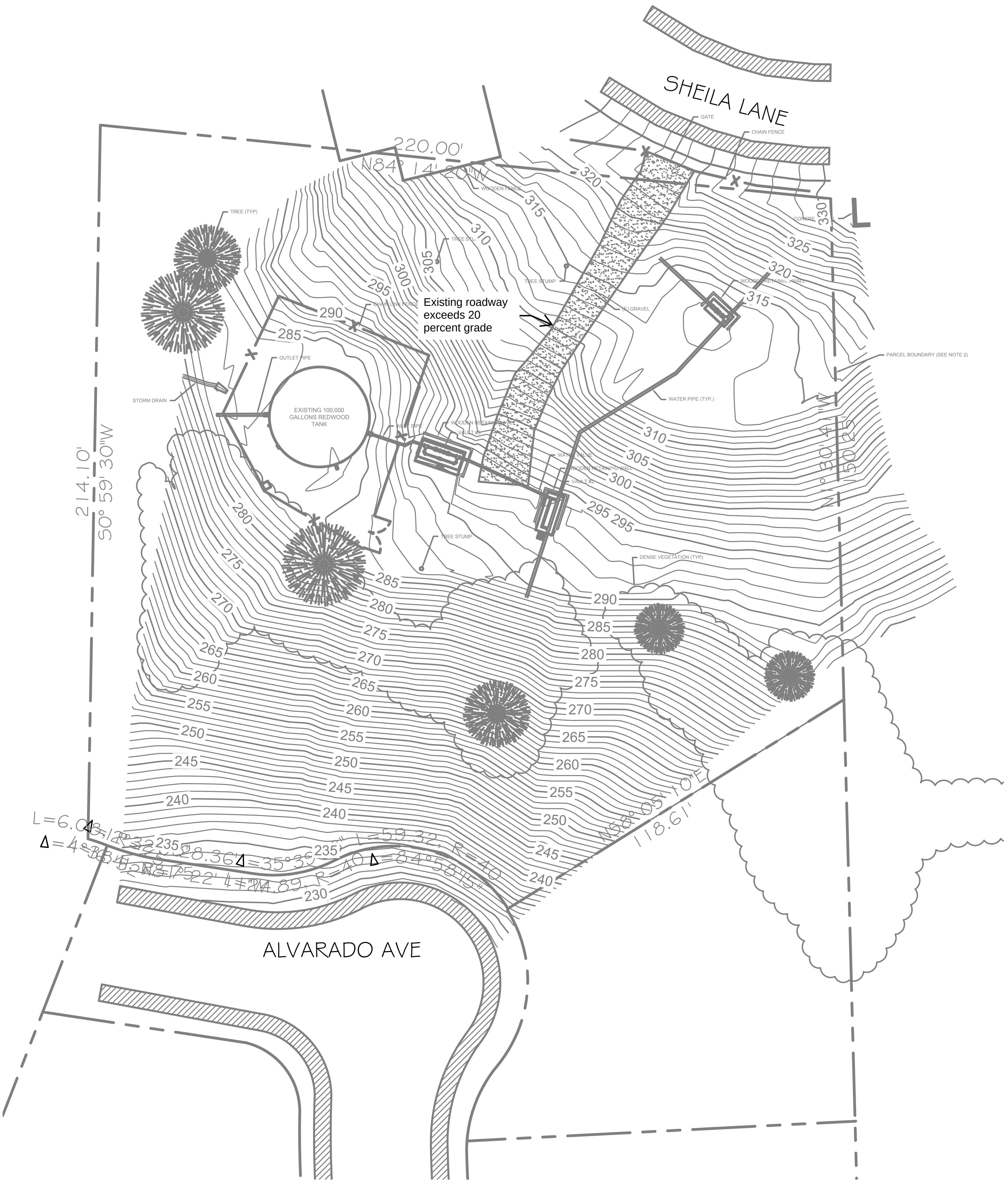


Existing roadway exceeds 20 percent grade

PLAN VIEW

SCALE: 1" = 30'

Brown AND Caldwell	SCALE: 1" = 30' 153918 DATE: August 6, 2020	NORTH COAST COUNTY WATER DISTRICT EXISTING SITE PLAN	FIGURE 1-2

Path: \\bcwckfp01\projects\153000\153918- NCCWD - Sheila Tank Re Eval\07 - CAD\2-SHEETS\F-FIGURES File Name: 153918-F-2-1 Plot Date: August 6, 2020 9:16 AM Cadd User: Tait Lambert

1.2 Previous Work Completed

The most recent 20-Year Long- Term Water Master Plan (Stetson Engineers, Inc. [Stetson], 2013), identified a 200,000-gallon storage deficit in the area (Zones 30 and 31) served by the Sheila Tank. The plan proposed removing the existing 100,000-gallon redwood storage tank (listed in District records as 13 feet high by 32 feet in diameter—note these dimensions suggest an actual storage volume of less than 80,000 gallons) and building a new tank at the existing Sheila Tank site. The new tank would increase storage capacity with a modern seismically durable tank. Due to site constraints, the Master Plan recommended replacing the existing Sheila Tank with a 200,000-gallon tank that would not fully mitigate the apparent storage deficit -- a 100,000-gallon deficiency would remain.

The District authorized Stetson to design a 200,000-gallon welded steel storage tank to replace the existing Sheila Tank. This design progressed to the 90 percent level, and included a geotechnical investigation completed by Miller Pacific and a site topography investigation completed by Stetson. Before completing the 200,000-gallon Sheila Tank replacement design, the District elected to re-evaluate site conditions and determine whether the District could construct a larger tank at the site to alleviate the full pressure-zone storage shortfall and possibly provide a modern, seismically-durable storage to support the overall water system.

BC completed a re-evaluation of the Sheila Tank site to determine the optimal tank volume, geometry and construction material which would best meet the multiple project objectives. BC considered six alternatives for tank replacement at the Sheila site. The alternatives include 300,000-, 450,000- and 600,000-gallon replacement tanks, each considered in two construction materials—welded steel (American Water Works Association [AWWA]/American National Standards Institute [ANSI] D100-11 Welded Carbon Steel Tanks for Water Storage) and prestressed concrete (AWWA/ANSI D110-13 Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, Type 1). For each alternative, BC developed and evaluated the following:

- Diameter, base elevation, water depth, and roof elevation
- Water quality impacts and mixing provisions
- Freeboard height required based on the geotechnical report and California Building Code’s structural and seismic design criteria, including sloshing protection for the design earthquake
- Connecting piping and valving
- Construction requirements and site limitations
- Environmental impact, including visual impact comparison at a conceptual level
- Capital costs AACE International (formerly Association for the Advancement of Cost Estimating International [AACEI]) -- Class 4/order-of-magnitude level

Based on the re-evaluation BC recommended the District proceed with detailed design and construction of a 450,000-gallon prestressed concrete tank at the Sheila Tank site. The District Board of Directors (Board) decided that the tank design should include 600,000 gallons in storage, if practicable, at the Sheila site to ensure adequate fire protection and more reserve water available during emergencies. The new tank design would conform to the current stringent standards and hence have maximum reliability after a seismic event. The Board favored prestressed concrete tank construction owing to its corrosion resistance and potentially lower maintenance costs at the site’s salty marine fog environment.

Section 2: Data Collection and Field Investigation

This section summarizes field investigations completed as part of basis of design and TM preparation.

2.1 Survey Update

The previous survey completed for the 2016 Stetson Sheila Tank Replacement design did not connect to a fixed established datum. LCC Engineering & Surveying, Inc updated survey information by performing the following:

- Tied the Control from the 2016 Survey to a NAVD88 benchmark
- Confirmed accuracy of 2016 survey with additional spot readings
- Converted elevations/surface to NAVD88 appropriate for detailed design

The updated survey, presented in Figure 1-2 above, will aid the tank design by using the new tank and water surface elevations to tie accurately into the District’s distribution system, and evaluate hydraulic impacts better.

2.2 Updated Geotechnical Report

In 2016 Miller Pacific prepared a geotechnical investigation report for the Sheila Tank site including existing conditions and a geologic hazards evaluation. To characterize the site more thoroughly for a partially buried concrete tank, on June 12, 2020, Miller Pacific completed an additional geotechnical boring and updated its 2016 report.

Field investigation include three borings, two immediately south (B1), north (B2) of the proposed 600,00-gal tank location and one boring (B3) about 15 feet upslope from proposed upslope excavation. Table 2-1 summarizes key information from the borings. The drilling encountered no groundwater.

Table 2-1. Sheila Tank Geotechnical Borings Information Summary

Boring and Ground Elevation (feet, NAVD 1988)	Depth within Boring (feet)	Blows per Foot	Materials Encountered
B1, 272	0 to 4	29 per foot	• Sandy clay
	4 to 8	43 per foot	• Pebble Conglomerate • Moderately hard in clayey weathered matrix with granitic and volcanic clasts up to 1-inch diameter
	8 to 15	43 to 56 per foot	• Moderately hard in clayey weathered matrix with granitic and volcanic clasts up to 1-inch diameter
B2, 280	0 to 4	39 per foot	• Sandstone
	4 to 13 (refusal)	45 to over 100 per foot	• Moderately hard with lesser interbedded shale • Moderately hard in clayey weathered matrix with granitic and volcanic clasts up to 1-inch diameter
B3, 294	0 to 2	NA	• Sandy clay
B1, 272	2 to 40.5	20 (3 ft) to 80 to over 100 (5 ft to bottom)	• Pebble Conglomerate • Multicolored gravels and cobbles (red, brown, white), highly to moderately weathered, weak to friable when extruded, low hardness, gravels and cobbles weathered and of metavolcanics origins.

For the proposed 600,000-gal partially buried tank alternative and associated site improvements, Miller Pacific “concludes that the site is suitable for the planned tank and site improvements.” Recommended site design criteria appear later in this TM. Excavation may encounter hard rock (materials not easily excavated with a Caterpillar 330 or equivalent excavator and hence require other methods, e.g., hoe-hammering. Onsite materials are suitable for backfilling. For a tank inside floor at least 5 feet below finished downslope grade as presented below, excavation will set the foundation in sandstone and/or conglomerate.

The updated geotechnical report presents more detailed recommendations to address these issues, see Attachment A.

Section 3: Evaluation of Tank Capacity and Dimensions

This section presents a discussion on potential tank capacity and associated tank dimensions.

3.1 Tank Capacity

The 2013 water master plan prepared by Stetson Engineers identified a 200,000-gallon storage deficit in this area and suggested that the Sheila Tank should be replaced with a 300,000-gallon storage tank. The Board expressed interest in maximizing the tank volume on this existing site to provide adequate fire flow protection and additional system-wide reliability. During this project's preliminary phase, BC re-evaluated the site use, tank capacity, tank construction materials, constructability, cost and schedule and recommended the District upsize the existing tank to a 450,000-gallon pre-stressed concrete tank, based on the District's desire for improved fire protection and emergency storage and water quality impacts and project cost.

Following review of BC's findings, the Board requested that BC further evaluate the maximum tank volume that can be reasonably constructed on the Sheila Tank Site (between 450,000 and 600,000 gallons) and develop detailed design documents for the selected volume. Taking the District's request and site constraints into account, BC found that maximizing the tank volume to 600,000 gallons was feasible.

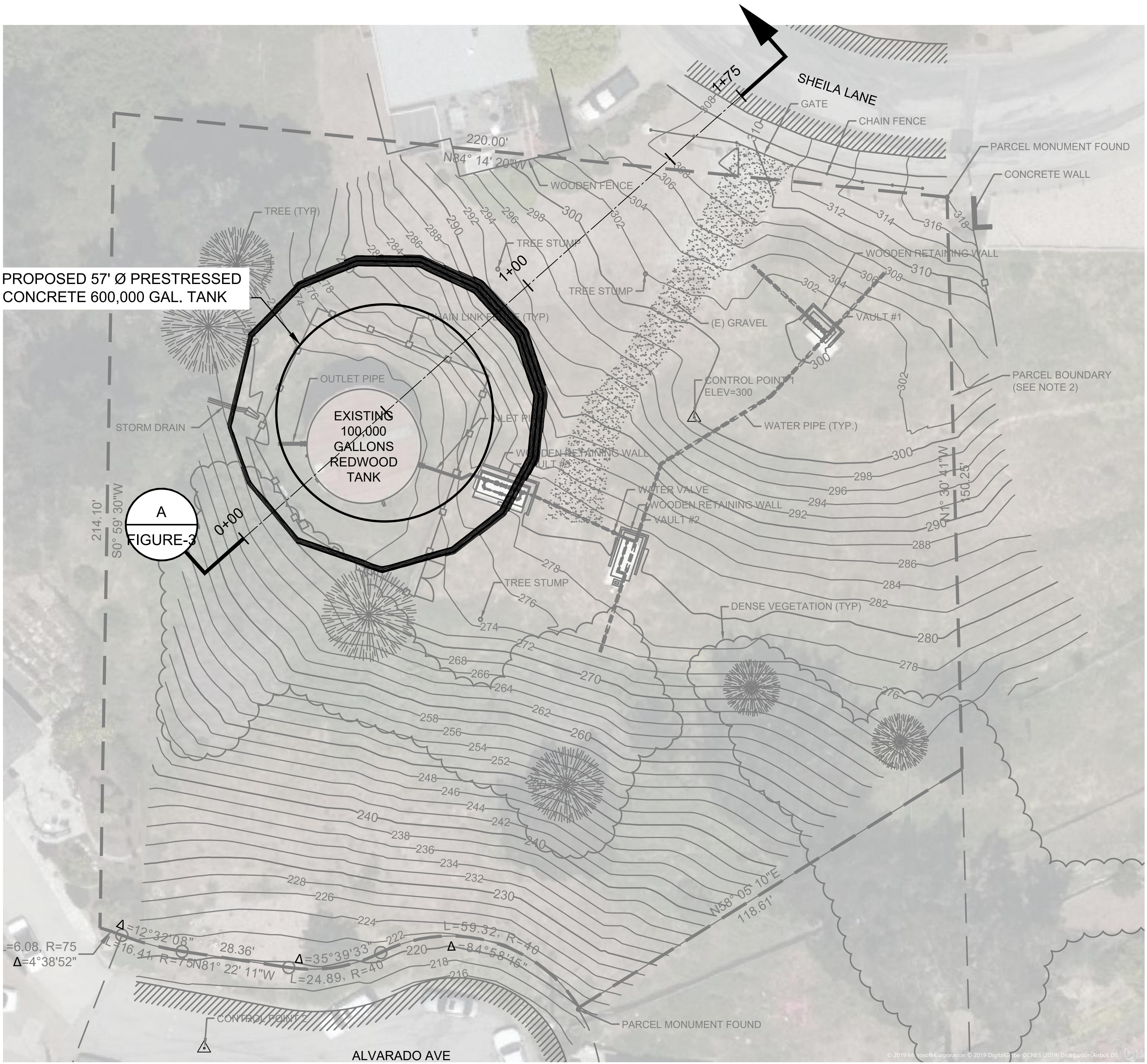
3.2 Design Components

BC considered the following requirements and constraints in determining the diameter, depth below ground surface of the new tank and site arrangement:

- The new tank will have a capacity of 600,000 gallons.
- Concrete tank construction requires a 10-foot clearance around the reservoir circumference.

We determined that the design would meet these criteria by constructing a new concrete tank that has an inside diameter of 55 feet, a side water depth of 34 feet and positioning the new tank on the site as shown in Figure 3-1. The iterative process of deciding the most feasible tank dimensions considers the lowest tank and construction cost possible for this site. These dimensions were the most economical for the given site constraints while still providing the District with the maximum tank capacity on site and maintaining system pressures. Partially burying the tank 10 feet below lowest adjacent grade will not only minimize the visual impact for surrounding neighbors but also mitigate costly foundation enhancements in event of seismic activity.

The most economical design would use the tank wall as a retaining wall with more backfill on the northern/upslope side. We consulted with DN Tank, the largest West Coast constructor for AWWA/ANSI D110 tanks, regarding partial tank burial and any issues/requirements flowing from such a configuration. DN Tanks responded that with differential backfill loading, the tank should have at least 5 feet of wall burial (tank interior floor 5 feet below finished grade. Furthermore, positioning the interior tank floor more than 10 feet below grade would increase costs considerable owing to extra shoring and excavation costs. The final tank height above grade based on the public outreach task results.



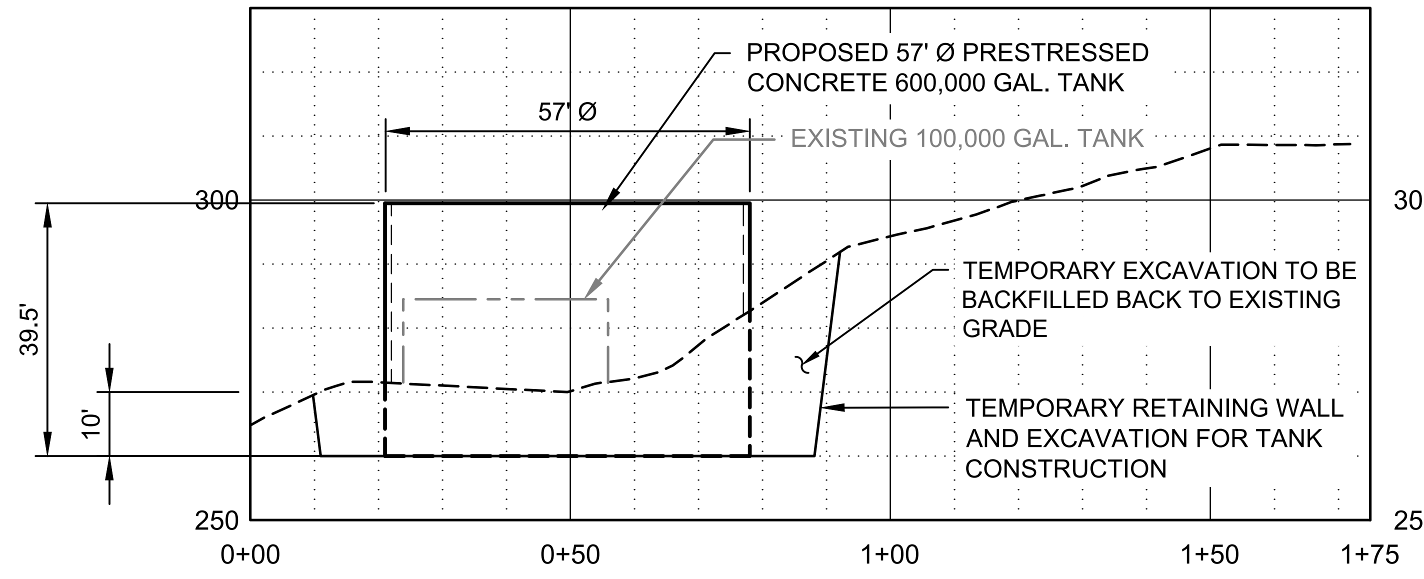
NORTH

PLAN VIEW

SCALE: 1" = 30'

0 30 60

NOTE:
CONTOURS ARE RELATIVE AND ARE NOT TIED TO AN ESTABLISHED BENCHMARK. ADDITIONAL SURVEY WORK WILL BE COMPLETED AS PART OF DETAILED DESIGN TO TIE THE BACKGROUND SURVEY TO A DATUM.



A
FIGURE-3

PROFILE

SCALE: 1" = 30'

0 30 60

Path: \\bcwckfp01\projects\153000\153918- NCCWD - Sheila Tank Re Eval\04 - Re-Evaluation Report\02 - CAD\2-SHEETS\C-CIVIL File Name: FIGURE-3 Plot Date: March 27, 2020 8:42 AM Cadd User: Robert Near

Brown AND Caldwell

SCALE: 1" = 30'
155221
DATE: August 17, 2020

NORTH COAST COUNTY WATER DISTRICT

600,000 GAL CONCRETE TANK PLAN & PROFILE

FIGURE
3-1

The prestressed concrete tank design will conform with the provisions of AWWA D110 Standard for Wire- and Strand-Wound Circular Prestressed-Concrete Water Tanks, Type I, ACI 350, ACI 350.3, ASCE 7 and CBC. Table 3-1 provided the basis of design for the new tank replacement.

Table 3-1. Design Basis for the Sheila Tank Replacement

Parameter	Design Basis
Tank volume, gal	600,000
Tank roof configuration	Low-rise dome
Tank inside diameter, feet	55
Tank outside diameter, feet	57
Freeboard, feet[a]	5.5
Side water depth, feet	34
Height above finished grade, feet[b]	35
Inlet and outlet size, inches	16
Overflow size, inches[c]	14
Drain size, inches	8
Inlet valves	Tideflex© check valves
Outlet valve	Waterflex© check valve or swing check valve
Flexibility of inlet/outlet pipe	Flexible couplings or EBAA Iron Flex-Tend fittings
Interior access	Fiberglass ladder
Interior ladder safety system	Saf-T-Climb device (stainless steel) with a notched rail system
Exterior access	Stairway with locking gate and surrounding anti-climb fencing and razor wire or caged latter
Shell manway, quantity	1
Shell manway diameter, inches	36
Roof hatch, quantity	1
Roof hatch dimensions, feet by feet	4 by 4 or 4 by 6 (depends on contractor access needs)
Water sampling ports, quantity	3
Water sampling port locations, feet above finished floor	8.5, 17.0, 25.5
Water level indication	Ultrasonic level transmitter
Intrusion alarm	On-roof access hatch

a. *This is a minimum freeboard height is preliminary and will be finalized during design, see section 4.3.2.*

b. *The height above finished grade is equivalent to top elevation of roof dome with respect to the downslope side of the tank.*

c. *The overflow will include a tee with a grill and insertion of bagged dechlorination chemical, i.e. sodium bisulfite or ascorbic acid [Vitamin C]) tabs or crystals, to accomplish dechlorination/dechloramination.*

Section 4: Structural and Seismic Design Criteria

This section presents the structural and seismic design criteria for an AWWA D110 Type I prestressed concrete tank.

4.1 Tank Material

Based on Board preferences and cost-effectiveness considerations, the Sheila Tank replacement will be prestressed concrete, designed in accordance with the following standards: ANSI/AWWA D110-13 (R18), ACI350.3, and .1 California Building Code (2019). Table 4-1 provides the basis of design for an ANSI/AWWA D110 Type I concrete reservoir.

Table 4-1. Tank Components

Tank Component	ANSI/AWWA D110 Type I
Floor	• Standard conventionally reinforced concrete membrane floor per ANSI/AWWA D110 with thickened footings at the wall • Monolithic; no joints
Roof	• Low-rise dome • Monolithic; no joints • Watertight per ACI 350
Wall Base	• Waterstop • Neoprene bearing pads
Wall-to-Roof Connection	• Flexible connection
Strand	• Post-tensioned galvanized horizontal stressing strand • Post-tensioned vertical thread bar in epoxy grout or bonding prestressing tendons with cementitious grout
Seismic Cables	• Galvanized prestressing strand • Seismic design per ANSI/AWWA D110
Reservoir Exterior	• Uninterrupted cylindrical surface • Troweled smooth finish

4.2 Structural Criteria

The prestressed concrete tank design and construction will conform to provisions of AWWA D110 Standard for Wire- and Strand-Wound Circular Prestressed-Concrete Water Tanks, Type I as modified by 2019 CBC and ASCE 7-16. Loadings and requirements for tank design calculations include:

- Roof Dead Load: estimated weight of all permanent imposed loads. Unit weight of concrete 150 pounds per cubic foot; steel 490 pounds per cubic foot.
- Live Load: the weight of all the liquid when the tank is filled to overflowing. Unit weight of water 62.4 pounds per cubic foot.
- Roof Live Load: As required per ASCE 7-16
- Equivalent Liquid At-Rest Pressure: per geotechnical report.
- Backfill Pressure Increase on Wall Under Seismic Excitation: per geotechnical report.
- Equivalent Liquid Passive Earth Pressure: per geotechnical report.

- Backfill Soil Density: per geotechnical report.
- Lateral Vehicle Surcharge on Tank Wall; based on burial and planned backfill depths
- Foundation Loads: proportioned so that soil pressure shall be less than the soil bearing capacity. Net soil bearing capacity is defined as the gross bearing capacity excluding liquid and/or soil overburden pressure.
- Settlements: designed for maximum total settlement and a maximum differential settlement of ¼ inches over 50 feet horizontal distance.
- Base Coefficient of Friction: per geotechnical report.

4.3 Seismic Design Criteria

Seismic design will conform to the applicable sections of AWWA D110-13, ACI 350.3, ASCE 7-16 and the local jurisdictional building code. The designer shall modify applicable sections of AWWA D110 and ACI 350.3 as required by ASCE 7-16 Section 15.7.7.3, with use of referenced documents in accordance with limitations set by ASCE 7-16, Section 15.4.1, paragraph 7. Table 4-2 presents the seismic design criteria.

4.3.1 ASCE 7 Design Criteria

Table 4-2. Seismic Design Criteria

Standard	Design Criteria
ASCE 7-16	Mapped MCER, 5% Damped, Spectral Response Acceleration Parameter at Short Periods (S_S) = 1.93 g
	Mapped MCER, 5% Damped, Spectral Response Acceleration Parameter at a Period of 1 sec (S_1) = 0.79 g
	Soil Site Class B
	Short-period Site Coefficient (F_a) = 1.0
	Long-period Site Coefficient (F_V) = 1.0
	Long Period Transition Period, T_L (Sec) = 12
	Importance Factor, I_e = 1.50 (1.0 for Sloshing per 15.7.6.1.2 Paragraph b)
	Risk Category IV
	Seismic Soil Surcharge per Geotechnical Report

4.3.2 Sloshing Height

BC estimated preliminary sloshing height and freeboard requirement based on ASCE7-16 using default soil parameters. Final freeboard calculations will conform to with ASCE7-16 using the seismic parameters established in the geotechnical report. The design may recognize roof weight as partially counteracting the sloshing wave forces and therefore reducing the required freeboard height.

4.3.3 Base-Restraint Cable Design

The base-restraint cables will have capacity for the total base shear obtained from the maximum values of impulsive and convective components and the dynamic effects of backfill, with allowable cable stress at 0.75 fpu.

4.3.4 Seismic Fittings and Potential Seismic Automatic Shutdown

Piping connections around the valve vaults will include appropriate flexibility provisions. Piping connections will be EBAA Iron Flex-tends or equal for inlet and outlet pipelines.

SCADA programming and use of controls for the actuated valves will address seismic shutoff provisions.

4.4 Geotechnical Considerations

Based upon the geotechnical report updates in Attachment A, Miller Pacific concluded that the Sheila tank site is suitable for the planned tank and site improvements. Excavation into the hillside and retaining wall are recommended to create the enlarge tank pad, limit extent of site grading, and reduce the exposed tank height. Minimum mitigation of ground shaking will be included in seismic design of the structures in conformance with California Building Code (2019).

4.4.1 Foundation Design

Bedrock is relatively shallow throughout the site, with up to about 4-ft of sandy clay encountered toward the downslope edge of the existing tank pad; therefore, the tank design will use a shallow foundation. The site is appropriate for a partially-buried tank without drilled piers. To reduce potential for differential settlement, the footings will need to be deepened to provide uniform bearing support on the weathered bedrock. Table 4-3 presents the shallow spread footings design criteria provided in Attachment A of the updated geotechnical report. The site material is competent for the tank foundation. Keying the tank foundation into the ground will provide an installation that easily resists lateral sliding and differential loading uphill to downhill.

Table 4-3. Shallow Spread Footings Design Criteria

Parameter	Design Criteria
Minimum depth[a]	18 inches
Base friction coefficient	0.35
Allowable bearing capacity[b]	
Weathered Bedrock	3,000 psf
Lateral passive resistance[c,d]	
Sandy Clay Soils	250 pcf
Weathered Bedrock	400 pcf

a. *Foundations to bear on weathered bedrock.*
Maintain at least 10 feet horizontal distance from base od footing to slope.

b. *May increase design values by 1/3 for total design loads including wind or seismic.*

c. *Equivalent fluid pressure. Not to exceed 4000 psf.*

d. *Ignore uppermost foot of resistance.*

4.4.2 Retaining Wall Design and Soil Management during Construction

Retaining walls will consist of shotcrete-faced walls supported with soil-nails or rock anchors where cuts are planned.

Planned grading will be mostly excavation with very little fill placement. Therefore bid documents and specifications will require that the Contractor off-haul and legally dispose of excess soil and rock off-site.

Section 5: Demolition and Removal of Existing Tank

This section describes demolition and removal of the existing tank and appurtenances as shown on Figure 6-2.

5.1 Existing Reservoir and Piping Demolition

The contractor will removal and dispose of existing 100,000-gal aboveground, redwood tank in accordance with applicable construction and demolition debris requirements. Additionally, the contractor will demolish the existing three valve vaults and surrounding yard piping. Prior to detailed design a visual inspection of the tank will identification of potential hazardous materials. BC will recommend any required hazardous materials testing, e.g., testing of caulk for PCBs.

The contractor will install temporary high density polyethylene (HDPE) pipe partially above grade, to bypass the construction area as required to maintain service to the pressure zones served by the Sheila Tank. Figure 5-1 is the preliminary existing site and demolition plan with conceptual bypass piping routing.

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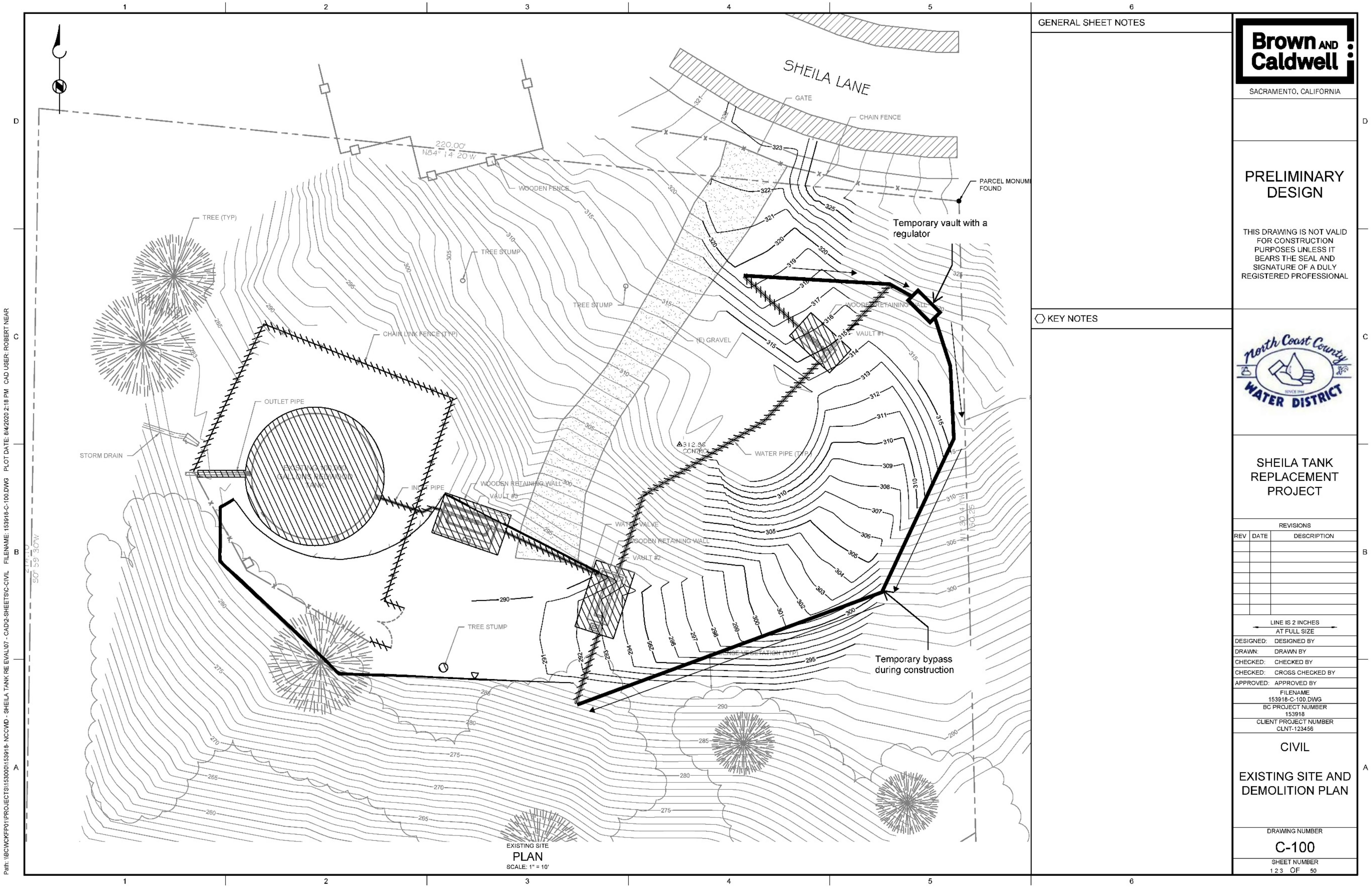

Figure 5-1. Preliminary existing site and demolition plan

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Section 6: Site Improvements

This section describes temporary and permanent site improvements.

6.1 Excavation and Temporary and Permanent Retaining Walls

For basis of design planning, the partially buried new tank will have its bottom interior elevation 10 feet below lowest adjacent grade. Construction will require a clear area extending at least 10 feet beyond the tank wall exterior to accommodate specialty construction equipment. The excavation will require temporary retaining walls. Similarly, the tank site will need upslope protection from sliding soil, again protected by temporary retaining walls. The contractor will select the retaining wall type, e.g., H piles and planks or soil nails and shotcrete, and design the walls. Permanent retaining walls likely constructed of mortarless block walls or equal designed and installed per vendor recommendations will define both the temporary working area and the permanent access area adjacent to the tank. Table 6-1 provides the estimated excavations associated with tank and temporary retaining wall construction. The temporary retaining wall quantity accounts for shoring of a 12-foot-deep excavation – buried portion of the tank plus floor slab and underlying drain rock thicknesses.

Table 6-1. Tank Construction Quantities

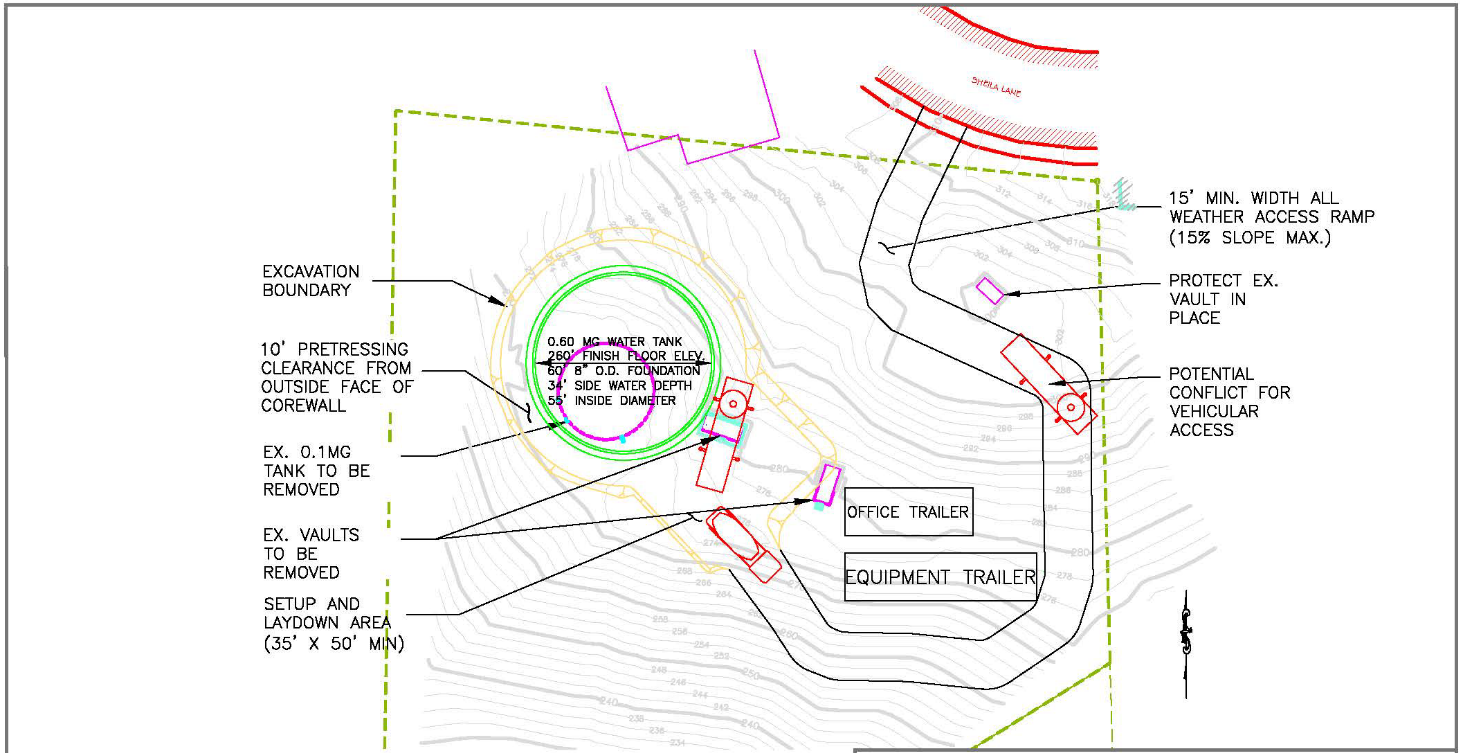
Volume (gallon)	Net Cut Volume (yd^3)	Temporary Retaining Wall (ft^2)
600,000	2,830	4,320

6.2 Site Access

Site access planning needs to consider both construction access and long-term access for future operation and maintenance.

6.2.1 Temporary Construction Access Considerations

As described above, constructing a prestressed concrete tank at the Sheila Tank site would require a temporary retaining wall and a 10-foot-wide path around the tank perimeter to facilitate circumferential pre-stressing and shotcrete application. A temporary gravel access road for construction access and removal of excavated material will start from Sheila Lane and run to the tank pad. Following tank construction, the contractor will backfill earth against the tank, with the tank wall acting as a retaining wall for the site slope. Figure 6-1 includes a preliminary temporary access road location and approximate equipment placement for the contractors during construction.



NOTES:

1. PLEASE USE THESE EX–DRAWINGS IN CONJUNCTION WITH THE DETAILED DN TANKS SCOPE LETTER AND SUBCONTRACT.
2. LEVEL AREAS MUST BE PROVIDED FOR EQUIPMENT AND OFFICE TRAILERS. ALSO PROVIDE ACCESS TO TRACK.
3. AT A MINIMUM, ALL WORK ROADS, ACCESS ROADS, RAMPS, AND THE CRANE AREAS, SHALL BE ALL WEATHER ROADS.
4. DN TANKS WILL REQUIRE A 60 FT X 15 FT AND A 40 FT X 15 FT AREA TO BE PREPARE FOR OUR EQUIPMENT TRAILER AND OFFICE TRAILER. THIS AREA SHOULD BE LOCATED WITHIN 150 FT OF THE TANK. THIS AREA MUST BE CLEARED, GRUBBED, LEVELED, AND EASILY ACCESSIBLE.

0.60 MG CAST IN PLACE, PRESTRESSED
CONCRETE WATER STORAGE TANK
CONSTRUCTION SITE LAYOUT - PLAN

DRAWN BY: RD	DATE: 07/22/20	SCALE: 1" = 45'–0"	DWG# EX-1	REV:
CHECKED: ***	FILE: M:\N. California Region\California\Pacifica (NCCWD) – 11814\Layouts & Sitework Estimates			
SITE LOCATION:	PACIFICA (NCCWD), CA			SHEET 1 OF 1

Figure 6-1. Preliminary construction site layout (DN Tanks)

6.2.2 Permanent Site Access Considerations

Following tank completion, the contractor will convert the temporary access road into a permanent access road, using concrete paving since the steep slope is unsuitable for asphalt paving. A concrete- or asphalt-paved flat area at the end of the driveway will provide an area for parking and turning around maintenance vehicles. The 12-ft-wide driveway will have a roughened finish for vehicle traction owing to the steep slope and guardrails along the sloped turns for staff safety. Figure 6-2 is a preliminary site plan with proposed access road with the ability to accommodate a large pickup truck, e.g., F-350 Crew Cab DRW LWB 4x4.

The tank will have a 5-foot-wide permanent path around the perimeter to ensure improved accessibility for future operations and maintenance. Depending upon District preference, the tank will have either a stairway or ladder for roof with appropriate security.

6.3 Grading and Drainage

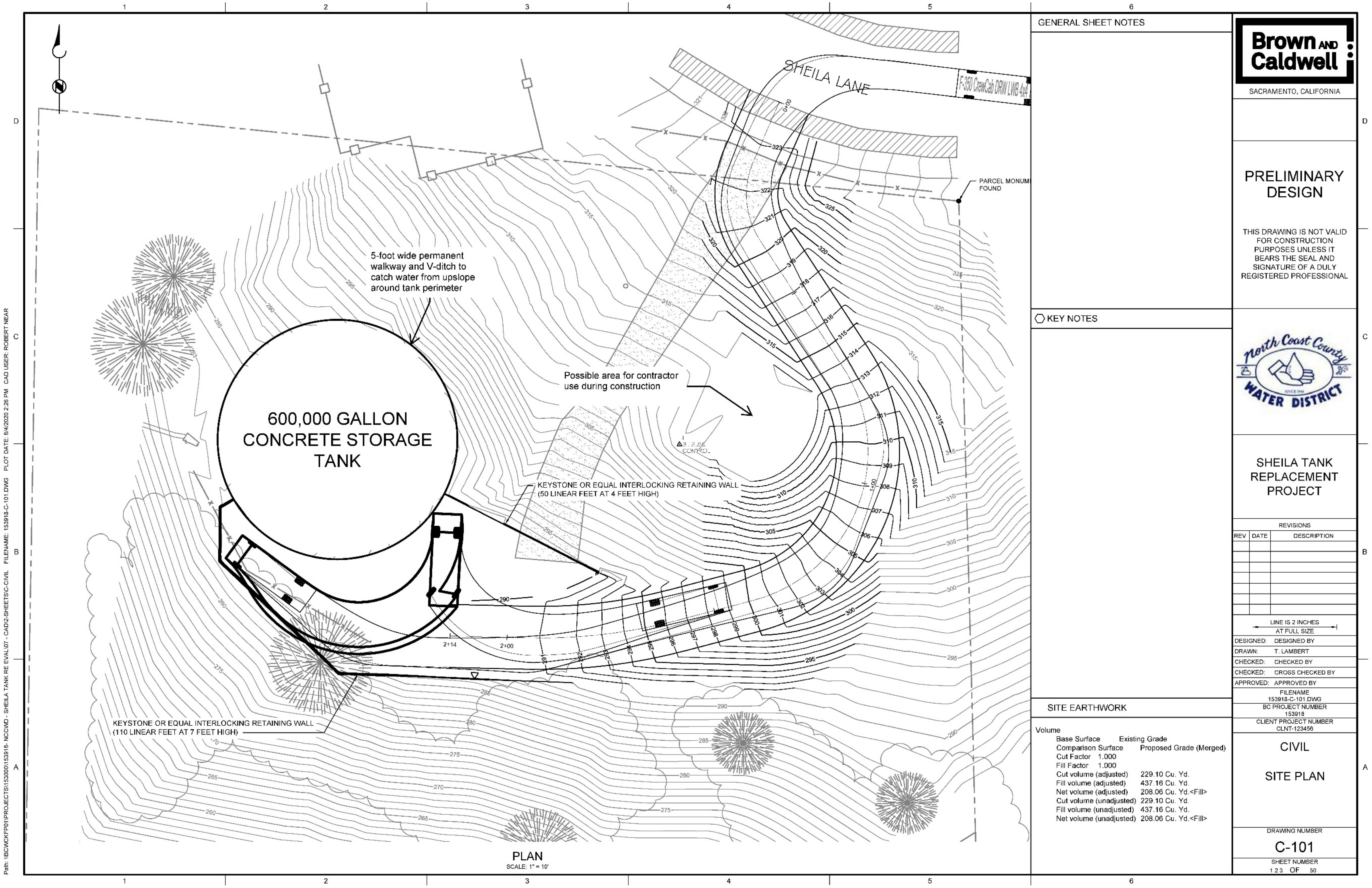
New construction will route tank and site drainage and overflows to the existing on-site storm drain if detailed design demonstrates sufficient fall and storm drain depth or to a new storm drain. Detailed design will explore the existing storm drain and determine whether the new tank requires a new storm drain to Alvarado. The upslope tank side would have a v-ditch to carry uphill runoff around and away from the tank. The access road will slope toward the catch basins that will be placed periodically along the entire length of driveway to ensure proper drainage and water capture, connected to the on-site storm drain. The tank will have three buried perforated pipe underdrains, a perimeter drain each half circumference and a centerline drain, all coming together in a vault. Each drain will have individual boxes with v-notch weirs for monitoring drainage flow and potential sampling, e.g., testing for fluoride as a leak indicator.

6.4 Fencing

A security fence that matches the District's standards will surround the tank and new valve vault. Razor wire will top the new fence to match existing security provisions. Detailed design will consider using 1-inch-mesh chain-link fencing, to make it more climb resistant and possibly use green or black vinyl coating to reduce fence visibility.

6.5 Optional Site Landscaping

If requested by the District, the design will add new landscape to screen the tank and its retaining walls from neighbors and to replace trees and shrubbery removed during construction. Such an approach will minimize visual impacts to surrounding neighbors. For example, on the northern side of the site along the earthen slope, the District may consider installing a trellis or frame for vines that is to soften the visual impact of the new reservoir. Plant selections will use native species if requested by the District, with water conserving, low maintenance and fire resistance as key criteria, selected based on plant tolerance to local soil and rainfall. The irrigation system will meet District standards for water conservation and efficiency; likely needed only for three to five years to establish vegetation initially. Landscaping will address any removed trees during construction and tree replacement if the District so requests.



SITE EARTHWORK

Volume

Base Surface	Existing Grade
Comparison Surface	Proposed Grade (Merged)
Cut Factor	1.000
Fill Factor	1.000
Cut volume (adjusted)	229.10 Cu. Yd.
Fill volume (adjusted)	437.16 Cu. Yd.
Net volume (adjusted)	208.06 Cu. Yd.<Fill>
Cut volume (unadjusted)	229.10 Cu. Yd.
Fill volume (unadjusted)	437.16 Cu. Yd.
Net volume (unadjusted)	208.06 Cu. Yd.<Fill>

DESIGNED: DESIGNED BY
DRAWN: T. LAMBERT
CHECKED: CHECKED BY
CHECKED: CROSS CHECKED BY
APPROVED: APPROVED BY
FILENAME 153918-C-101.DWG
BC PROJECT NUMBER 153918
CLIENT PROJECT NUMBER CLNT-123456
DRAWING NUMBER C-101
SHEET NUMBER 1 2 3 OF 50

Figure 6-2. Preliminary site plan with proposed access road

Section 7: Piping, Valves, and Appurtenances

This section describes piping, valving and other appurtenances for the new tank.

7.1 Piping and Valve Design

Figure 7-1 shows the proposed new piping configuration schematically including inlet/outlet, overflow and drain piping, isolation and control valves. The system will receive flow from Zone 28 and release stored water into Zone 30 and 31. An altitude valve on the inlet line will prevent overfilling the tank and maintain back pressure on the system. A pressure reducing valve across the inlet to the outlet will allow direct feed from Zone 28 to Zones 30 and 31, bypassing the tank. A solenoid-controlled diaphragm valve with a check feature on tank outlet will ensure flow only through the altitude valve into the tank. A new valve vault southeast of the tank will house the control valves. Per the District's request the detailed design will include a remote operated outlet valve in the detailed design to allow tank drainage shut off using its SCADA system.

The overflow pipe will have interior funnel top and exterior Tideflex Check valve, terminating 24 inches above grade, discharging over a grated drain connected to existing storm drain or routed to a new storm drain. The tank overflow pipe will have a stainless steel (SST) tee with SST flanged door (with locking provision) and SST screen on its lower flange for insertion of dechlorination chemical. Additionally, tank foundation drain and retaining wall drains will flow to the storm drain system.

Three interior sampling tubes (3/4-inch diameter stainless steel (SST) pipe) with exterior valves in a locked box, will allow tank water quality sampling at the ¼, ½, and ¾ depth points inside the tank. The tubes shall extend 18 inches from the tank wall radially toward the tank center, to avoid wall effects and draw representative samples.

The projected design inlet/outlet flows to the tank will be 1200 gallons per minute (gpm) for peak hour demand and 320 (gpm) for average day demand.

The design will base the maximum tank fill rate, hence, the overflow rate, based on tank mixing and storm drain capacity details. District staff will have control for tank drainage rate based on the drain valve's percent open. Maximum tank volume, internal floor elevation, and required freeboard set the overflow elevation.

Table 7-1 presents additional design basis for the piping and valves.

Table 7-1. Piping and Valve Design

Item	Type	Size (inch)	Location
Altitude Valve	Diaphragm	6	Vault
Pressure Reducing Valve	Diaphragm	6	Vault
Check Valve	Tideflex©	10	Vault
Drain Isolation Valve	Gate	8	Buried
Inlet/Outlet/Tank Drain Isolation Valve(s)	Gate	10	Buried
Overflow Pipe	Stainless or coated steel	12	Above ground
Tank Inlet Connection	Flexible couplings or EBAA Iron Flex-Tend	10	Above ground
Tank Outlet Connection	Flexible couplings or EBAA Iron Flex-Tend	10	Above ground

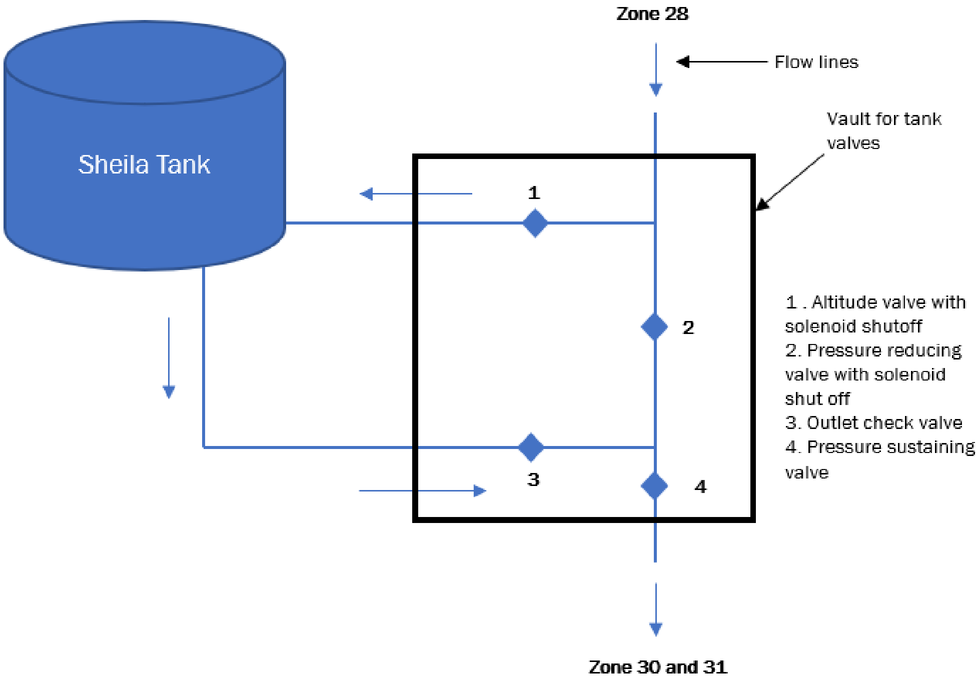


Figure 7-1. Preliminary valve vault flow schematic

7.2 Mixing System

A passive mixing system for the new tank will mitigate risks associated with stagnant water and disinfectant residual loss, using Tideflex© mixing system or similar. This mixing system will provide a high level of mixing with minimal head loss and without external electrical power draw. Attachment D presents literature on this proposed mixing system.

7.3 Tank Appurtenances

Preliminary tank appurtenances will include those listed below, with the list modified based on discussions with District staff:

- 36-inch-diameter hinged, flanged access hatch set about two feet above exterior finish grade at the paved access area.
- Exterior SST access ladder equipped with a cable safety climb, safety cage, and bottom isolation door or aluminum or SST stairs.
- Platform at the exterior ladder top with 42-inch-high handrailing. The platform will extend about 3 feet outboard beyond the tank wall.
- Screened top vent.
- SST safety cable around the top or SST belay points around the cover.
- 120-volt GFCI outlets near the exterior ladder or stairway base and on the top platform.

- Exterior lights at the ladder or stairway base and on the top platform, controlled by a switch in a locked box at the ladder or stairway base.
- Ultrasonic interior level sensor connected to the SCADA system.
- 4-foot by 4 or 6-foot top hatch with cover, with micro-switch connected to the SCADA system for intrusion detection. Interior platform below the hatch, to accommodate entry for diver cleaning and inspection.
- Interior SST or fiberglass ladder with SST cable safety climb.

Tank appurtenances will conform with District and CalOSHA safety requirements.

Section 8: Electrical System

This section describes an upgraded electrical system serving the new tank.

8.1 Electric Service

Pacific Gas and Electric Company (PG&E) will provide permanent electric service. BC estimates that the tank site will generate a 30-ampere (A), 240-volt/120-volt, single-phase load:

1. SCADA panel: 10 A at 120 V
2. Instrumentation: 1 A at 120 V
3. Lighting: 5 A at 120 V
4. Future: 10 A at 120 V
5. Two 20-amp receptacles for District or contractor tools

BC has prepared a draft PG&E service application (see Attachment B), based on the loads above. This draft service application sample is a representative of the information PG&E will require to approve the application and commence their service design. The District needs to complete the information highlighted in yellow on Pages 1 and 2. To accommodate future, unknown loads, the facility will have a 100 A service entrance panelboard with a 100-A main disconnect circuit breaker. The panel capacity will have ample extra capacity. The service voltage will be 240/120 V, single phase. BC recommends that the District initiate the service application by contacting the PG&E representative assigned to them. For seismic isolation, the inlet and outlet valves can have controls through the SCADA system for seismic event shutdown, without special, dedicated seismic valves.

8.2 Electrical Design Criteria

All electrical work will conform to the latest edition of the California Electrical Code.

Detailed design will include a complete conduit and wire system to provide power, control and signal wiring to all facility devices and equipment. Underground conduit will be Schedule 40 polyvinyl chloride (PVC) directly buried in sand. Transitions to above grade conduit will be PVC-coated galvanized rigid steel (GRS). Above ground conduit will be GRS unless the District prefers PVC coated conduit owing to corrosive salty fog conditions. Power and control wiring will have XHHW insulation. Signal wiring will be twisted, shielded pairs. Sunlight-resistant, liquid-tight, flexible metal conduit will provide for final terminal connections to equipment and devices. The grounding electrode system shall consist of bare copper wire from the service entrance panelboard ground bus to a copper coated steel ground rod. The connection to the ground rod shall be irreversible, compression style. The top 12-inches of ground rod shall be accessible in a round, precast concrete box with a steel cover stamped "GROUND".

Section 9: Instrumentation and Controls

This section describes an upgraded instrumentation and controls serving the new tank.

9.1 Instrumentation

The facility will include the following instrumentation:

1. Ultrasonic level transmitter inside the tank
2. Position indicator for altitude valve
3. Position indicator for outlet valve

9.2 Control System

The local control system will include a programmable logic controller (PLC) and operator interface terminal (OIT). The OIT will have 15-inch color touch screen. Minimally the OIT will indicate tank level and motorized or solenoid valve position. The display will include alarm display and management functionality. A NEMA 3R, steel enclosure with a padlock-able outer door and inner dead front door will house the PLC, with the OIT installed on the inner dead front door.

The control system will include an uninterruptible power supply (UPS) to power the control system for at least one hour in the event of a utility power failure with the UPS located in the same enclosure as the PLC.

The control system will include radio telemetry to communicate with the District's office for remote monitoring of the facility by the District's existing SCADA system.

The project manual will specify the enclosure (Control Panel) for the PLC and appurtenances through a performance specification to be sole-sourced to the District's system integrator. The system integrator will perform as a subcontractor to the general contractor for supplying the control panel.

9.3 Programming and Configuration

The project manual will specify design programming and configuration of the PLC, OIT, and additions to the existing SCADA system as a performance specification to be sole-sourced to the District's system integrator.

Section 10: Construction Sequencing Plan

This section presents an overview of expected construction activities.

10.1 Preliminary Construction Sequencing Plan

The technical specifications will require the contractor to schedule and conduct the work to minimize interference with water system operation and maintenance. During construction, the contractor shall coordinate and schedule the work in such a sequence that the existing facilities and proposed work will function properly with no disruption to water transmission and distribution.

Table 10-1 describes the preliminary anticipated construction sequencing.

Table 10-1. Preliminary Construction Sequencing Plan

Construction Sequence	Activity	Details
1	Temporary Site Access	• Install, disinfect and test temporary water mains; and construct gravel temporary access road
2	Demolition	• Demolish existing tank, yard piping and valve vaults • Remove debris and legally dispose of in accordance with the City's construction and demolition debris requirements
3	Temporary Retaining Wall	• Construct temporary retaining wall and a 10-foot-wide path around the tank perimeter to facilitate circumferential pre-stressing and shotcrete application • Carry out earthwork associated with construction of temporary retaining wall and post construction backfill
4	Excavation and Foundation	• Excavate tank footprint • Excavate and install buried piping and underdrains. • Pour reinforced membrane concrete floor
5	Tank Construction	• See Section 10.2 for Tank construction sequencing
6	Tank Leak Testing and Disinfection	• Tank leak testing and disinfection per AWWA requirements. • District will provide water for the initial testing but the Contractor will pay for water if repeat testing is needed
7	Electrical Work	• Install new PG&E service
8	Tank Startup and Testing	• Test new electrical and controls systems
9	Landscaping	• Option task • New landscape to screen the tank and its retaining walls from neighbors and to replace trees and shrubbery removed during construction
10	Demobilization	• Final site clean up
11	Piping Connections	• Install valve vault installation and piping connections
12	Backfill and Grading	• Backfill earth against the tank, with the tank wall acting as a retaining wall for the site slope • Construct a 5-foot-wide permanent path around the unburied perimeter of the tank • Complete final site grading upon Sheila Tank completion (Grading will conform to the elevations shown on the civil drawings, the specifications covering earthwork, and recommendations in the geotechnical report
13	Fencing and Gates	• Install security fencing
14	Driveway	• Pave temporary access road with roughened concrete for future maintenance access • Install guardrails permanent access road

10.2 Tank Construction Sequencing

Construction sequencing for the concrete tank includes:

1. Construct tank floor, including a cast-in-place concrete foundation.
2. Construct cast-in-place walls and dome roof.
3. Apply vertical pre-stressing by incorporating vertical pre-stressing threadbars within the wall to provide vertical compression and counteract bending.
4. Install circumferential pre-stressing to counteract the liquid load and place the tank wall in 200-psig residual compression by wrapping the circumference of the tank with a continuous high-strength stranded cable.
5. Spray the exterior surface of the wrapped tank with shotcrete to provide corrosion protection and a permanent bond.
6. Install accessories, such as roof and wall access hatches, interior and exterior ladders, vents, safety railings, level sensing equipment, or specialized security hardware.
7. If requested by the District, stain or coat the reservoir exterior.

Based on recommendations in the geotechnical report and as noted above, constructing a prestressed concrete tank at the Sheila Tank site will require a temporary retaining wall and a 10-foot-wide path around the tank perimeter to facilitate circumferential pre-stressing and shotcrete application. Following tank construction, the contractor would remove the temporary retaining wall if required (e.g., the contractor could leave a soil nail wall in place) and backfill earth against the tank, with the tank wall acting as a retaining wall for the site slope. Upon completion of back filling, the contractor will add a 5-foot-wide permanent path around the unburied perimeter of the tank. The upslope tank side would have a v-ditch to carry uphill runoff around and away from the tank.

Section 11: Planning Level Cost Estimate

This section presents the preliminary construction cost for the tank and surrounding appurtenances and site improvements.

11.1 Construction Cost Estimate

BC based the construction cost estimate for a prestressed concrete tank on the following assumptions:

- Tank backfill will vary from 12 ft on the downslope side to almost 25 ft on the tank uphill side.
- No soil or excessive live loads are present on the tank roof.
- The roof will have a free-spanning concrete dome.
- The tank will have an interior floor elevation about 10 ft below final grade on the down slope.
- Construction will require a temporary retaining wall. The tank wall may serve as a permanent retaining wall following construction. The tank does not require 360-degree perimeter vehicle access.

Table 11-1 summarizes the preliminary cost estimate for the Sheila Tank Replacement. Attachment C contains the detailed estimate. The estimate conforms to AACE International standards for a Class 4 /order-of-magnitude estimate with a contingency of 30 percent and a probable cost range of -30 to + 50 percent.

Table 11-1. Sheila Tank Replacement Construction Cost Development[a]	
Item	Estimated Cost (million dollars)
Traffic Control	$0.06
Mobilization/Demobilization	$0.05
Miscellaneous Existing Conditions and Demolition	$0.05
Access road[b]	$0.10
Concrete Tank and Dome	$2.05
Electrical and Instrumentation[c]	$0.56
Excavation and backfill, Pad Cut	$0.12
Excavation and backfill, Tank Cut	$0.08
Excavation and backfill at Utility Vault	$0.04
Excavation and backfill at Access Road	$0.02
Temporary retaining wall[d]	$0.29
Miscellaneous Exterior Improvements	$0.14
Fence and Guardrail	$0.03
Landscaping and Permanent Retaining Wall[e]	$0.08
Grand total (million dollars)	$3.67
AACE Class 4 accuracy range (-30% to +50%) (million dollars)	$2.57 - $5.51
Cost per gallon ($/gallon) (-30% to +50%)	$4.28 - $9.18

a. *The construction cost of each item includes various mark-ups and a 30% contingency, see Attachment C for the detailed estimate.*

b. *The access road cost is based on an 8-inch thick roughened concrete overlay along the proposed site access road in Figure 6-3.*

c. *Electrical and Instrumentation costs are factored. Associated electrical costs are estimated at 15% of the total project costs. Associated instrumentation costs are estimated at 10% of the total project costs.*

d. *The retaining wall cost is based on a temporary retaining wall during construction.*

e. *The retaining wall cost is based on a permanent segmental retaining wall during construction.*

Section 12: Preliminary Drawing List

Based on the project described in this TM, BC developed an updated list of expected design drawings, (Table 12-1).

Table 12-1. Preliminary Design Drawings

GENERAL	
CS	COVER SHEET
G1	GENERAL NOTES 1
G2	GENERAL NOTES 2
CIVIL	
C-100	OVERALL SITE PLAN AND SURVEY CONTROL
C-101	SITE DEMOLITION PLAN
C-102	TEMPORARY GRADING PLAN
C-103	FINAL GRADING AND PAVING PLAN
C-104	SITE ACCESS ROAD PLAN AND PROFILE
C-105	SITE PIPING PLAN
C-500	CIVIL DETAILS 1
C-501	CIVIL DETAILS 2
STRUCTURAL	
S001	GENERAL NOTES
S002	STANDARD DETAILS
S101	TANK FOUNDATION AND ROOF PLAN
S102	TANK SECTIONS
PROCESS	
P-001	GENERAL NOTES
P-101	PROCESS AND INSTRUMENTATION DIAGRAM
MECHANICAL	
M-001	GENERAL NOTES
M-002	STANDARD DETAILS
M-101	PIPING PLAN AND SECTION
M-102	MIXING MANIFOLD
ELECTRICAL	
E-001	GENERAL NOTES
E-002	STANDARD DETAILS
E-003	SITE PLAN
E-004	SINGLE LINE DIAGRAM AND CONTROL DIAGRAM FOR MOTORIZED VALVE

References

Brown and Caldwell, Sheila Tank Re-Evaluation Technical Memorandum, Pacifica, California, North Coast County Water District, 2019.

Stetson Engineers, Inc., *20-year Long-Term Water Master Plan*, North Coast County Water District, 2016.

Attachment A: Updated Geotechnical Report

MPEG
MILLER PACIFIC
ENGINEERING GROUP

UPDATED GEOTECHNICAL INVESTIGATION
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

July 13, 2020

Project 2281.001

Prepared For:
North Coast County Water District
c.o. Brown and Caldwell
201 North Civic Drive, Suite 300
Walnut Creek, California 94596

Attn: Ms. Rachel Philipson

CERTIFICATION

This document is an instrument of service, prepared by or under the direction of the undersigned professionals, in accordance with the current ordinary standard of care. The service specifically excludes the investigation of radon, asbestos, toxic mold and other biological pollutants, and other hazardous materials. The document is for the sole use of the client and consultants on this project. Use by third parties or others is expressly prohibited without written permission. If the project changes, or more than two years have passed since issuance of this report, the findings and recommendations must be reviewed by the undersigned.

MILLER PACIFIC ENGINEERING GROUP
(a California corporation)

REVIEWED BY:

SCOTT A. STEPHENS
2398
Exp. 6/30/21

Monica Thornton

Monica Thornton
Project Engineer

Scott Stephens
Geotechnical Engineer 2398
(Expires 6/30/21)

UPDATED GEOTECHNICAL INVESTIGATION
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

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UPDATED GEOTECHNICAL INVESTIGATION
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

1.0 INTRODUCTION

This report summarizes our Updated Geotechnical Investigation for the planned Sheila Water Tank replacement project located downslope of Sheila Lane and upslope of Alvarado Avenue (APN 023-311-010) in Pacifica, California as shown on Figure 1. The purpose of our Geotechnical Investigation is to explore subsurface conditions, evaluate potential geotechnical hazards associated with the planned development, and provide geotechnical recommendations and design criteria for the project. We previously provided a Geotechnical Investigation Report dated July 26, 2016. In accordance with our Agreement dated June 1, 2020, we are providing our additional geotechnical engineering services in two phases: 1) Updated Geotechnical Investigation and Report and 2) supplemental consultation. This report completes our updated geotechnical report and includes the following:

- Review of readily available geotechnical and geologic reference materials within the site vicinity. Review of options and conceptual plans.
- Subsurface exploration consisting of one boring utilizing portable drilling equipment, that will extend through the near-surface soils and into firm soils or bedrock (extending to a depth of about 40 feet).
- Laboratory testing to characterize subsurface soils and aid in our geotechnical evaluation.
- Evaluation of relevant geologic hazards including seismic shaking, slope instability, and other hazards.
- Preparing geotechnical recommendations and design criteria related to building foundations, site grading, retaining walls, seismic design, and other geotechnical-related items.
- Preparation of a written report that summarizes the subsurface exploration and laboratory testing programs, evaluation of relevant geologic hazards, and geotechnical recommendations and design criteria.

2.0 PROJECT DESCRIPTION

The project includes replacement of an existing +/- 100,000-gallon redwood water tank with +/- 450/600,000-gallon concrete tank, roughly in the same location. Additional site grading (primarily excavation) is expected to enlarge the tank pad, and a moderate sized retaining wall / shoring wall will be needed to retain cuts on the upslope side of the tank. Locations of the planned improvements are shown on Figure 2.

3.0 SITE CONDITIONS

3.1 Regional Geology

The site is located within the Coast Range Geomorphic Province of California. The regional bedrock geology consists of complexly folded, faulted, sheared, and altered sedimentary, igneous, and metamorphic rock of the Jurassic-Cretaceous age (65-190 million years ago) Franciscan Complex. Bedrock of the Franciscan Complex is characterized by a diverse assemblage of greenstone, sandstone, shale, chert, and mélange, with lesser amounts of conglomerate, calc-silicate rock, schist, and other metamorphic rocks.

The regional topography is characterized by northwest-southeast trending mountain ridges and intervening valleys that were formed from tectonic activity between the North American Plate and the Pacific Plate. Extensive faulting during the Pliocene Age (1.8-7 million years ago) formed the ridge crests and adjoining uneven depression that is now the San Francisco Bay. The more recent tectonic activity within the Coast Range Geomorphic Province is concentrated along the San Andreas Fault zone, a complex group of generally parallel faults.

Regional geologic maps (Pampeyan, 1994) by the United States Geologic Survey indicate the site is underlain by conglomerate bedrock (fcg). The unit is described as well-consolidated pebble to cobble conglomerate, with clasts composed primarily of coarsely crystalline igneous rocks. Adjacent areas are mapped as “sheared bedrock”, which generally includes highly deformed sedimentary deposits of shale and sandstone. A regional geologic map is presented on Figure 3.

3.2 Surface Conditions

The project site is located on the southwest-facing hillside between Sheila Lane and Alvarado Avenue, in eastern Pacifica, California. The existing, redwood-sided, 100,000-gallon water tank is located on a flat pad cut into the hillside. An existing gravel driveway provides access to the project site from Sheila Lane. The area of the existing tank is surrounded by a chain-link and barbed wire fence. Natural slopes generally slope down to the southwest at inclinations of about 1.5:1 to 2:1 (horizontal:vertical). The slopes are vegetated with low grasses and some mature trees and shrubs.

3.3 Field Exploration and Laboratory Testing

We performed subsurface exploration at the project site with two auger borings conducted on April 4, 2016 and one additional boring conducted on June 12, 2020. Borings were excavated at the approximate locations shown on Figure 2 with a portable hydraulic-powered or track-mounted drilling rig equipped with 4-inch solid flight auger. Materials encountered were examined and logged in the field by our Geologist, who collected samples at select intervals for laboratory testing. Brief descriptions of the terms and methodology used in classifying earth materials are presented on the Soil and Rock Classification Charts, Figures A-1 and A-2, respectively, and the exploratory boring logs are shown on Figures A-3 through A-6.

Laboratory testing of relatively “undisturbed” samples from our exploratory borings includes moisture content, dry density, unconfined compressive strength, and triaxial compression testing. The results of our laboratory testing are presented on the Boring Logs and the results of the triaxial compression testing are presented on Figures A-7 and A-8. The field exploration and laboratory testing program is discussed in greater detail in Appendix A.

3.4 Subsurface Conditions

Our subsurface exploration generally confirms the regionally mapped geologic conditions at the site. Boring 1, drilled on the southwest (downslope) side of the existing tank pad, encountered about 3- to 4-feet of stiff to very stiff, sandy clay colluvial soils over approximately 4-feet of pebble conglomerate bedrock. This was in turn underlain by interbedded sandstone and shale bedrock to the maximum explored depth of 15-feet. Boring 2, excavated upslope of the tank pad, encountered approximately 4-feet of stiff to very stiff, clayey residual soils over weathered conglomerate bedrock. Boring 2 was terminated at depth of 13.0-feet due to auger refusal in hard rock. Boring 3, excavated upslope of the tank pad, encountered 1- to 2-feet of loose to medium dense silty sand underlain by pebble/cobble conglomerate bedrock to the maximum explored depth of 40.5-feet.

Based on the exploration, there is a geologic contact between the conglomerate and sandstone bedrock units which dips downward into the hillside and thus is not in an adverse orientation.

3.5 Groundwater

Groundwater was not encountered in any of our borings. The borings were backfilled shortly after drilling was completed, so it is possible a stabilized depth to groundwater was not observed. We note groundwater can vary seasonally and be at higher elevations during the winter and spring months. The hillside topography is such, that high groundwater would not be expected. Groundwater seepage should be expected along the soil to bedrock contact during winter.

3.6 Seismicity

3.6.1 Active Faults in the Region

The project site is located within a seismically active region that includes the Central and Northern Coast Mountain Ranges. Several active faults are present in the area including the San Andreas, San Gregorio, Hayward, West Napa, and Rodgers Creek, among others. An “active” fault is defined as one that shows displacement within the last 11,000 years and, therefore, is considered more likely to generate a future earthquake than a fault that shows no evidence of recent rupture. The California Department of Conservation, Division of Mines and Geology has mapped various active and inactive faults in the region (CDMG, 1972 and 2000). These faults are shown in relation to the project site on the attached Active Fault Map, Figure 4. The San Andreas and San Gregorio Faults are the nearest known active faults to the site and are located about 5.0-km southwest and 4.7-km northeast, respectively.

3.6.2 Historic Fault Activity

Numerous earthquakes have occurred in the region within historic times. A map showing the distribution of M>2.0 earthquakes since 1985 in the San Francisco Bay Region is shown on Figure 5.

3.6.3 Probability of Future Earthquakes

The site will likely experience moderate to strong ground shaking from future earthquakes originating on any of several active faults in the San Francisco Bay region. The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probabilities in California, the USGS has assembled a group of researchers into the “Working Group on California Earthquake Probabilities” (USGS 2003, 2008; Field, et al, 2015) to estimate the probabilities of earthquakes on active faults. These studies have been published cooperatively by the USGS, CGS, and Southern California Earthquake Center (SCEC) as the Uniform California Earthquake Rupture Forecast, Versions 1, 2, and 3 (aka UCERF, UCERF2, and UCERF3, respectively). In these studies, potential seismic sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, micro-seismicity, and other factors to arrive at estimates of earthquakes of various magnitudes on a variety of faults in California.

The 2003 study UCERF specifically analyzed fault sources and earthquake probabilities for the seven major regional fault systems in the Bay Area region of northern California. The 2008 study UCERF2 applied many of the analyses used in the 2003 study to the entire state of California and updated some of the analytical methods and models. The most recent 2013 study UCERF3 further expanded the database of faults considered and allowed for consideration of multi-fault ruptures, among other improvements.

Conclusions from the most recent UCERF3 and USGS' 2016 Fact Sheet indicate there is a 72% chance of an M>6.7 earthquake in the San Francisco Bay Region between 2014 and 2043. The highest probability of a M>6.7 earthquake on any of the active faults in the region is assigned to the Hayward and Rodgers Creek Faults, located approximately 34.6-km northeast of the site, at 33%. The nearest known active fault is the San Andreas Fault, located 5.0-km southwest, is assigned a 22% probability of a M>6.7 earthquake by 2043. Additional studies regarding earthquake probabilities in the Bay Area are ongoing.

4.0 GEOLOGIC HAZARDS EVALUATION

This section summarizes our review of commonly considered geologic hazards, discusses their potential impacts to the planned development, and identifies potential mitigation options. The primary geologic hazards which could affect the proposed water tank are strong ground shaking, erosion, and slope instability. Other hazards, such as fault rupture, liquefaction, seiche and tsunami, flooding, and expansive soils are not considered significant at the site. Geologic hazards, their potential impacts, and recommended mitigation measures are discussed below.

4.1 Fault Surface Rupture

Under the Alquist-Priolo Earthquake Fault Zoning Act, the California Geological Survey (CGS) produced 1:24,000 scale maps showing all known active faults and defining zones within which special fault studies are required. Based on currently available published geologic information, the project site is not located within an Alquist-Priolo Earthquake Fault Zone (CDMG, 1972). The locations of known active faults relative to the project site are shown on Figure 4. We judge the potential for fault surface rupture in the development area to be low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.2 Seismic Shaking

The site will likely experience seismic ground shaking similar to other areas in the seismically active Bay Area. Earthquakes along several active faults in the region could cause moderate to strong ground shaking at the site.

Deterministic Seismic Hazard Analysis – Deterministic Seismic Hazard Analysis (DSHA) predicts the intensity of earthquake ground motions by analyzing the characteristics of nearby faults, distance to the faults and rupture zones, earthquake magnitudes, earthquake durations, and site-specific geologic conditions. A summary of the principal active faults affecting the site, their closest distance, moment magnitude of characteristic earthquake and probable peak ground accelerations (PGA), which an earthquake on the fault could generate at the site are shown in Table A.

TABLE A
DETERMINISTIC PEAK GROUND ACCELERATION
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

Fault	Approx. Fault Distance[1]	Max. Moment Magnitude[1]	Median PGA[2,3]	+1σ PGA[2,3]
San Andreas	5.0 km	8.0	0.44 g	0.79 g
San Gregorio	4.7 km	7.4	0.41 g	0.75 g
Hayward	34.6 km	7.3	0.10 g	0.20 g
Zayante-Vergeles	50.5 km	7.0	0.08 g	0.12 g
Silver Creek	41.6 km	6.9	0.07 g	0.13 g

Notes:
1. Caltrans ARS V2.3.06 (2019)
2. Abrahamson, Silva and Kamai (2014), Boore, Stewart, Seyhan and Atkingson (2014), Campbell and Borzognia (2014), Chiou and Youngs (2014)
3. Values determined using Vs^{30} = 760 m/s for Site Class “B”

Probabilistic Seismic Hazard Analysis – Probabilistic Seismic Hazard Analysis (PSHA) analyzes all possible earthquake scenarios while incorporating the probability of each individual event to occur. The probability is determined in the form of the recurrence interval, which is the average time for a specific earthquake acceleration to be exceeded. The design earthquake is not solely dependent on the fault with the closest distance to the site and/or the largest magnitude, but rather the probability of given seismic events occurring on both known and unknown faults.

We calculated the PGA for two separate probabilistic conditions, the 2% chance of exceedance in 50 years (2,475-year statistical return period) and the 10% chance of exceedance in 50 years (475-year statistical return period), utilizing the USGS Unified Hazard Tool (USGS, 2008b). Deterministic methods, as discussed above, or the PGA arising from a probabilistic analysis for a 10% chance of exceedance in 50 years are commonly utilized for residential, commercial, and industrial developments, while the PGA arising from a probabilistic analysis for a 2% chance of exceedance in 50 years is typically used for “critical” facilities such as schools and hospitals. The results of the probabilistic analyses are presented below in Table B.

TABLE B
PROBABILISTIC SEISMIC HAZARD ANALYSES
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

	Statistical Return Period	Mean Moment Magnitude[1]	Peak Ground Acceleration (g)[1]
2% in 50 years	2,475 years	7.6	0.89 g
10% in 50 years	475 years	7.5	0.45 g

Notes:
1.) USGS Unified Hazard Tool, Dynamic Conterminous US (2008) model version 3.3.1, https://earthquake.usgs.gov/hazards/interactive, accessed July 13, 2020.

The potential for strong seismic shaking at the project site is high. Due to its close proximity, the San Andreas Fault presents the highest potential for severe ground shaking. The most significant adverse impact associated with strong seismic shaking is potential damage to structures and improvements.

Ground shaking can result in structural failure and collapse of structures or cause non-structural building elements, such as light fixtures, shelves, cornices, etc., to fall, presenting a hazard to building occupants and contents. Compliance with the provisions of the most recent edition (2019) of the California Building Code (CBC) should result in structures that do not collapse in an earthquake. Hazards associated with falling objects or damage to non-structural building elements will remain.

Evaluation: *Less than significant with mitigation.*

Mitigation: *Mitigation measures should include, as a minimum, designing the structure in accordance with the 2019 California Building Code (CBC). Recommended CBC seismic coefficients are provided in Section 5.2 of this report. If requested by the project Structural Engineer, we can prepare a site-specific seismic response spectrum for the building design.*

4.3 Landsliding and Slope Stability

Slope instability generally occurs in relatively steep slopes and/or on slopes underlain by weak materials. No landslides are shown on regional maps close to the site; however, we did observe some shallow sloughing and raveling of the cut slope upslope of the existing tank. We judge the risk of damage to new improvements due to significant landsliding is generally low to moderate. The fill slope below the tank may be susceptible to shallow sloughing an erosion.

Evaluation: *Less than significant with mitigation.*

Mitigation: *Grading for the new tank pad and foundations for the new tank and site retaining walls should be designed as described in Section 5.0. Tall unsupported vertical cuts should be avoided. The foundation for the new tank should bear on bedrock and permanent cut slopes should not be steeper than 2:1.*

4.4 Liquefaction Potential and Related Impacts

Liquefaction refers to the sudden, temporary loss of soil strength during strong ground shaking. This phenomenon can occur in saturated, loose, granular deposits (typically sand) when the sediments are subjected to seismic shaking. Liquefaction can result in flow failure, lateral spreading, and settlement. Based on our experience at nearby sites and our subsurface exploration we do not expect liquefiable soils at the site.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.5 Seismic Induced Ground Settlement

Seismic ground shaking can induce settlement of unsaturated, loose, granular soils. Settlement occurs as the loose soil particles rearrange into a denser configuration when subjected to seismic ground shaking. Varying degrees of settlement can occur throughout a deposit, resulting in differential settlement of structures founded on such deposits. The site includes shallow bedrock with a varying layer of loose to medium dense silty sands at the ground surface. Therefore, we judge there is a low risk of damage to improvements due to seismically induced ground settlement.

Evaluation: *Less than significant with mitigation.*
Mitigation: *To reduce the risk of damage due to seismically induced settlement, site preparation should include scarifying and recompacting loose surface soils during building pad preparation. Recommendations for site preparation and grading are presented in Section 5.3 of this report.*

4.6 Lurching and Ground Cracking

Lurching and associated ground cracking can occur during strong ground shaking. The ground cracking generally occurs along the tops of slopes where stiff soils are underlain by soft deposits or along steep slopes or channel banks. These conditions were not encountered or observed during our exploration and therefore, the risk of lurching and ground cracking is low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.7 Erosion

Sandy soils on moderate slopes or clayey soils on steep slopes are susceptible to erosion when exposed to concentrated water runoff. Construction of the new tank will occur on existing level pad, however, grading for the new tank pad will result in some disturbance of surficial soils. Therefore, we judge there is a low to moderate risk of damage to improvements due to erosion.

Evaluation: *Less than significant with mitigation.*
Mitigation: *All disturbed slopes should be provided with erosion-control measures and be re-vegetated as soon as practical following construction to reduce the risk of erosion. During construction, erosion- and sediment-control measures should be implemented in accordance with the most recent edition of the California Stormwater Quality Association Best Management Practiced Handbook.*

4.8 Seiche and Tsunami

Seiche and tsunamis are short duration, earthquake-generated water waves in large enclosed bodies of water and the open ocean, respectively. The project elevations range from approximately +230 to +320 above mean sea level and is not located near a large body of water, therefore the risk of damage to improvements from seiche or tsunami inundation is remote.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.9 Expansive Soils

Typically, clayey, and silty soils tend to change volume due to fluctuations in moisture content, with expansion occurring when wetted and shrinking when dry. The change in volume is attributed to the molecular attraction of small clay and/or silt particles to water. The soil particles push apart from each other to allow water molecules to attach between. Conversely the soil particles pull back together as the water leaves the soil matrix. Sand and gravel particles tend to be non-expansive.

Expansive soils can vary in the degree of volume change from very low to very high. At the higher end of volume change, expansive soils are capable of exerting significant expansion pressures on building foundations, interior floor slabs and exterior flatwork. Distress from expansive soil movement can include cracking of brittle wall coverings (stucco, plaster, drywall, etc.), racked door and/or window frames, and uneven floors and cracked slabs. Lightly loaded flatwork, pavements, and concrete slabs-on-grade are particularly vulnerable to distress.

Surficial soils were typically sandy in nature with low plasticity clay so the risk of expansive soil/bedrock at the project site is judged to be low.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.10 Settlement/Subsidence

Settlement of foundations may occur when structures are constructed over compressible clay layers or loose sands. Soft compressible clay deposits are not expected at the project site. Provided foundations bear on bedrock, settlement is not expected to be a significant hazard at the site.

Evaluation: *No significant impact.*
Mitigation: *No mitigation measures are required.*

4.11 Flooding

The project site is located on a hillside and is well above large scale flood elevations. However, as with all development sites, localized ponding/flooding is possible due to changes in the natural drainage patterns. The project Civil Engineer or Architect is responsible for site drainage and should evaluate localized flooding potential around the structures and provide appropriate mitigation measures.

Evaluation: *Less than significant with mitigation.*
Mitigation: *The project Civil Engineer or Architect should evaluate the risk of localized flooding and provide appropriate surface slopes and storm drain design.*

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the results of our investigation, we conclude that the site is suitable for the planned tank and site improvements. The primary geotechnical issues include appropriate seismic design and adequate foundation support for new water tank. Design level geotechnical recommendations and criteria for the project are presented in the following sections.

5.2 Seismic Design

Minimum mitigation of ground shaking includes seismic design of the structures in conformance with the provisions of the most recent versions of American Water Works Association (2011) or the California Building Code (2019). We recommend seismic design per the more recently updated CBC. The magnitude and character of these ground motions will depend on the particular earthquake and the site response characteristics. Based on the interpreted subsurface conditions and proximity of the San Andreas and San Gregorio Faults, we recommend the CBC coefficients and site values shown in Table C below to calculate the design base shear. To determine site seismic coefficients, we used the USGS Earthquake Ground Motion Parameters Java application, Version 5.1.0, using the latitude and longitude shown on Figure 4.

TABLE C
2019 CBC SEISMIC DESIGN FACTORS
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

Factor Name	Coefficient	Site Specific Value(1)
Site Class(2)	$S_{A,B,C,D,E,\text{ or }F}$	S_B
Spectral Acc. (short)	S_s	1.93 g
Spectral Acc. (1-sec)	S_1	0.79 g
Site Coefficient	F_a	1.0
Site Coefficient	F_v	1.0

1) Values determined in accordance with the ASCE 7-16 Section 11.4.8 standard.
2) Site Class B Description: Rock, Shear Wave Velocity between 2,500 and 5,000 feet per second, Standard Penetration Test N value greater than 50, and Undrained Shear Strength greater than 2,000 psf.

5.3 Site Grading

Based on our review of the preliminary project plans we anticipate a moderate amount of site grading during construction in order to create the level pad for the new tank and moderate retaining wall. Site preparation and grading should conform to the following recommendations and criteria:

5.3.1 Surface Preparation

Clear all trees, brush, roots, over-sized debris, and organic material from areas to be graded. Trees that will be removed (in structural areas) must also include removal of stumps and roots larger than four inches in diameter. Excavated areas (i.e., excavations for stump removal or old concrete foundations or other debris) should be restored with properly moisture conditioned and compacted fill as described in the following sections. Any loose soil or rock at subgrade will need to be excavated to expose firm natural soils or bedrock. Debris, rocks larger than six inches and vegetation are not suitable for structural fill and should be removed from the site. Alternatively, vegetation strippings may be used in landscape areas.

Where fills or other structural improvements are planned, any soil subgrade surface should be scarified to a depth of about eight inches, moisture conditioned to above the optimum moisture content, and compacted to a minimum of 90 percent relative compaction (ASTM D-1557). Relative compaction should be increased to a minimum of 95% where new pavements subjected to vehicle loads are planned. Relative compaction, maximum dry density, and optimum moisture content of fill materials should be determined in accordance with ASTM Test Method D 1557, "Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using a 10-lb. Rammer and 18-in. Drop." Exposed bedrock does not need to be scarified and recompacted. If soft, wet, or otherwise unsuitable materials are encountered at the subgrade elevation during construction, we will provide supplemental recommendations/field directives to address the specific condition.

5.3.2 Excavations

Site excavations for new tanks, underground utilities, and other improvements will generally encounter shallow pebble conglomerate bedrock. Based on the drilling conditions encountered, we judge that some of the onsite excavations within the site bedrock may be accomplished with “traditional” grading equipment such as backhoes and moderately sized dozers with rock rippers and excavators with “rock” teeth. However, specialized excavation techniques, such as “hoe-ramming”, low-impact blasting or rock splitting using expansive chemical grouts may be needed to excavate deeper hard bedrock. Therefore, we recommend including a line item for hard rock excavation in the project bid documents. “Hard rock” should be defined as material which cannot be excavated at a reasonable production rate with equipment typically used for excavation work in similar terrain (i.e., Caterpillar 330 or equivalent excavator equipped with a bucket and “rock” teeth). If hard rock is encountered during construction which prohibits excavation to the required depths, we should be consulted to observe conditions and revise our recommendations and/or design criteria, as appropriate.

All excavations greater than 5-feet in depth which will be entered by workers must be shored or braced in accordance with Cal/OSHA regulations. Based on our exploration, we judge the majority of bedrock should be considered “Type A” soils per OSHA guidelines. Some bedrock may be considered stable rock. We should inspect subgrade materials to confirm this recommendation. The project contractor is responsible for site safety and should provide shoring as needed to maintain stability in open excavations. Many types of shoring systems are available, and the selected system should be capable of providing immediate support to the sides of the excavation to minimize the amount of time the walls are unsupported.

5.3.3 Materials

Soil and rock mixtures generated from on-site excavations should be suitable for use as fill provided they are free of organic materials, have maximum particle sizes less than 4-inches, and are sufficiently mixed well with a range of particle sizes so voids do not exist in compacted materials. Any moderately or highly expansive soils observed during grading should be excavated and removed from the site. The plasticity index of any new fill material should be less than 20.

5.3.4 Compacted Fill

Fill should be placed on a properly prepared level subgrade as described above. Properly moisture conditioned and cured on-site, or imported materials should subsequently be placed in loose horizontal lifts of 8-inches thick or less, and uniformly compacted to at least 90 percent relative compaction.

If imported fill is required, the material shall consist of soil and rock mixtures that: (1) are free of organic material, (2) have a Liquid Limit less than 40 and a Plasticity Index of less than 15, and (3) have a maximum particle size of 4-inches. Any imported fill material needs to be tested to determine its suitability for use as fill material.

5.3.5 Permanent and Temporary Cut Slopes

Temporary (steeper) cut slopes will be required during construction until retaining walls are constructed and backfilled. For planning purposes, the majority of site excavations encountered pebble conglomerate bedrock. Based on our experience with these rock types, subsurface conditions should be classified as OSHA Type “A” Soils. Geologic inspection during excavation will be required to verify that the above recommendations are appropriate for the conditions encountered.

Performance of temporary cut slopes will be heavily dependent on the amount of time the cut is unsupported, seepage and surface runoff over the face, bedding and fracture planes of rock and soil materials, and other factors. The steeper (temporary) cut slopes may exhibit some sloughing, especially during wet weather conditions, and cleanup of soil and rock debris at the base of slopes may be required. We recommend the project grading contractor be responsible for the performance of temporary cut slopes, and we should be present intermittently during construction to verify that the above recommendations remain appropriate for actual conditions encountered.

Top down construction with soil nail walls and shotcrete would allow for vertical excavation and provide lateral support as the excavation deepens. Temporary vertical cuts for the wall should not exceed 6 feet without lateral support from soil nails and shotcrete facing.

Permanent cut slopes excavated into soil/soft rock and competent bedrock should be inclined no steeper than 2:1 and 1:1, respectively. Concrete lined v-ditches should be provided 5-feet back from the top of the cut slope. Additionally, the top of the cut slope should be trimmed and rounded to reduce the potential of minor sloughing at the grade break.

Properly designed and constructed cut slopes should perform as well as adjacent slopes. However, rock conditions in this geologic area are variable, not totally predictable, and may therefore need modification during construction. Periodic slope maintenance after construction, such as the cleanup of rock debris, may be required.

5.4 Foundation Design

Bedrock is relatively shallow throughout the site, with up to about 4 feet of sandy clay encountered toward the downslope edge of the existing tank pad. The tank can utilize a shallow foundation, but to reduce potential for differential settlement, the footings should be deepened to provide uniform bearing support on the weathered bedrock. Drilled, cast-in-place piers could also be utilized for the tank foundation to extend through soils and into the underlying bedrock. Drilled piers or rock anchors can be utilized for overturning resistance. Geotechnical design criteria for the tank foundation are presented in Table D.

TABLE D
FOUNDATION DESIGN CRITERIA
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

Shallow Spread Footings	
Minimum depth:[1]	18 inches
Allowable bearing capacity:[2]	
Weathered Bedrock	3,000 psf
Base friction coefficient:	0.35
Lateral passive resistance:[3,4]	
Sandy Clay Soils	250 pcf
Weathered Bedrock	400 pcf
Rock Anchors	
Min. Diameter:	4 inches
Allowable Skin Friction[5]	2,500 psf
Drilled Piers	
Minimum embedment:	5 feet
Allowable skin friction [2, 6]:	
Sandy Clay Soils	1,000 psf
Weathered Bedrock	2,500 psf
Lateral passive resistance[7]:	
Sandy Clay Soils	250 pcf
Weathered Bedrock	400 pcf

Notes:
(1) Foundations to bear on weathered bedrock. Maintain at least 10 feet horizontal distance from base of footing to slope.
(2) May increase design values by 1/3 for total design loads including wind or seismic.
(3) Equivalent fluid pressure. Not to exceed 4000 psf.
(4) Ignore uppermost foot of resistance.
(5) Anchors should be specified with a minimum bonded length and minimum capacity. All rock anchors shall be double corrosion-protected anchors and should be tested to at least 1.33 times the design load per the “Recommendations for Prestressed Rock and Soil Anchors” by the Post-Tensioning Institute, Phoenix, Arizona.
(6) Use 80 percent of skin friction for uplift design.
(7) Apply lateral passive resistance over width of two pier diameters.

5.5 Retaining Wall Design

We understand retaining walls will be utilized to create a level building pad for the planned improvements to reduce required extent of grading. For cost-effective construction and to avoid deep unsupported cuts, we recommend that taller site retaining walls consist of shotcrete-faced walls supported with soil-nails or rock anchors where cuts are planned. This wall could be used as a temporary shoring wall with the new tank constructed immediately adjacent, or it could be a permanent, separate site wall to provide an access road all around the tank. Alternatively, laid-back excavation of temporary slopes and construction of conventional cast-in-place reinforced concrete walls could be used. However, extent of required grading or temporary shoring of cut slopes will significantly complicate the construction of these types of walls.

Steeper, temporary slopes (than those discussed in Site Grading) may be possible during dry conditions and for short term excavations, such as cuts for soil-nail wall construction. However, adversely bedded rock or seepage/weak soils near the ground surface may require flattening the temporary slopes. Six-foot-high vertical cuts should generally be feasible for construction of wall segments.

Retaining walls that can deflect at the top, such as site walls, can be designed using the unrestrained criteria shown in Table E. Walls that are structurally connected at the top and not allowed to deflect, such as basement or tied-back walls, are considered restrained. Restrained conditions are commonly designed using a uniform earth pressure distribution rather than an equivalent fluid pressure. Lateral support can be obtained from either passive soil resistance (i.e., keyways) or frictional sliding resistance of footings or from tiebacks. In addition to the soil loads, the retaining walls should be designed to resist temporary seismic loads.

TABLE E
RETAINING WALL DESIGN CRITERIA
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

Foundation: See Table D

	Unrestrained Earth Pressure[1,2]	Restrained Earth Pressure[1,3]
Level Ground	40 pcf	30 X H psf
2:1 Slope	60 pcf	40 X H psf
Seismic Surcharge[3,4]		15 x H psf

Tiebacks[5]:

Minimum Diameter:	5 inches
Design Skin Friction:	
Pebble Conglomerate Bedrock:	2,500 psf
Unbonded Zone:	0.7 x Wall Height, 6 Feet Min

	Phi[6]	C (psf)[7]	Gamma (pcf)[8]
Sandy Clay Soils (upper 5')	32°	500	125
Weathered Bedrock	36°	1,500	130

Notes:

(1) Interpolate earth pressures for intermediate slopes.
(2) Equivalent fluid pressure.
(3) Rectangular distribution. H = Wall Height = top of soil backfill to bottom of wall.
(4) The factor of safety for short-term seismic conditions can be reduced to 1.1 or greater.
(5) Tiebacks should be specified with a minimum bonded length and minimum capacity. All tiebacks shall be double corrosion protected anchors that are installed and tested to at least 1.33 times the design load per the "Recommendations for Pre-stressed Rock and Soil Anchors" by the Post-Tensioning Institute, Phoenix, Arizona.
(6) Angle of Internal Friction, effective stress.
(7) Apparent (effective) Cohesion, for seismic conditions 250 psf of additional cohesion may be included.
(8) Unit Weight of Soil
(9) Ignore skin friction within active wedge of wall (approximately equal to wall height).

All walls higher than 3-feet require drainage to prevent the build-up of hydrostatic pressure. Either Caltrans Class 1B permeable material within filter fabric, drainage panels, or Caltrans Class 2 permeable material can be used. The project Architect should design a water-proofing system for walls adjacent to living space. The drainage should be collected in 4-inch, perforated, Schedule 40 PVC drain line placed at the base of the wall or discharged through weep-holes in the case of soil nail or cast-in-place concrete walls. Seepage collected in the drains should be conveyed in a closed pipe system to a suitable discharge outlet well away from the structures.

To maintain the wall drainage system, clean-outs must be provided for perforated pipes at the upstream end. Sweep fittings should be used at all major changes in direction. A typical retaining wall drain detail is shown on Figure 6. Retaining wall backfill should be compacted in accordance with the recommendations presented in site grading.

5.6 Concrete Slabs-on-Grade

Slab floors may be poured monolithically or independently from the foundation system, at the Structural Engineer's discretion. We generally recommend a minimum 5-inch thick slab section that is reinforced with bars (not mesh). The upper 8-inches of soil subgrade beneath any concrete slabs should be scarified and compacted to a minimum of 95 percent relative compaction per ASTM D-1557.

5.7 Underground Utilities

New utility line trenches should be backfilled with soil compacted to at least 90 percent relative compaction. Refer to County Standards and/or the pipe manufacturer for utility backfill bedding. In areas where utility trenches cross under concrete slab areas that are not subjected to vehicle loads, the top 12 inches should be compacted to at least 95 percent relative compaction.

5.8 Site Drainage and Erosion Control

To control surface water near the new structure, slope the area around the tank downward at least 0.25 feet for 5 feet away from foundations, or as specified in the CBC. Surface water should be directed into a suitable storm drainage facility. All sloped surfaces disturbed during the construction operations should be planted for erosion protection and regularly maintained. If construction occurs during the rainy season (typically between October 15 and April 15), then erosion control measures such as silt fences and straw wattles shall be designed by the project Civil Engineer.

Surface runoff from the slopes above the proposed water tank site will need to be re-directed away from the new structures. The retaining wall upslope of the tank should be designed with enough "freeboard" that a surface drainage swale and/or concrete V-ditch can be constructed upslope of the retaining wall to capture and re-direct surface runoff around the water tanks and into the surface drainage system. Details of the required drainage improvement should be designed by the project civil engineer.

5.9 Pavements

We have calculated thicknesses for asphalt pavements in accordance with Caltrans procedures for flexible pavement design. Our calculations assume an R-value of 20 for subgrade soils and a range of Traffic Indices from 4.0 to 7.0 depending on the expected traffic loads for a twenty-year design life. The R-value should be confirmed with laboratory testing. In general, areas expected to experience loading from heavy vehicles should be designed using the higher Traffic Index, while parking areas and other lightly loaded areas can utilize a thinner pavement section based on the lower Traffic Index. The recommended pavement sections are presented in Table F.

TABLE F
ALTERNATIVE ASPHALT PAVEMENT SECTIONS
NORTH COAST COUNTY WATER DISTRICT
SHEILA TANK REPLACEMENT PROJECT
PACIFICA, CALIFORNIA

Traffic Index	Asphalt Concrete (inches)	Class 2 Aggregate Base (inches)
4.0	2.5	6.0
5.0	3.0	8.0
6.0	4.0	9.0
7.0	5.0	10.0

Notes:

1. Traffic Index for final pavement design to be determined by the project Civil Engineer

In pavement areas, the upper 12 inches of subgrade should be compacted to at least 95 percent relative compaction. The aggregate base and asphalt-concrete should conform to the most recent version of Caltrans Standard Specifications and should be compacted to at least 95 percent relative compaction. Additionally, the subgrade and aggregate base should be firm and unyielding under heavy, rubber-tired construction equipment. If heavier truck traffic or "superior" performance is desired, the thickness of the aggregate base and asphalt may be increased.

6.0 LIMITATIONS

We believe this report has been prepared in accordance with generally accepted geotechnical engineering practices in San Mateo County at the time the report was prepared. This report has been prepared for the exclusive use of North Coast County Water District and/or their assignees specifically for this project. No other warranty, expressed or implied, is made. Our evaluations and recommendations are based on the data obtained during our subsurface exploration program and our experience with soils in this geographic area.

Our approved scope of work did not include a detailed environmental assessment of the site. Consequently, this report does not contain detailed information regarding the presence or absence of toxic or hazardous wastes.

The evaluations and recommendations do not reflect variations in subsurface conditions that may exist between boring locations or in unexplored portions of the site. Should such variations become apparent during construction, the general recommendations contained within this report will not be considered valid unless MPEG is given the opportunity to review such variations and revise or modify our recommendations accordingly. No changes may be made to the general recommendations contained herein without the written consent of MPEG.

We recommend that this report, in its entirety, be made available to project team members, contractors, and subcontractors for informational purposes and discussion. We intend that the information presented within this report be interpreted only within the context of the report as a whole. No portion of this report should be separated from the rest of the information presented herein. No single portion of this report shall be considered valid unless it is presented with and as an integral part of the entire report.

7.0 SUPPLEMENTAL GEOTECHNICAL SERVICES

If requested, we can perform engineering analyses and design the soil nail and shot-crete retaining walls. Our service could include plans, details, technical specifications, and calculation package for use in the contract documents. We can provide a scope and fee estimate upon request.

We must review the plans and specifications for the project when they are nearing completion to confirm that the intent of our geotechnical recommendations has been incorporated and provide supplemental recommendations, if needed. During construction, we need to observe and/or test site preparation and foundation excavations along with other geotechnical work items to adjust the work if needed and confirm that the conditions encountered are consistent with the design criteria.

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Idriss, I.M. "An Overview of Earthquake Ground Motions Pertinent to Seismic Zonation." Fifth International Conference on Seismic Zonation, Nice French Riviera, 1995.

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United States Geologic Survey, "Documentation for the 2008 Update of the United States National Seismic Hazard Maps," Open-File-Report 2008-1128, 2008.

United States Geological Survey (USGS), “Earthquake Probabilities in the San Francisco Bay Region, 2002 to 2031 – A Summary of Finding,” The Working Group on California Earthquake Probabilities, Open File Report 99-517, 2003.

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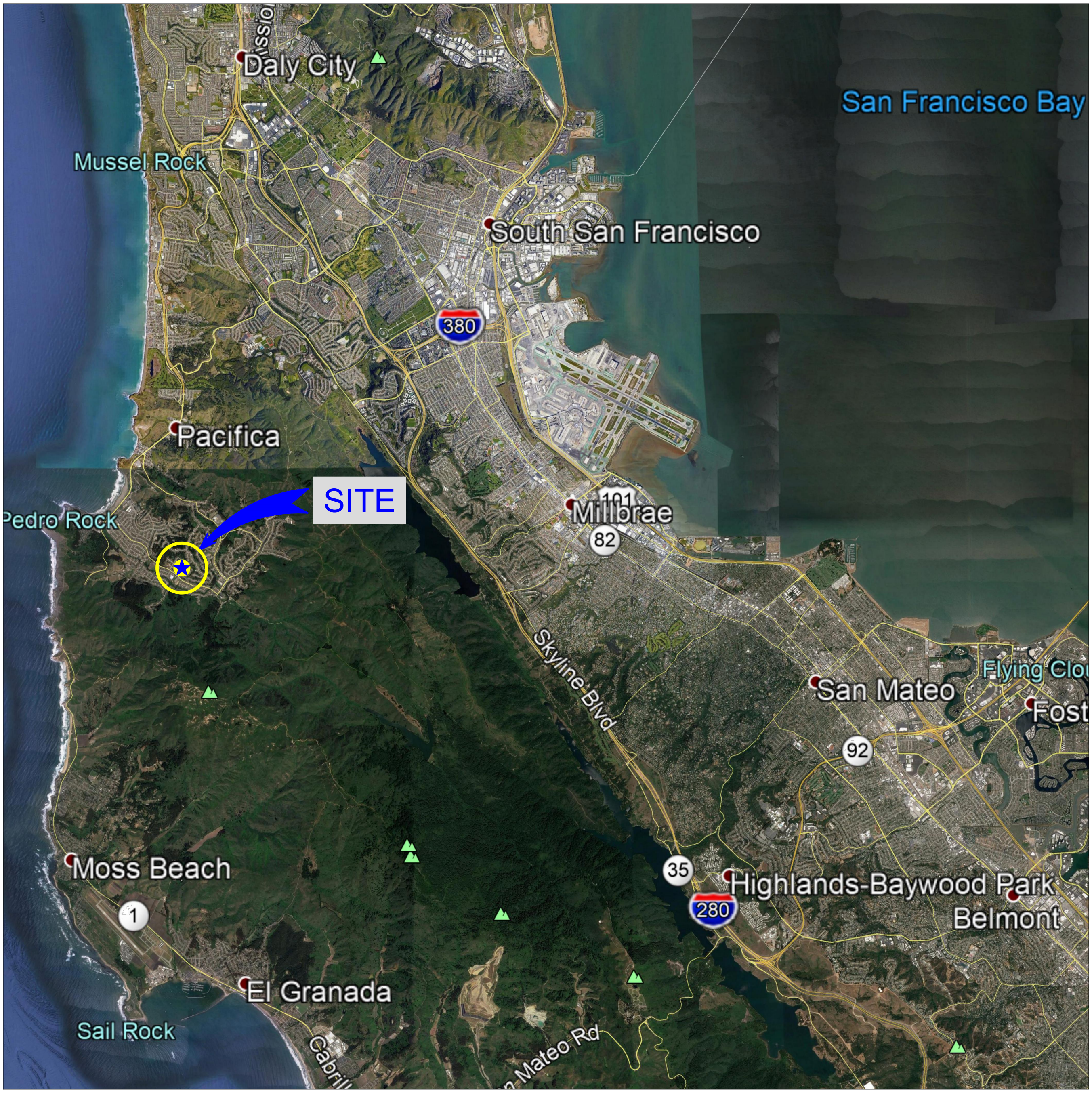
Wesnousky, Steven G., "Earthquakes, Quaternary Faults, and Seismic Hazard in California," Journal of Geophysical Research, Vol. 91, No. B12, pp. 12587-12631, 1986.



SITE: LATITUDE, 37.5861°
LONGITUDE, -122.4857°

SITE LOCATION

N.T.S.

NORTH

REFERENCE: Google Earth, 2020

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SITE LOCATION MAP

North Coast County Water District
Sheila Tank Replacement
Pacifica, California

Project No. 2281.001 Date: 7/10/2020

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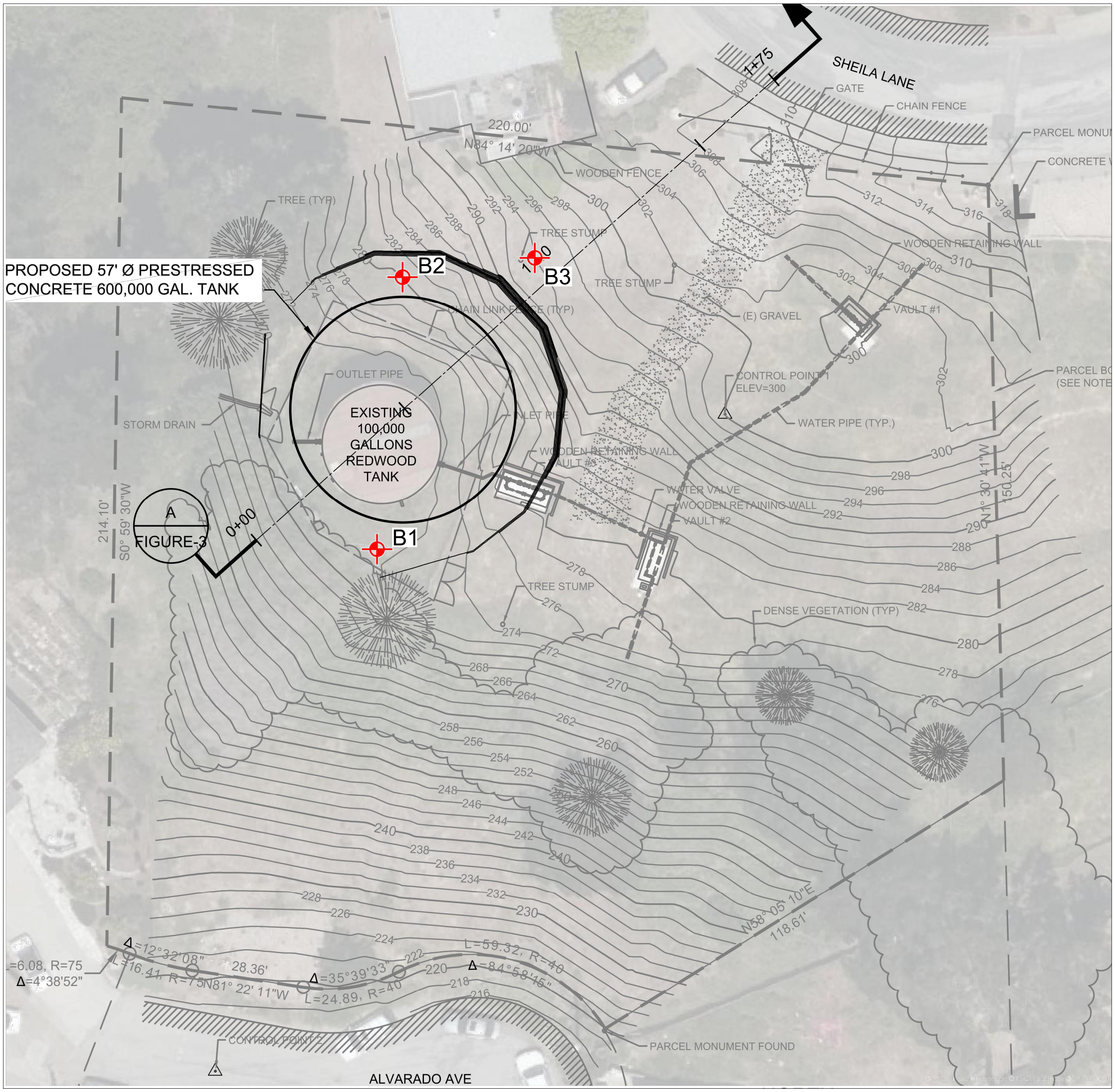
1
FIGURE



SITE PLAN

SCALE

0 20 40 80 FEET

NORTH

● Approximate location of borings completed by MPEG, April 2016 and June 2020

REFERENCE: Brown and Caldwell, "North Coast County Water District, 600,000 Gal Concrete Tank Plan & Profile" November 25, 2019.

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SITE PLAN

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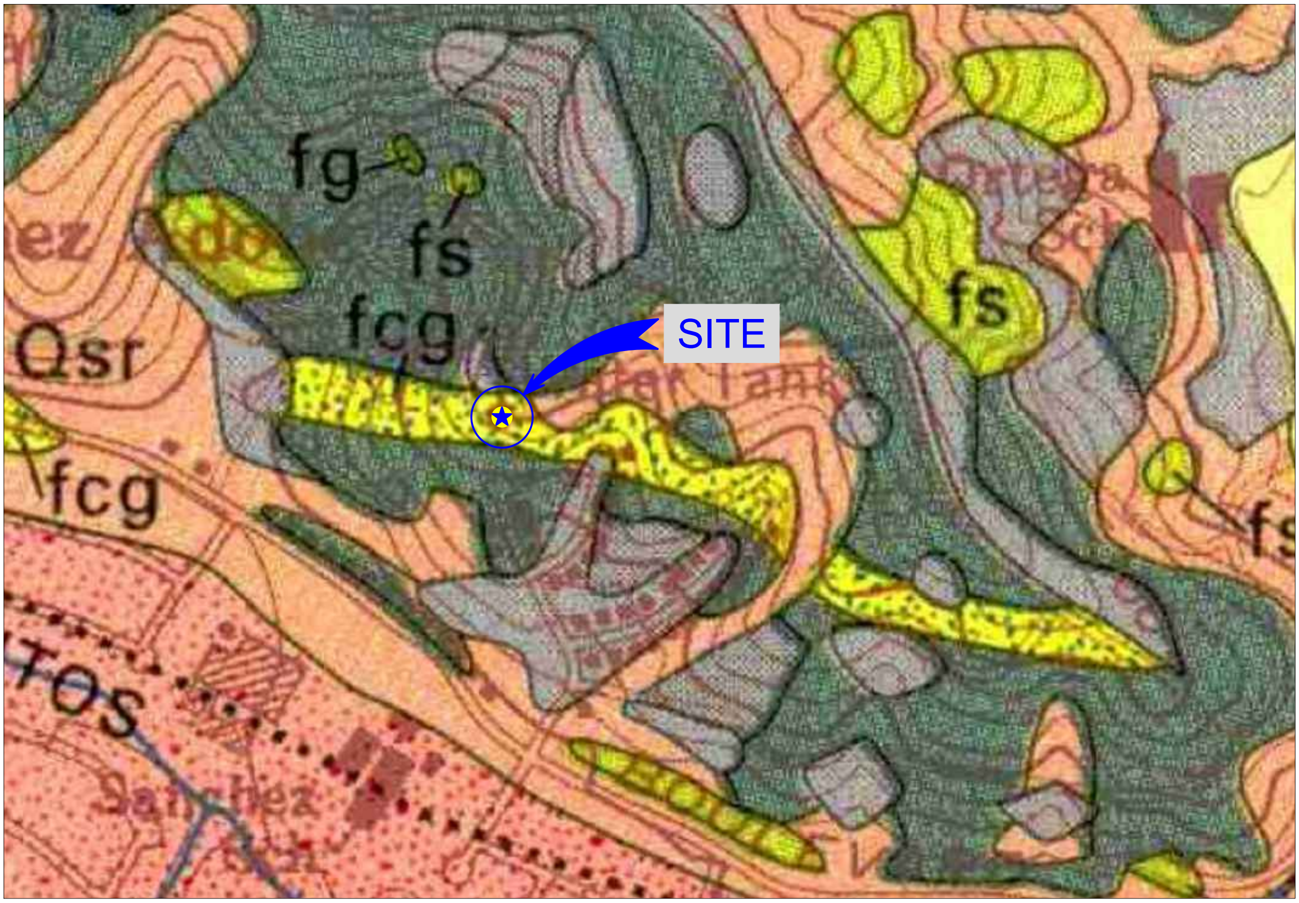
2
FIGURE



REGIONAL GEOLOGIC MAP

(NOT TO SCALE)

NORTH

LEGEND

Qac	Coarse-grained alluvium (Holocene) - Unconsolidated, moderately sorted sand and gravel forming stream levees, fans, and flood plains.
Qsr	Slope wash, ravine fill, and colluvium (Holocene) - Unconsolidated to moderately consolidated deposits of sand, silt, clay and rock fragments.
Qf	Artificial Fill (Holocene) - Poorly consolidated to well consolidated gravel, sand, silt, and rock fragments.
fs	Sandstone - Medium to coarse-grained, poorly sorted, locally tuffaceous sandstone with interbedded siltstone, shale, and sparse coal.
fcg	Conglomerate - Well-consolidated, medium-hard, well-rounded pebble to cobble conglomerate consisting of medium to coarse-crystalline granitic rocks.
fsr	Sheared Rock - Predominantly soft, light to dark gray, sheared shale, siltstone, and graywacke.

Reference: Pampeyan, Earl H. (1994), "Geologic Map of the Montara Mountain and San Mateo 7-1/2' Quadrangle, San Mateo County, California," USGS, Miscellaneous Investigation Series, Map I-2390, Scale 1:24,000.

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REGIONAL GEOLOGIC MAP

North Coast County Water District
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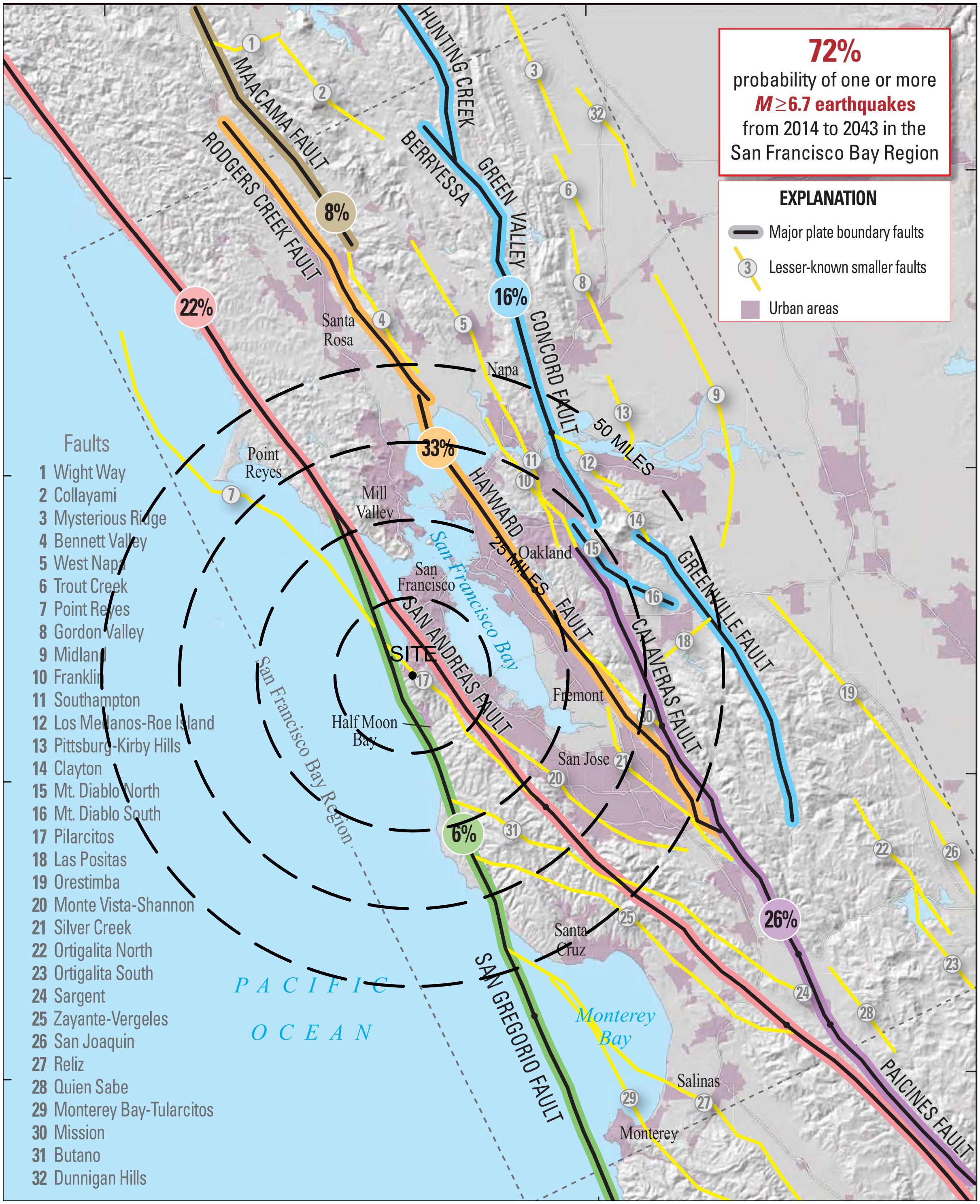
3
FIGURE



SITE COORDINATES
LAT. 37.5861°
LON. -122.4857°

SCALE
0 12.5 25 50 MILES

NORTH

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Known Active Faults in the San Francisco Bay Region, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

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ACTIVE FAULT MAP

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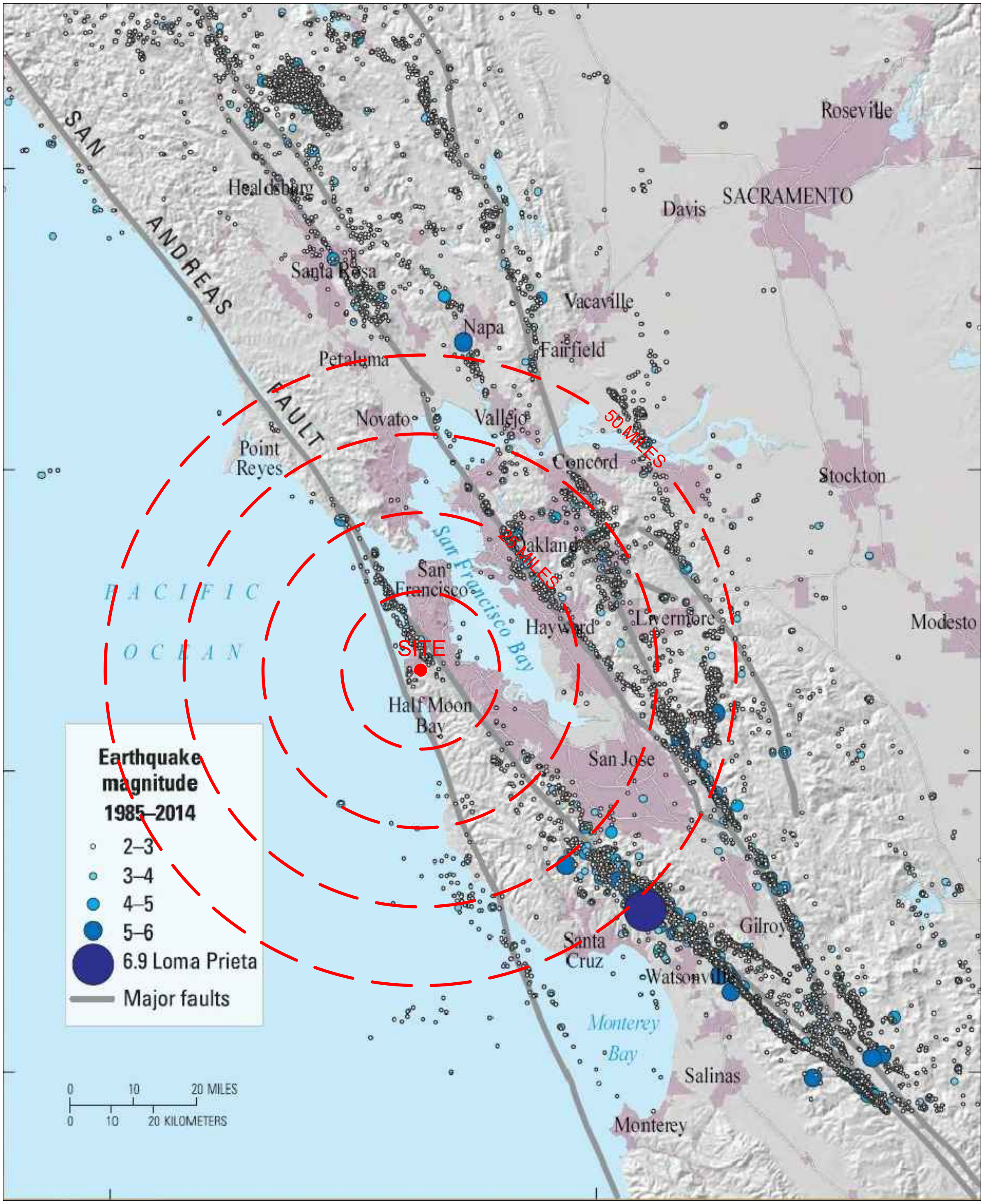
4
FIGURE



SITE COORDINATES
LAT. 37.5861°
LON. -122.4857°

SCALE
0 12.5 25 50 MILES

NORTH

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Earthquakes Greater Than Magnitude 2.0 in the San Francisco Bay Region from 1985-2014, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

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HISTORIC EARTHQUAKE ACTIVITY

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Project No. 2281.001
Date: 7/10/2020

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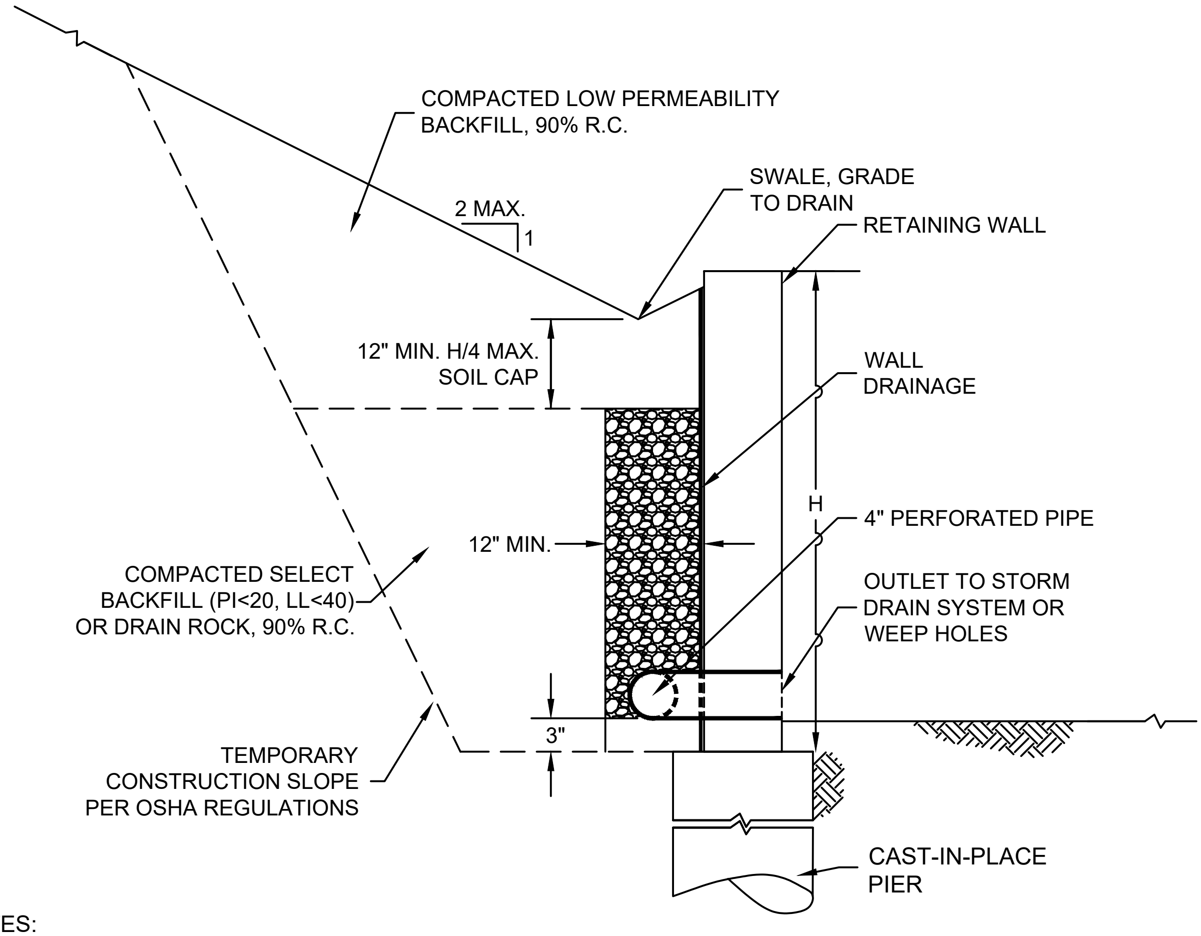
5
FIGURE



NOTES:

1. Wall drainage should consist of clean, free draining 3/4 inch crushed rock (Class 1B Permeable Material) wrapped in filter fabric (Mirafi 140N or equivalent) or Class 2 Permeable Material. Alternatively, a pre-fabricatd drainage panels (Miradrain G100N or equivalent) installed per the manufactures recommendations, may be used in lieu of drain rock and fabric.

2. All retaining walls adjacent to interior living spaces shall be water/vapor proofed as specified by the project architect or structural engineer.

3. Perforated pipe shall be SCH 40 or SDR 35 for depths less than 20 feet. Use SCH 80 or SDR 23.5 perforated pipe for depths greater than 20 feet. Place pipe perforations down and sloped at 1% to a gravity outlet. Alternatively, drainage can be outlet through 3" diameter weep holes spaced approximately 20' apart.

4. Clean outs should be installed at the upslope end and at significant direction changes of the perforated pipe. Additionally, all angled connectors shall be long bend sweep connections.

5. During compaction, the contractor should use appropriate methods (such as temporary bracing and/or light compaction equipment) to avoid over stressing the walls. Walls shall be completely backfilled prior to construction in front of or above the retaining wall.

6. Refer to the geotechnical report for lateral soil pressures.

7. All work and materials shall conform with Section 68, of the latest edition of the State of California Standard Specifications (Caltrans).

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RETAINING WALL BACKDRAIN CRITERIA

North Coast County Water District
Sheila Tank Replacement
Pacifica, California

Project No. 2281.001 Date: 7/10/2020

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6
FIGURE

APPENDIX A
SUBSURFACE EXPLORATION AND LABORATORY TESTING

1.0 Subsurface Exploration

We explored subsurface conditions at the site with two test borings on April 4, 2016 and one additional test boring on June 12, 2020 at the locations shown on Figure 2. Our borings terminated at depths of approximately 15- to 40-feet below the existing ground surface. The borings were drilled using portable hydraulic and track-mounted drilling equipment.

The soils encountered were logged and identified by our Geologist in general accordance with ASTM Standard D 2487, "Field Identification and Description of Soils (Visual-Manual Procedure)" and the Unified Soil Classification System. The soil classification system and symbols used for the soil borings and in discussions throughout this report are briefly explained on Figures A-1, Soil Classification Chart, and A-2, Rock Classification Chart. The boring logs are presented on Figures A-3 through A-6.

We obtained “undisturbed” samples using a 2-inch diameter, split-barrel Standard Penetration Test (SPT) sampler. The sampler was driven with a 140-pound hammer falling 30-inches. The number of blows required to drive the samplers 18-inches was recorded and is reported on the boring logs as blows per foot for the last 12-inches of driving. The samples obtained were examined in the field, sealed to prevent moisture loss, and transported to our laboratory.

2.0 Laboratory Testing

We conducted laboratory tests on selected intact samples to verify field identifications and to evaluate engineering properties. The following laboratory tests were conducted in accordance with the ASTM standard test method cited:

- Unconfined Compressive Strength of Cohesive Soil, ASTM D 2166;
- Laboratory Determination of Water (Moisture Content) of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D 2216;
- Density of Soil in Place by the Drive-Cylinder Method, ASTM D 2937;
- Undrained Triaxial Compression, ASTM D 4767[M]; and
- Shear Stress and Deviation Charts, ASTM D 2850.

The moisture content test results are shown on the exploratory Boring Logs, Figures A-3 through A-6 and the triaxial compression test results are presented on Figure A-7 and A-8.

The exploratory boring logs, description of soils encountered, and the laboratory test data reflect conditions only at the location of the borings at the time they were excavated or retrieved. Conditions may differ at other locations and may change with the passage of time due to a variety of causes including natural weathering, climate, and changes in surface and subsurface drainage.

MAJOR DIVISIONS		SYMBOL		DESCRIPTION
COARSE GRAINED SOILS over 50% sand and gravel	CLEAN GRAVEL	GW	▨	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	▨	Poorly-graded gravels or gravel-sand mixtures, little or no fines
	GRAVEL with fines	GM	▨	Silty gravels, gravel-sand-silt mixtures
		GC	▨	Clayey gravels, gravel-sand-clay mixtures
	CLEAN SAND	SW	▨	Well-graded sands or gravelly sands, little or no fines
		SP	▨	Poorly-graded sands or gravelly sands, little or no fines
	SAND with fines	SM	▨	Silty sands, sand-silt mixtures
		SC	▨	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS over 50% silt and clay	SILT AND CLAY liquid limit <50%	ML	▥	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	▨	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays
		OL	▥	Organic silts and organic silt-clays of low plasticity
	SILT AND CLAY liquid limit >50%	MH	▥	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		CH	▨	Inorganic clays of high plasticity, fat clays
		OH	▨	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS		PT	▤	Peat, muck, and other highly organic soils
ROCK			▩	Undifferentiated as to type or composition

KEY TO BORING AND TEST PIT SYMBOLS

CLASSIFICATION TESTS

PI	PLASTICITY INDEX
LL	LIQUID LIMIT
SA	SIEVE ANALYSIS
HYD	HYDROMETER ANALYSIS
P200	PERCENT PASSING NO. 200 SIEVE
P4	PERCENT PASSING NO. 4 SIEVE

SAMPLER TYPE

■	MODIFIED CALIFORNIA	▩	HAND SAMPLER
▯	STANDARD PENETRATION TEST	⊠	ROCK CORE
▨	THIN-WALLED / FIXED PISTON	X	DISTURBED OR BULK SAMPLE

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the excavation location during the time of exploration. Subsurface rock, soil or water conditions may vary in different locations within the project site and with the passage of time. Boundaries between differing soil or rock descriptions are approximate and may indicate a gradual transition.

STRENGTH TESTS

TV	FIELD TORVANE (UNDRAINED SHEAR)
UC	LABORATORY UNCONFINED COMPRESSION
TXCU	CONSOLIDATED UNDRAINED TRIAXIAL
TXUU	UNCONSOLIDATED UNDRAINED TRIAXIAL
	UC, CU, UU = 1/2 Deviator Stress

SAMPLER DRIVING RESISTANCE

Modified California and Standard Penetration Test samplers are driven 18 inches with a 140-pound hammer falling 30 inches per blow. Blows for the initial 6-inch drive seat the sampler. Blows for the final 12-inch drive are recorded onto the logs. Sampler refusal is defined as 50 blows during a 6-inch drive. Examples of blow records are as follows:

25	sampler driven 12 inches with 25 blows after initial 6-inch drive
85/7"	sampler driven 7 inches with 85 blows after initial 6-inch drive
50/3"	sampler driven 3 inches with 50 blows during initial 6-inch drive or beginning of final 12-inch drive

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SOIL CLASSIFICATION CHART

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A-1
FIGURE

FRACTURING AND BEDDING

Fracture Classification	Spacing	Bedding Classification
Crushed	less than 3/4 inch	Laminated
Intensely fractured	3/4 to 2-1/2 inches	Very thinly bedded
Closely fractured	2-1/2 to 8 inches	Thinly bedded
Moderately fractured	8 to 24 inches	Medium bedded
Widely fractured	2 to 6 feet	Thickly bedded
Very widely fractured	greater than 6 feet	Very thickly bedded

HARDNESS

Low	Carved or gouged with a knife
Moderate	Easily scratched with a knife, friable
Hard	Difficult to scratch, knife scratch leaves dust trace
Very hard	Rock scratches metal

STRENGTH

Friable	Crumbles by rubbing with fingers
Weak	Crumbles under light hammer blows
Moderate	Indentations <1/8 inch with moderate blow with pick end of rock hammer
Strong	Withstands few heavy hammer blows, yields large fragments
Very strong	Withstands many heavy hammer blows, yields dust, small fragments

WEATHERING

Complete	Minerals decomposed to soil, but fabric and structure preserved
High	Rock decomposition, thorough discoloration, all fractures are extensively coated with clay, oxides or carbonates
Moderate	Fracture surfaces coated with weathering minerals, moderate or localized discoloration
Slight	A few stained fractures, slight discoloration, no mineral decomposition, no affect on cementation
Fresh	Rock unaffected by weathering, no change with depth, rings under hammer impact

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the location and time of exploration. Subsurface rock, soil and water conditions may differ in other locations and with the passage of time.

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ROCK CLASSIFICATION CHART

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Project No. 2281.001 Date: 7/10/2020

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A-2
FIGURE

BORING 1

EQUIPMENT: Portable Hydraulic Drill Rig with 4.0-inch Solid Flight Auger
DATE: 04/04/16
ELEVATION: 272 - feet*
*REFERENCE: Topo Provided by Brown and Caldwell, 2019

DEPTH meters	DEPTH feet		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	DRILL RATE (FEET/MIN)
0	0	Sandy CLAY (CL) Light brown, moist, very stiff, low plasticity, ~40% fine to medium sand. [Colluvium]						
			29	107	18.9	UC 800		
1								
		PEBBLE CONGLOMERATE Moderately hard, friable, highly to completely weathered, clayey matrix with highly weathered granitic and volcanic clasts present throughout to max of +/-1" diameter. [Bedrock]	43	114	15.4	UC 1175		
	5							
2								15
		SANDSTONE Moderately hard, moderately strong, highly weathered, medium grained sandstone, with lesser interbedded shale [Bedrock]	43	108	17.8			
3	10							5.7
		Grades to moderately weathered						
			50/5"	105	15.8			
4								4.4
	15		56		12.0			
		Bottom of boring at 15.0 feet. No groundwater observed during drilling.						
5								
6	20							

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

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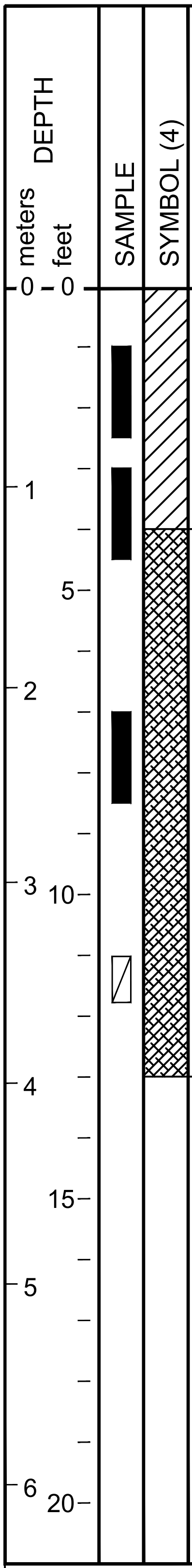
Project No. 2281.001 Date: 7/10/2020

A-3
FIGURE

BORING 2

EQUIPMENT: Portable Hydraulic Drill Rig with 4.0-inch Solid Flight Auger
DATE: 04/04/16
ELEVATION: 280 - feet*
*REFERENCE: Topo Provided by Brown and Caldwell, 2019



Description	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	DRILL RATE (FEET/MIN)
Sandy CLAY (CL) Dark brown, moist, very stiff, low plasticity, ~40% fine to medium sand. [Colluvium]	39	120	10.9	UC 425		
PEBBLE CONGLOMERATE Moderately hard, friable, highly to completely weathered, clayey matrix with highly weathered granitic and volcanic clasts present throughout to +/-1" diameter. [Bedrock]	45	119	15.6	UC 550		7.5
	93/9"	119	10.6			3.75
Auger refusal at 13.0 feet.	50/4"		8.2			1.4

Boring terminated at 13.0 feet due to auger refusal.
No groundwater observed during drilling.

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

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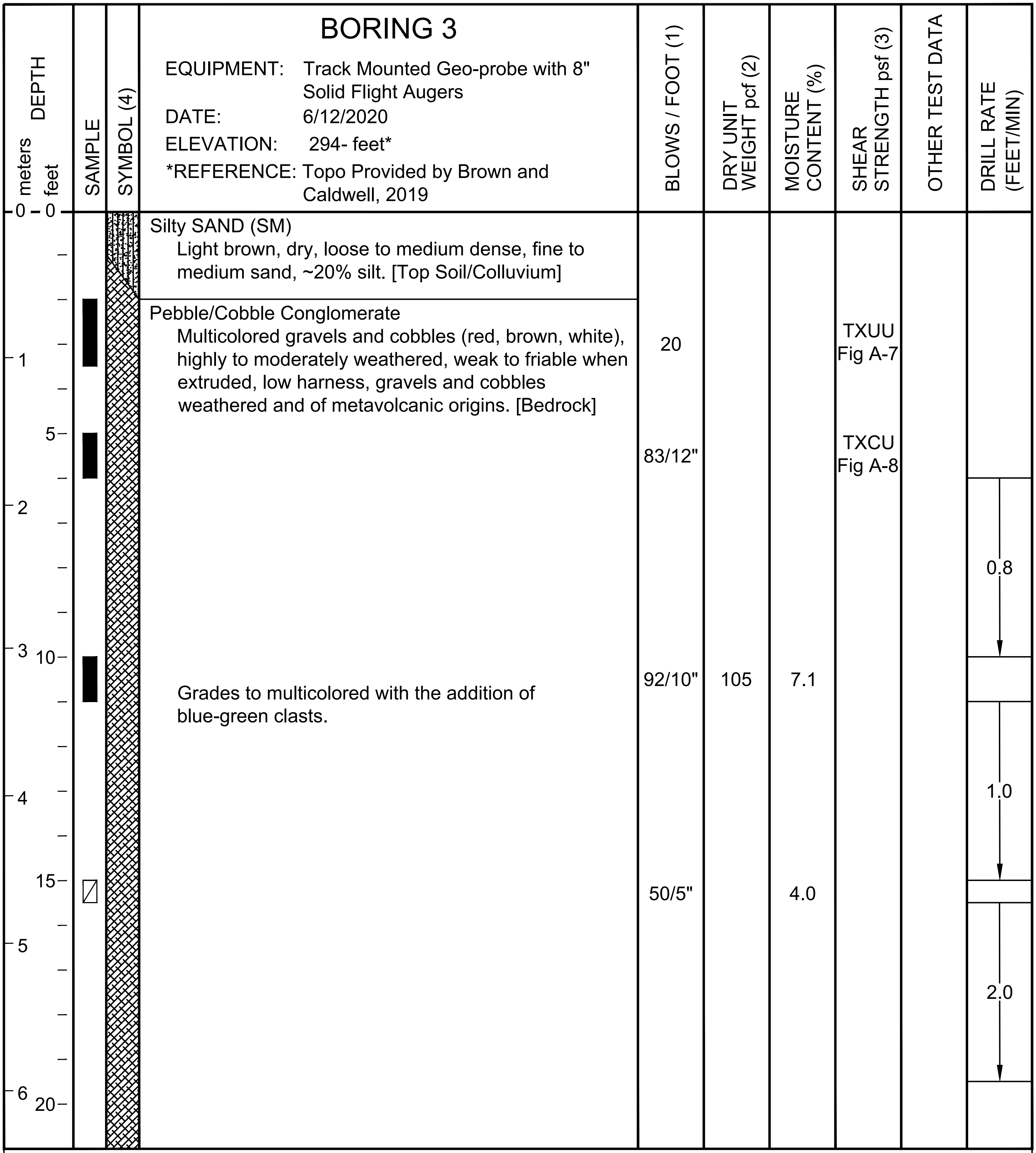
A-4
FIGURE

BORING 3

EQUIPMENT: Track Mounted Geo-probe with 8" Solid Flight Augers
DATE: 6/12/2020
ELEVATION: 294- feet*
*REFERENCE: Topo Provided by Brown and Caldwell, 2019



Silty SAND (SM)
Light brown, dry, loose to medium dense, fine to medium sand, ~20% silt. [Top Soil/Colluvium]

Pebble/Cobble Conglomerate
Multicolored gravels and cobbles (red, brown, white), highly to moderately weathered, weak to friable when extruded, low harness, gravels and cobbles weathered and of metavolcanic origins. [Bedrock]

Grades to multicolored with the addition of blue-green clasts.

BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA
20			TXUU Fig A-7	
83/12"			TXCU Fig A-8	
92/10"	105	7.1		
50/5"		4.0		

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

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A-5
FIGURE

BORING 3
(CONTINUED)

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	DRILL RATE (FEET/MIN)
	20			Pebble/Cobble Conglomerate Multicolored gravels and cobbles (red, brown, white), highly to moderately weathered, weak to friable when extruded, low harness, gravels and cobbles weathered and of metavolcanic origins. [Bedrock]	90/12"		7.2			
7										4.0
	25				50/6"		6.6			
8										3.6
9	30									
					82/9"		15.2			
10										2.9
	35			Grades softer from 34-feet to 37-feet.						
11					64		6.0			
										3.1
12	40				50/5"					
				Bottom of boring at 40.5-ft. No groundwater encountered.						

▽ Water level encountered during drilling

▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
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BORING LOG

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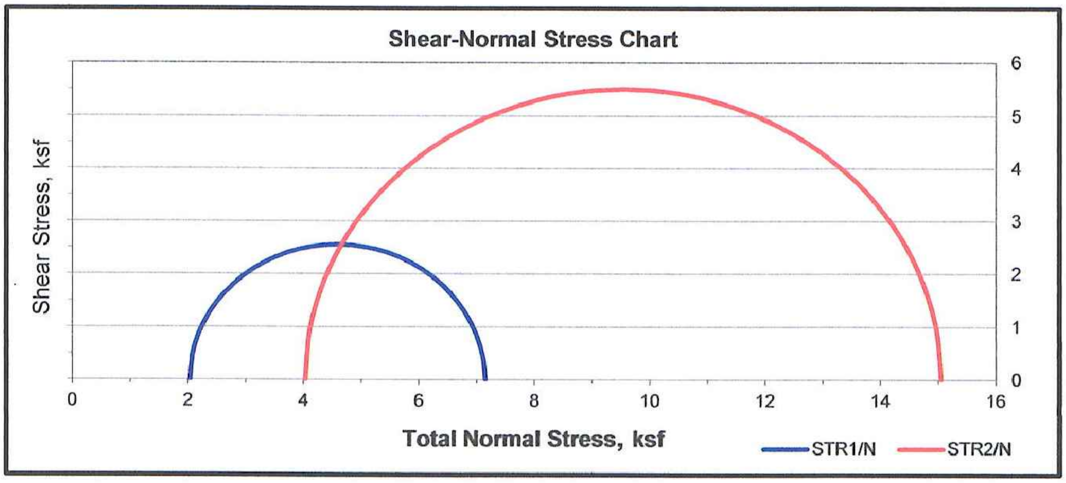
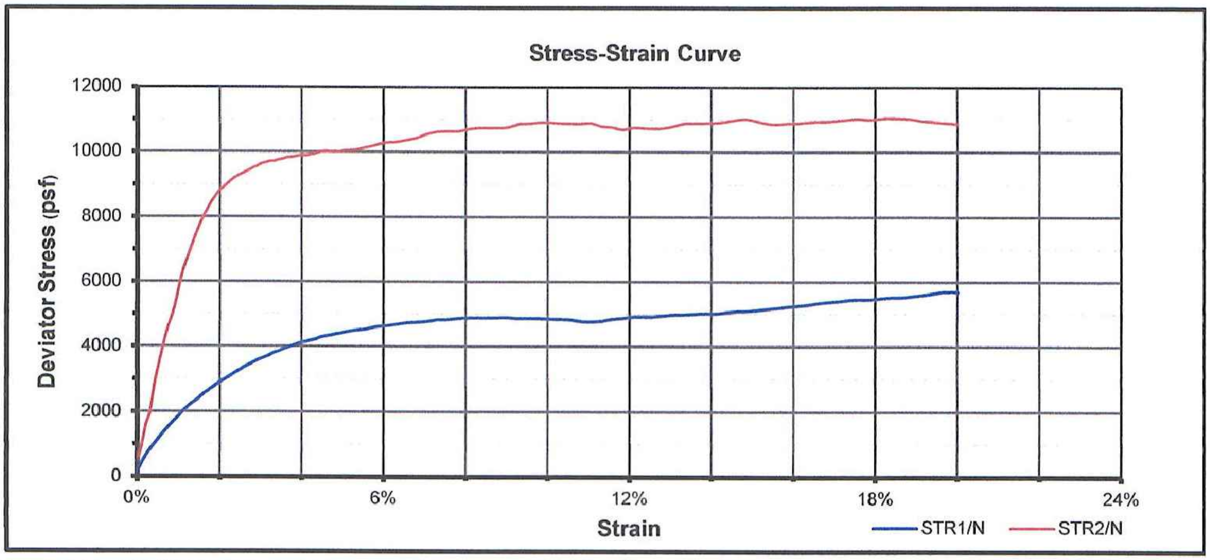
A-6
FIGURE

Shear Stress & Deviation Charts (ASTM D2850)





TEST DATA w/ SAMPLE INFORMATION

PARAMETER/TEST #	#1	#2
% Moisture	**14.5**	**13.5**
Dry Density (lbs/cuft)	**106.2**	**113.8**
Saturation %	**66.6**	**75.5**
Void Ratio	**0.587**	**0.481**
Sample Diameter (in)	**2.410**	**2.430**
Sample Height (in)	**5.00**	**5.00**

SpGr (gm/cc) *{ass.}* **--->** ***2.70***

STRESS, STRAIN & PRESSURE DATA		
Run Data	#1	#2
Strain %	**15.00**	**15.00**
Deviator (psf)	**5,109**	**11,023**
Rate, %/min	**1.00**	**1.00**
Rate in./min	**0.050**	**0.050**
Cell Pressure (psi)	**14.1**	**28.0**
Peak Points		
Stress	**39.57053**	**76.5990**
Strain	**20.0131**	**18.2440**

TEST TYPE & SAMPLE INFORMATION

Type of Test: TXUU - #1 @ 2000 psf; #2 @ 4000 psf
Sample Condition: Undisturbed & Undrained
Sample Descriptions: #1 - Brown Silty Sand w/ Gravel ; #2 - Olv-Brn Clayey Sand w/ Gravel
Sample IDs: #1 - B3 @ 2.5'; #2 - B3 @ 3.0'

**Environmental
Technical
Services**

TRIAXIAL TEST REPORT

CLIENT: Miller Pacific Engineering Group
504 Redwood Blvd., Suite 220, Novato, CA 94947
ATTENTION: Scott Stephens DATE: Jul. 1, 2020
PROJECT ID/#: Sheila Tank Replacement, Novato, California

Plate: **1**

MPEG
MILLER PACIFIC
ENGINEERING GROUP

FILENAME: 2281.001 BL3.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

TRIAXIAL TEST RESULTS

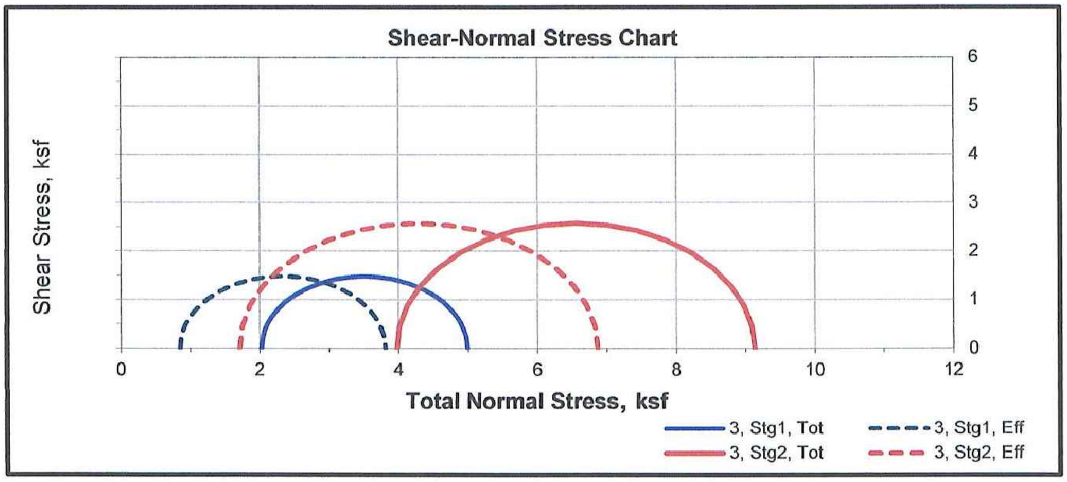
North Coast County Water District
Sheila Tank Replacement
Pacifica, California

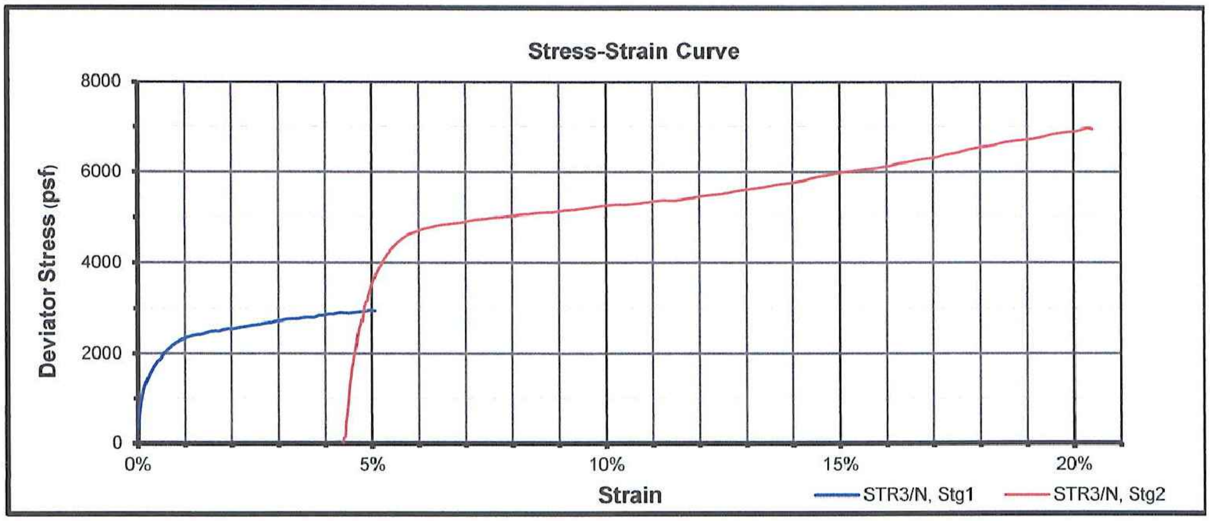
Project No. 2281.001 Date: 7/10/2020

Drawn MMT
Checked

A-7
FIGURE

Staged Consolidated Undrained Triaxial Compression w/ Pore Pressure Charts (ASTM D4767[M])





TEST DATA w/ SAMPLE INFORMATION

PARAMETER/TEST #	Initial	Stage 1	Stage 2
% Moisture	8.1	14.4	13.6
Dry Density (lbs/cuft)	121.5	122.9	125.0
Saturation %	53.7	100.0	100.0
Void Ratio	0.413	0.397	0.374
Sample Diameter (in)	2.42	2.42	2.46
Sample Height (in)	5.01	4.97	4.75
Cell Pressure (psi)	-	133.9	147.4
Back Pressure (psi)	-	119.9	119.9

STRESS, STRAIN & PRESSURE DATA

Run Data	Stage 1	Stage 2
Strain %	5.00	5.00
Deviator (psf)	2,962	5,160
Excess pp (psi)	8.20	15.8
Sigma 1 (ksf)	3.809	6.862
Sigma 3 (ksf)	0.847	1.703
P (ksf)	2.328	4.283
Q (ksf)	1.481	2.580
Stress Ratio	4.498	4.030
Rate (in/min)	0.0005	0.0005

TEST TYPE & SAMPLE INFORMATION

Type of Test: TXCU - 2 Stage, @ 2000 psf & 4000 psf

Sample Condition: Staged, Consolidated & Undrained

Sample ID: B3 @ 5.5'

Sample Description: Gry-Brn Clayey Gravel w/ Sand

Environmental Technical Services

STAGED TRIAXIAL COMPRESSION TEST REPORT

CLIENT: Miller Pacific Engineering Group
504 Redwood Blvd., Suite 220, Novato, CA 94947
ATTENTION: Scott Stephens DATE: Jul. 2, 2020
PROJECT ID/#: Sheila Tank Replacement, Novato, California

Plate: 1

MPEG MILLER PACIFIC ENGINEERING GROUP

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FILENAME: 2281.001 BL3.dwg

504 Redwood Blvd.
Suite 220
Novato, CA 94947
T 415 / 382-3444
F 415 / 382-3450
www.millerpac.com

STAGED TRIAXIAL COMPRESSION TEST RESULTS

North Coast County Water District
Sheila Tank Replacement
Pacifica, California

Project No. 2281.001 Date: 7/10/2020

Drawn MMT
Checked

A-8
FIGURE

Attachment B: PG&E Service Application

Pacific Gas and Electric Company

APPLICATION FOR SERVICE
COMMERICAL / INDUSTRIAL DEVELOPMENT

Please complete this application and submit the completed form and attachments to PG&E Application for Service at P.O. Box 24047, Fresno, CA, 93706-2010. You may also submit applications at www.pge.com/mybusiness/customerservice/otherrequests/newconstruction/ or call 1-877-PGE-SRVC.
**Indicates optional fields.*

Project Type

☐ Commercial Service (new) ☐ Commercial/Industrial Development ☐ Commercial/Industrial Service Upgrade (additional load / equipment)

☒ Industrial Service (new) ☐ Mixed Use Commercial/Residential Number of Buildings Number of Electric Services

Project Information

☐ Gas Service ☒ Electric Overhead Service ☐ Electric Underground Service Date Initial Service Needed

Project Address or Lot Number City County Zip

Nearest Cross Street

*Assessor's Parcel No. * Building Permit No. N/A

Applicant / Company Name

☐ Individual ☐ Partnership ☐ Corporation ☐ Limited Liability Corporation ☒ Governmental Agency

☐ Sole Proprietor ☐ Other

Day Phone *Cell Phone *Fax ( ) *Email address

(Correspondence will be sent via e-mail)

Applicant Address City State Zip

Contract Information

Legal name to appear on contract

☐ Individual ☐ Partnership ☐ Corporation ☐ Limited Liability Corporation ☒ Governmental Agency

☐ Sole Proprietor ☐ Other

*State of incorporation or LLC

Name of person authorized to sign contracts * Title

(First Name, Middle Initial, Last Name)

Mailing address for contract City State Zip

Representative Information (Party who will relay project information and updates to the PG&E representative)

Name of Representative Rajan Palani

Day Phone ( ) *Cell Phone (510) 599-2596 *Fax ( ) *Email address SPuthuveeduPalani@BrwnCald.com

Mailing address City State Zip 201 North Civic Drive, Suite 300, Walnut Creek, CA 94596

*Contractor's Name *Contractor's Phone ( )

Pacific Gas and Electric Company

APPLICATION FOR SERVICE
COMMERICAL / INDUSTRIAL DEVELOPMENT

Credit Information (Party responsible for energy use after the meter is installed)

Name/Company Name to appear on bill Day Phone *Evening Phone
(First Name, Middle Initial, Last Name)

☐ Individual ☐ Partnership ☐ Corporation ☐ Limited Liability Corporation ☒ Governmental Agency

☐ Sole Proprietor ☐ Other

Mailing address for bill City State Zip

Does the customer currently have service with PG&E? ☐ No ☒ Yes

*If yes, please provide the PG&E Account Number

*Do you want the new service included on your existing bill? ☐ ☒No ☐☐Yes

*NAICS (North America Industrial Classification System) Code *Business Activity

*Desired Electric Rate Schedule *Desired Gas Rate Schedule

If you want additional information on rate options or want to request a free rate analysis, visit

http://www.pge.com/mybusiness/myaccount/rates/ or call 1-877-PGE-SRVC. If a rate schedule is not selected, PG&E will select an applicable rate schedule.

Applicant Design and Installation Options

As an applicant for new gas or electric service, you can choose either PG&E or a qualified contractor to design new gas/electric distribution and/or service facilities. You can also choose either PG&E or a qualified contractor to construct all or a portion of new gas/electric distribution and/or service facilities. PG&E will provide you with a bid for the design and the construction work, to assist you in making a selection. You will then have the opportunity to choose either a qualified contractor to perform the design/or construction work.

In accordance with PG&E's filed tariffs, electric trenching, conduits, substructures and gas service trenching are the applicant's responsibility. Once you make a decision about who will perform the work, if you subsequently change your selection, you will be responsible for any re-engineering charges incurred as a result of that change.

You should become familiar with the applicant design installation requirements, including PG&E's Applicant Design Guide and General Terms and Conditions, before you make your selection. For copies of these documents and/or for additional information, visit Document, Preliminary Statement Part A *www.pge.com/newconstruction/processguide/step1/appdes.shtml* or request information by calling 1-877-PGE-SRVC.

PG&E must provide project specific information to design contractors. PG&E can provide this information sooner if we know whether or not you are considering using a design contractor to design gas/electric distribution or service facilities.

Providing this information on this Application is voluntary and is not binding. PG&E will provide you with a bid for the design work regardless of whether or not you answer this question now and will not require a final decision from you until later in the process.

Are you currently planning to use a design contractor? Yes [✓ No]

APPLICATION FOR SERVICE
COMMERICAL / INDUSTRIAL DEVELOPMENT

Construction Information

**Please note if you have selected “Electric Overhead Service” without “Gas Service” all trench related questions become optional fields.

Joint trench drawing to be prepared by: ☐ Applicant ☐ PG&E ☒ Not required

Who will trench and backfill for the distribution facilities? ☒ Applicant / Elec ☐ PG&E / Elec ☐ Date Joint Trench Required

Proposed distribution trench occupants or joint pole occupants: (check all that apply) ☒ Electric ☐ Gas ☐ Phone ☐ CATV

☐ Other

Who will install distribution conduit and substructures? ☒ Applicant ☐ PG&E

Who will trench and backfill for the service facilities? ☐ Applicant / Gas ☐ PG&E / Gas ☐ Date Joint Trench Required

☒ Applicant / Elec ☐ PG&E / Elec

Proposed service trench occupants or joint pole occupants: (check all that apply) ☒ Electric ☐ Gas ☐ Phone ☐ CATV

☐ Other

Who will install service conduit and substructures? ☒ Applicant ☐ PG&E

*Transformer type requested: ☒ Padmounted ☐ Subsurface (additional Special Facilities charges may apply)

Water, sanitary sewer, storm drain, low pressure gas, oil or other fluid carrying piping or facilities or private utilities (e.g. fire alarm, private streetlight systems, private phone, private CATV or gate controllers) are not permitted in a PG&E occupied joint trench.

General Construction Information

Include on this application any eligible Rule 20B or Rule 20C conversion work or any eligible relocation work.

*Will temporary electric service be required? ☒ No ☐ Yes Date needed

*Will temporary gas service be required? ☐ No ☐ Yes Date needed

If, yes please complete the following:

*Will Temporary Service power be operated for less than one year? ☐ No ☐ Yes

Have you ever completed a temporary power project with us before? ☐ No ☐ Yes

*Who will trench and backfill for Temporary Service?

☐ Applicant/Gas ☐ PG&E/Gas

☐ Applicant/Electric ☐ PG&E/Electric

Electric Temporary Services

*Panel, Main Breaker Size amps

*Will Applicant or Contractor Install Pole? ☐ No ☐ Yes

Gas Temporary Services

APPLICATION FOR SERVICE
COMMERICAL / INDUSTRIAL DEVELOPMENT

*Gas Service Delivery Pressure Requested: ☐ ¼ psig ☐ other

*Number of Meters at each service location?

*Total Gas Load

Will existing PG&E electric overhead facilities require under grounding?

☐ No ☐ Yes ☐ Not sure Date needed

Will any existing PG&E gas or electric facilities require relocation or removal?

☐ No ☐ Yes ☐ Not sure Date needed

Load Information

Square footage of building (including all floors) Number of stories of building

IN THE EVENT THAT APPLICANT SHALL MAKE ANY MATERIAL CHANGE EITHER IN THE AMOUNT OR CHARACTER OF THE APPLIANCES OR APPARATUS INSTALLED UPON THE PREMISES TO BE SUPPLIED BY PG&E, INCLUDING PANEL SIZE OR HOURS OF OPERATION. APPLICANT SHALL IMMEDIATELY GIVE PG&E WRITTEN NOTICE OF THIS FACT.

Operating Hours

Hours per day 24 Days per week 7 Months per year 12

Typical daily operating hours: From ☐ AM ☐ PM To ☐ AM ☐ PM

Please describe other operating characteristics

Electric Load Information

Main Switch Size (Service Termination Enclosure) amps Number of meters at each service location

Voltage: (select one)

☒ 120/240 Volt, 3-wire, 1Ø ☐ 120/208Volt, 3-wire, 1Ø ☐ 240/120 Volt, 4-wire, 3Ø ☐ 208/120 Volt, 4-wire, 3Ø

☐ 480/277 Volt, 4-wire, 3Ø ☐ Primary voltage (> 2,400 Volts) ☐ Other (specify)

Single Largest 1Ø Motor (hp) Total 1Ø Motors (hp) Single Largest 3Ø Motor (hp) Total 3Ø Motors (hp)

Single Largest 1Ø Air Conditioning (tons) Single Largest 3Ø Air Conditioning (tons)

Total Lighting (kW) Parking Lot Lighting (2 kW) Streetlights (kW)

Receptacles (kW) Water Heating (kW) Cooking (kW)

Additional electric load (if additional space is needed please attach a spread sheet using same format as below)

Number of Appliances	Phase	Description of Appliance		Connected Load		Units	
	☒ 1Ø ☐ 3Ø	Control Panel	at	2.4	☒ kW	☐ hp	☐ tons
	☒ 1Ø ☐ 3Ø	Instruments	at	1	☒ kW	☐ hp	☐ tons
	☒ 1Ø ☐ 3Ø	Tools	at	2	☒ kW	☐ hp	☐ tons
	☐ 1Ø ☐ 3Ø		at		☐ kW	☐ hp	☐ tons

*Please provide motor codes for motors that have reduced voltage starting or are 25 hp and greater.

* Street Light Load Information

Number of street lights to be added in development   Watts per lamp   Number of existing street lights to be removed

Bulb type: ☐ High Pressure Sodium Vapor ☐ Low Pressure Sodium Vapor ☐ Mercury Vapor
☐ Metal Halide ☐ Incandescent ☐ Other

What rate schedule will the lights be placed on? ☐ LS1 ☐ LS2 ☐ OL1 ☐ LS3 ☐ Other (additional forms may be required)

Who is responsible for the street light billing?

Billing address for streetlights: City: State: Zip:

Important Note: *For city or county owned street lighting, a letter will be required from the city/county accepting ownership of the lighting, which includes the date of acceptance and states they will be responsible for the billing. Until the letter is received and dated with the city/county acceptance, the billing will be placed in the applicant's name and billed according to the rate schedule requested once the lights have been energized.*

Natural Gas Load Information

Natural gas standard service delivery pressure is provided at ¼ psig (7" water column). Requests for elevated service delivery pressure require PG&E's review and approval. If granted, elevated service delivery pressure may be reduced at any time due to PG&E operational needs. Special Facilities costs and cost-of-ownership charges may apply for elevated service delivery pressure. For further information, contact your local PG&E office and refer to Gas Rule 2. MBtu/h = 1,000 Btu/h

Gas Service Delivery Pressure Requested: ☐ ¼ psig ☐ Other (psig)

Number of meters at each service location

Check all that apply: (If additional space is required please attach a spreadsheet using same format as below)

☐ Space Heating Equipment (MBtu/h) ☐ Boilers (MBtu/h) ☐ Water Heating (MBtu/h)
☐ Air Conditioning (MBtu/h) ☐ Cooking (MBtu/h) ☐ Dryers (MBtu/h)

Other gas load (specify)

IMPORTANT NOTE: Do NOT install your electric main switch or gas house line until the meter location is approved by PG&E.

Self-Generation and Net Metering Options

If you are planning to install any self generation equipment, photovoltaic, or wind generation, additional applications for interconnection to PG&E's electric system must be submitted and approved by PG&E prior to engineering for your new construction project. The information you provide on your generation interconnection application may affect the final PG&E design for your project.

For information on PG&E's net metering programs, including eligibility guidelines, generation interconnection program application forms, links to the California Public Utilities Commission, Energy Commission and the US Department of Energy, visit *www.pge.com/b2b/newgenerator/* or contact PG&E's Generation Interconnection Services at (415) 972-5676.

Are you planning on installing any self generation equipment? Yes ☐ No ☐

If yes, please provide us with an estimate of the Generation proposed for this project.

*Total # of generation units   *Total output of all generation(kW)   *Generation Type

APPLICATION FOR SERVICE
COMMERICAL / INDUSTRIAL DEVELOPMENT

Attachment – 2 copies required

A. Complete set of site improvement plans, including grading plans. (Include 3 ½" high-density disk with AutoCAD 2000i.dwg file of the site plan.)

B. Building floor plan and exterior elevations.

C. Electric drawings and schedules with complete breakdown of equipment; include single line drawing if available.

D. Electric switchboard drawings. (Must be approved by PG&E prior to manufacturing the main panel.)

E. Plumbing plans.

F. Assessors parcel map showing all easements, rights-of-way, property lines, etc.

G. Detailed site plan showing roads, sidewalk, driveways, location of fire hydrants and other structures, proposed location of gas and electric meters, building elevations, and proposed future improvements. (Meter locations are subject to PG&E approval).

H. Landscaping plans including sprinkler controller meter location.

I. Streetlight and traffic signal plans.

J. Title 24 Utility Report or building permit.

K. Copies of all environmental permits and/or conditions of approval.

Applicant is responsible for identifying all environmental requirements within said permits, approvals and/or conditions. For additional information visit *www.pge.com/mybusiness/customerservice/otherrequests/newconstruction.*

Agreement to Pay and Signature

I understand that service will be engineered and installed based upon the information provided here. I agree to pay PG&E, on demand, for all work PG&E performs and all costs PG&E incurs for this application for service. PG&E may cancel this Application for Service (a) if the application is incomplete and I do not provide all necessary supporting documents and project data after being notified by PG&E, (b) if I fail to provide an engineering advance within ninety days after one is requested by PG&E, or (c) if PG&E sends a proposed contract and I do not return the contract, with the required payment, within ninety days. If the project is postponed or cancelled, by either party, I will pay PG&E for all such work and costs incurred by PG&E prior to the postponement or cancellation. PG&E's costs may include, for example, labor, material and supplies, (including long lead time materials), transportation, and other direct costs which PG&E allocates to such work. Incomplete information or any changes made at my request during the engineering, or after it is completed, will subject me to additional charges and may delay the establishment of service. I further agree to pay for any damage to new or existing PG&E facilities caused by my contractors or me. Service shall be subject to all of PG&E's applicable tariff schedules on file with and authorized by the California Public Utilities Commission (CPUC) and shall at all times be subject to such changes or modifications as the CPUC may direct from time to time in the exercise of its jurisdiction.

I understand that PG&E may require an engineering advance to cover some or all of its costs for project review, design work and cost development in connection with this application for service. I understand that any advance will be based upon current costs and the amount of work anticipated by PG&E based upon the information submitted in this application. I understand that any advance will be credited against the amount I owe, applied to the amount I may owe on the resulting line extension agreement, or refunded to me without interest when PG&E has completed its engineering work or if the project has been cancelled or postponed.

I have read the above information. I understand and agree with the provisions and my responsibilities.

Applicant's Signature ______________________________ Print Name ______________________________Date _____________
First Name, Middle Initial, Last Name

Attachment C: Planning/Conceptual Level – Class 4 Estimate

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Date: August 7, 2020

To: Rachel Philipson, Sacramento

From: Ryan Manocchio, Cincinnati

Reviewed by: Bill Agster, Denver

Copy to: Kaitly Konecny, Sacramento

Project No.: 155221.002.003

Subject: Sheila Tank

Planning/Conceptual Level - Class 4 Estimate

Basis of Estimate of Probable Construction Cost

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the Sheila Tank project.

Class 4 1%-15% Design Completion
In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate. A Class 4 estimate is defined as a Planning Level or Design Technical Feasibility Estimate. Typically, engineering is from 1 percent to 15 percent complete.

The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday.
2. Contractor has complete access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates, and/or rates contained in the estimating database.
4. Major equipment costs are based on both vendor supplied price quotes obtained by the project design team and/or estimators, and on historical pricing of like equipment.
5. Bulk material quantities are based on manual quantity take-offs.
6. There is enough electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.
7. Soils are of adequate nature to support the structures. No piles have been included in this estimate.
8. The quote for the concrete dome is all inclusive for all labor, material, equipment and freight.
9. Temporary and permanent access road will be required.

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project with the exception of the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.

4. Permits beyond those normally needed for the type of project and project conditions.

The following allowances were made in the development of this estimate.

1. Tank appurtenances
2. Piping and valves
3. Electrical and instrumentation (factored)

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups can be found at the end of the detailed estimate report.

Estimate Summary Report

8/7/2020 7:19 AM

BC Project Number: 155221.002.003
Estimate Version Number: 5
Estimate Date: 8/7/2020
Lead Estimator: Manocchio, Ryan

Sheila Tank Re-Evaluation

North Coast County Water District
Sheila Tank Re-Evaluation
Planning/Conceptual Level - Class 4 Estimate

Estimator	Manocchio, Ryan
BC Project Manager	Rachel Philipson
BC Office	Walnut Creek
Est Version Number	5
QA/QC Reviewer	Bill Agster
QA/QC Review Date	7/28/2020
BC Project Number	155221.002.003

Estimate Summary Report

8/7/2020 7:19 AM
BC Project Number: 155221.002.003
Estimate Version Number: 5
Estimate Date: 8/7/2020
Lead Estimator: Manocchio, Ryan

Sheila Tank Re-Evaluation

Phase	Description	Gross Total Cost with Markups
01 TOTALS		
06 Concrete Dome, 0.60 MG		
01543 Traffic Control		**55,671**
01999 Mobilization and Demobilization		**47,787**
02999 Misc Existing Conditions or Demolition		**54,283**
03330 Concrete Paving 8" Thick, at Access Road		**98,760**
03999 Concrete Tank and Dome		**2,054,682**
26001 Electrical and Instrumentation (FACTORED)		**564,806**
31250 Shoring Systems		**292,099**
31315 Excavation and Backfill, Pad Cut		**117,282**
31315 Excavation and Backfill, Tank Cut		**79,327**
31315 Excavation and Backfill at Utility Vault		**37,384**
31315 Excavation and Backfill, at Access Road		**19,570**
32999 Misc. Exterior Improvements		**144,127**
32999 Fence and Guardrail		**27,351**
32999 Exterior Improvements		**79,396**
06 Concrete Dome, 0.60 MG		**3,672,525**
01 TOTALS		**3,672,525**

Estimate Detail Report

Sheila Tank Re-Evaluation

North Coast County Water District
Sheila Tank Re-Evaluation
Planning/Conceptual Level - Class 4 Estimate

Estimator	Manocchio, Ryan
BC Project Manager	Rachel Philipson
BC Office	Walnut Creek
Est Version Number	5
QA/QC Reviewer	Bill Agster
QA/QC Review Date	7/28/2020
BC Project Number	155221.002.003

01 TOTALS

06 Concrete Dome, 0.60 MG

01543 Traffic Control

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01-54-33.40	Rent reflectorized barrels 1 to 99 barrels	1600	900.00 day	-	2.62	-	-	-	2.62	2,362
01-54-33.40	Rent barricade, portable with flasher 1 to 6 units	1670	60.00 day	-	4.06	-	-	-	4.06	244
01-54-33.40	Rent illuminated board, trailer mount, with generator	1650	60.00 day	-	108.75	-	-	-	108.75	6,525
01-51-03.00	Rent traffic control sign, aluminum 36" x 36"	BC-0018	180.00 day	-	3.19	-	-	-	3.19	575
01-51-03.00	Rent traffic control sign stand, for aluminum signs	BC-0022	180.00 day	-	2.13	-	-	-	2.13	383
01-51-03.00	Traffic Control, equipment setup/relocate	BC-0014	2.00 hr	90.17	-	-	-	-	90.17	180
01-51-03.00	Traffic Control, flaggers	BC-0008	10.00 day	721.31	-	-	-	-	721.31	7,213
01-51-03.00	Traffic Control, labor management and breaks	BC-0010	15.00 day	721.31	-	-	-	-	721.31	10,820
01-56-23.10	Barricades, wood, fixed, 3 rail, 5' high, 3 rail @ 2" x 8"	0020	20.00 lf	84.04	-	6.80	-	-	90.84	1,817
	Traffic Control		**60.00 day**	**331.56**	**168.13**	**2.27**			**501.96**	**30,118**

01999 Mobilization and Demobilization

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
01-00-10.00	Mobilization	BC-0027	3.00 day	2,872.80	1,436.40	-		-	4,309.20	12,928
01-00-10.00	Demobilization	BC-0028	3.00 day	2,872.80	1,436.40	-		-	4,309.20	12,928
	Mobilization and Demobilization		**1.00 ls**	**17,236.80**	**8,618.40**				**25,855.20**	**25,855**

02999 Misc Existing Conditions or Demolition

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
02-41-13.44	Selective demolition, tanks and related components, cast in place tanks, 100,000 gal., excludes excavation	1100	1.00 ea	4,980.01	7,559.14	-	-	-	12,539.15	12,539
02-41-13.62	Selective demolition, chain link fences & gates, fence, 12' high	0675	200.00 lf	4.73	0.91	-	-	-	5.64	1,128
02-41-13.33	Site demolition, equip. removal, valve vault, 4'-8' deep	0020	3.00 ea	946.34	272.64	-	-	-	1,218.98	3,657
02-41-13.33	Minor site demolition, pipe, sewer/water, 27" to 36" diameter, remove, excludes excavation, hauling	3000	150.00 lf	21.71	18.18	-	-	-	39.89	5,984
02-41-19.19	Selective demolition, rubbish handling, dumpster, 40 c.y., 10 ton capacity, weekly rental, includes one dump per week, cost added to demolition cost	0840	8.00 week	-	-	740.90	-	-	740.90	5,927
	Misc Existing Conditions or Demolition		**1.00 ls**	**12,022.45**	**11,285.33**	**5,927.20**			**29,234.98**	**29,235**

03330 Concrete Paving 8" Thick, at Access Road

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
31-22-16.10	Fine grading, fine grade for slab on grade, machine	1100	513.89 sy	1.28	0.72	-	-	-	2.00	1,028
03-05-13.25	Aggregate, stone, 3/4" to 1-1/2", prices per C.Y., includes material only	1050	85.65 cy	-	-	38.18	-	-	38.18	3,270
03-11-13.65	C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning	3050	393.33 sfca	8.74	-	0.75	-	-	9.50	3,736
03-21-10.60	Reinforcing steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	0600	6.85 ton	1,725.74	-	967.50	-	-	2,693.24	18,454
03-21-10.60	Reinforcing in place, unloading & sorting, add to above - slabs	2005	6.85 ton	67.09	7.97	-	-	-	75.07	514
03-31-05.35	Structural concrete,ready mix,normal weight,4500 psi,includes local aggregate,sand,portland cement and water,excludes all additives and treatments	0350	119.91 cy	-	-	116.07	-	-	116.07	13,917

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
03330 Concrete Paving 8" Thick, at Access Road										
03-31-05.70	Structural concrete, placing, slab on grade, pumped, over 6" thick, includes vibrating, excludes material	4650	119.91 cy	32.04	6.44	-	-	-	38.48	4,614
03-35-29.30	Concrete finishing, floors, monolithic, screed and bull float(darby) finish	0100	4,625.00 sf	0.58	-	-	-	-	0.58	2,665
03-39-13.50	Curing, sprayed membrane curing compound	0300	46.25 csf	14.87	-	11.03	-	-	25.90	1,198
03-35-29.30	Concrete finishing, floor, dustproofing, solvent-based, 1 coat	3800	4,625.00 sf	0.42	-	0.16	-	-	0.58	2,682
03-15-05.25	Sawcut control joints, slab on grade	X9000	69.00 lf	1.14	0.45	0.75	-	-	2.35	162
	Concrete Paving 8" Thick, at Access Road		**114.20 cy**	**224.18**	**10.76**	**222.51**			**457.45**	**52,240**
03999 Concrete Tank and Dome										
03-99-99.99	Free spanning concrete tank and dome, 0.60 MG, inside diameter 55', appurtenances, quote includes SOG, labor, material and eqpt for a complete installation (see quote from DN Tanks)	MISC	1.00 ls	-	-	-	882,100.00	-	882,100.00	882,100
03-99-99.99	Tank appurtenances, allowance	MISC	1.00 ls	-	-	-	100,000.00	-	100,000.00	100,000
03-99-99.99	Piping and valve, site and mechanical piping, allowance	MISC	1.00 ls	-	-	-	150,000.00	-	150,000.00	150,000
	Concrete Tank and Dome		**1.00 ls**				**1,132,100.00**		**1,132,100.00**	**1,132,100**
26001 Electrical and Instrumentation (FACTORED)										
26-00-00.02	Electrical (5% of Total Project Costs)	FACTORED	1.00 ls	-	-	-	155,600.00	-	155,600.00	155,600
27-20-00.01	Instrumentation (5% of Total Project Costs)	FACTORED	1.00 ls	-	-	-	155,600.00	-	155,600.00	155,600
	Electrical and Instrumentation (FACTORED)		**1.00 LS**				**311,200.00**		**311,200.00**	**311,200**
31250 Shoring Systems										
31-41-16.10	Sheet piling, steel, 22 psf, 15' excavation, per S.F., drive, extract and salvage, excludes wales	1300	4,320.00 sf	16.01	11.34	8.39	-	-	35.74	154,377
31-41-16.10	Sheet piling, wales, connections and struts, 2/3 salvage	2500	3.52 ton	-	-	688.38	-	-	688.38	2,423
	Shoring Systems		**4,320.00 sf**	**16.01**	**11.34**	**8.95**			**36.30**	**156,800**
31315 Excavation and Backfill, Pad Cut										
31-23-16.46	Excavating, bulk, dozer, open site, bank measure, common earth, 200 HP dozer, 150' push	4220	2,830.00 bcy	1.99	2.85	-	-	-	4.84	13,696
31-23-23.18	Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	1255	2,830.00 lcy	8.19	9.29	-	-	-	17.49	49,486
01-54-36.50	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	0020	2.00 ea	202.98	113.64	-	-	-	316.61	633
	Excavation and Backfill, Pad Cut		**2,830.00 cy**	**10.33**	**12.22**				**22.55**	**63,815**
31315 Excavation and Backfill, Tank Cut										
31-23-16.42	Excavating, bulk bank measure, 3 C.Y. capacity = 260 C.Y./hour, backhoe, hydraulic, crawler mounted, excluding truck loading	0300	2,214.07 bcy	0.65	1.24	-	-	-	1.89	4,179

31315 Excavation and Backfill, Tank Cut

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
31-23-23.18	Hauling, excavated or borrow material, loose cubic yards, 20 mile round trip, 0.5 loads/hour, 20 C.Y. dump trailer, highway haulers, excludes loading	1255	1,498.89 lcy	8.19	9.29	-	-	-	17.49	26,210
31-23-23.13	Backfill, bulk, 6" to 12" lifts, dozer backfilling, compaction with vibrating roller	1600	715.00 ecy	1.28	2.44	-	-	-	3.72	2,662
31-23-23.17	Fill, gravel fill, compacted, under floor slabs, 12" deep	0800	5,978.00 sf	0.63	0.03	0.88	-	-	1.54	9,201
01-54-36.50	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	0020	2.00 ea	202.98	113.64	-	-	-	316.61	633
	Excavation and Backfill, Tank Cut		**2,214.00 cy**	**8.49**	**8.50**	**2.39**			**19.37**	**42,885**

31315 Excavation and Backfill at Utility Vault

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
31-23-16.46	Excavating, bulk, dozer, open site, bank measure, common earth, 105 HP dozer, 150' haul	3220	177.78 bcy	3.81	2.57	-	-	-	6.38	1,134
31-23-23.16	Fill by borrow and utility bedding, borrow, for embankments, 1 mile haul, spread, by dozer	0020	95.00 lcy	1.92	2.30	7.90	-	-	12.12	1,152
31-23-23.14	Backfill, structural, common earth, 105 HP dozer, 300' haul, from existing stockpile, excludes compaction	3320	94.78 lcy	2.48	1.67	-	-	-	4.15	393
31-23-23.24	Compaction, structural, common fill, 8" lifts, sheepsfoot or wobbly wheel roller	0300	94.78 ecy	0.79	1.16	-	-	-	1.95	185
31-23-23.18	Hauling,excavated borrow material,loose cubic yards,10 mile round trip,.6 loads/hr ,base wide rate,12 cy truck,highway haulers,excludes loading	0550	178.00 lcy	11.02	11.14	-	-	-	22.16	3,944
31-22-16.10	Fine grading, fine grade for slab on grade, machine	1100	25.00 sy	1.28	0.72	-	-	-	2.00	50
31-31-16.13	Chemical termite control, slab and walls, commercial, maximum	0200	225.00 flr	0.44	-	0.33	-	-	0.77	174
01-54-36.50	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	0020	2.00 ea	202.98	113.64	-	-	-	316.61	633
33-05-63.13	Utility structures, utility vaults precast concrete, 15' x 15' x 10' high, ID, 6" thick, excludes excavation and backfill	0300	1.00 ea	4,464.49	1,320.77	6,500.00	-	-	12,285.26	12,285
	Excavation and Backfill at Utility Vault		**177.78 cy**	**45.74**	**25.28**	**41.20**			**112.22**	**19,950**

31315 Excavation and Backfill, at Access Road

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
31-23-16.46	Excavating, bulk, dozer, open site, bank measure, common earth, 200 HP dozer, 150' push	4220	230.00 bcy	1.99	2.85	-	-	-	4.84	1,113
31-23-23.14	Backfill, structural, common earth, 200 HP dozer, 300' haul, from existing stockpile, excludes compaction	4420	438.00 lcy	1.40	2.00	-	-	-	3.40	1,488
31-23-23.24	Compaction, structural, common fill, 8" lifts, sheepsfoot or wobbly wheel roller	0300	438.00 ecy	0.79	1.16	-	-	-	1.95	854
31-23-23.18	Hauling, excavated or borrow material, loose cubic yards, 10 mile round trip, 0.6 load/hour, 16.5 C.Y. dump trailer, highway haulers, excludes loading	1120	230.00 lcy	7.99	8.85	-	-	-	16.84	3,873
31-22-16.10	Fine grading, finish grading, small area, to be paved with grader	0012	514.00 sy	3.33	1.87	-	-	-	5.20	2,673

Phase	Description	Item	Takeoff Quantity	Labor Cost/Unit	Equip Cost/Unit	Material Cost/Unit	Sub Cost/Unit	Other Cost/Unit	Total Cost/Unit	Total Amount
31315 Excavation and Backfill, at Access Road										
01-54-36.50	Mobilization or demobilization, dozer, loader, backhoe or excavator, 70 H.P. to 150 H.P., up to 50 miles	0020	2.00 ea	202.98	113.64	-	-	-	316.61	633
	Excavation and Backfill, at Access Road		**206.00 cy**	**26.07**	**25.56**				**51.63**	**10,635**
32999 Misc. Exterior Improvements										
32-32-13.10	Cast-in place retaining walls,concrete gravity wall with vertical face,level embankment,10'high,includes excavation&backfill,excludes reinforcing	2500	100.00 lf	391.75	32.63	176.02	-	-	600.40	60,040
32-11-23.23	Temp access road, base course drainage layers, aggregate base course for roadways and large paved areas, stone base, compacted, 3/4" stone base, to 12" deep	0300	50.00 sy	1.01	1.30	10.41	-	-	12.72	636
32-31-13.53	High-security chain link fences, gates & systems, chain link fence, 7' high, standard FE-7, includes excavation and posts	0100	200.00 lf	3.73	0.47	49.01	-	-	53.21	10,642
32-31-11.10	Chain link fence gates and posts, motor operators for gates, up to 20' wide swing, excludes electric wiring & excavation	7815	1.00 ea	2,836.34	-	1,633.70	-	-	4,470.04	4,470
31-25-13.10	Synthetic erosion control, silt fence, polypropylene, adverse conditions, 3' high	1100	500.00 lf	1.28	-	0.15	-	-	1.43	713
	Misc. Exterior Improvements		**1.00 ls**	**43,445.72**	**3,421.65**	**29,633.25**			**76,500.62**	**76,501**
32999 Fence and Guardrail										
01-56-23.10	Barricades, guardrail, portable metal with base pads, buy	1200	240.00 lf	-	-	14.57	-	-	14.57	3,496
32-31-13.20	Fence,chain link industrial,galvanized steel,3 strands barb wire,2"posts @ 10'oc,9ga wire,6'high,schedule 40,includes excavation,& concrete	0200	250.00 lf	7.46	0.94	21.03	-	-	29.42	7,356
32-31-13.20	Fence, chain link industrial, double swing gates, 6' high, 20' opening, includes excavation, posts & hardware in concrete	5070	1.00 opng	688.36	86.64	2,710.00	-	-	3,485.00	3,485
	Fence and Guardrail		**1.00 ls**	**2,552.67**	**321.28**	**11,462.59**			**14,336.54**	**14,337**
32999 Exterior Improvements										
32-99-99.99	Landscaping, allowance	MISC	1.00 ls	-	-	-	20,000.00	-	20,000.00	20,000
32-32-23.13	Segmental retaining walls,unit masonry interlocking wall system,3 plane split,4"high x 18"wide x 10"deep,includes pins and void fill	7180	970.00 sf	4.63	0.49	18.18	-	-	23.30	22,602
	Exterior Improvements		**1.00 ls**	**4,494.90**	**470.60**	**17,636.54**	**20,000.00**		**42,602.04**	**42,602**
	06 Concrete Dome, 0.60 MG									**2,008,272**
	01 TOTALS									**2,008,272**

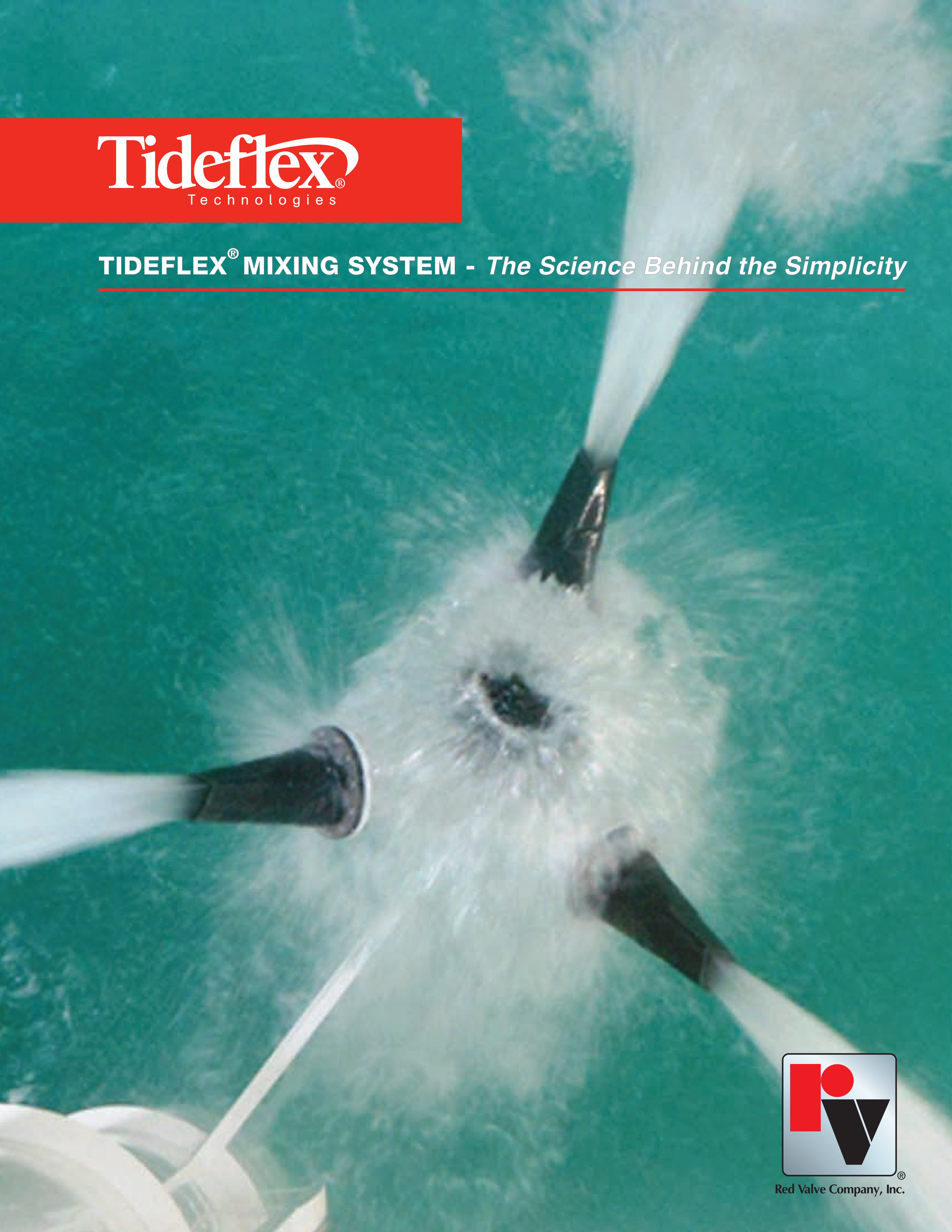
Estimate Totals

Description	Rate	Hours	Amount	Totals
Labor		2,739 hrs	255,924	
Material			141,485	
Subcontract			1,463,300	
Equipment		12,576 hrs	147,564	
Other				
			2,008,273	**2,008,273**
Labor Mark-up	15.00 %		38,389	
Material Mark-up	10.00 %		14,148	
Subcontractor Mark-up	10.00 %		146,330	
Construction Equipment Mark-up	10.00 %		14,756	
Other - Process Equip Mark-up	8.00 %			
			213,623	**2,221,896**
Material Shipping & Handling	2.00 %		2,830	
Material Sales Tax	8.50 %		12,026	
Other - Process Eqp Sales Tax	8.50 %			
Net Markups			**14,856**	**2,236,752**
Contractor General Conditions	15.00 %		335,513	
			335,513	**2,572,265**
Start-Up, Training, O&M	2.00 %		51,445	
			51,445	**2,623,710**
Undesign/Undevelop Contingency	30.00 %		787,113	
			787,113	**3,410,823**
Bldg Risk, Liability Auto Ins	2.00 %		68,216	
			68,216	**3,479,039**
Payment and Performance Bonds	1.50 %		52,186	
			52,186	**3,531,225**
Escalation to Midpoint (ALL)	4.00 %		141,249	
Gross Markups			**141,249**	**3,672,474**
Total				**3,672,474**

Attachment D: Tideflex© Mixing System Technical Information

Tideflex®
Technologies

TIDEFLEX® MIXING SYSTEM - *The Science Behind the Simplicity*



Red Valve Company, Inc.

Tideflex®
Technologies

Custom Engineered for an Innovative Mixing Solution

TIDEFLEX® MIXING SYSTEM

The Science Behind the Simplicity

Since 1953, Red Valve Company has been the trusted global leader in developing innovative, custom-engineered valve products and mixing systems that solve flow control problems in both municipal and industrial applications.

Our dedication and drive has led us to an unparalleled approach to eliminate short-circuiting, water stagnation, and achieve complete mixing in water storage tanks - the Tideflex® Mixing System (TMS).

The key to the TMS is the Tideflex® Check Valve. Developed in the 1980s from a United States EPA grant, the check valve was created to solve backflow problems in outfall pipes.

Red Valve's engineering team further expanded the use of the Tideflex® Check Valve by developing it into a Variable Orifice Inlet Nozzle that provides superior mixing characteristics when compared to a fixed-diameter pipe. When used in the TMS, the Tideflex® Variable Orifice Nozzles optimize jet velocity at all flow rates and discharge an elliptically shaped jet, which produces rapid and complete mixing that improves water quality. The TMS also separates the inlet and outlet with one manifold pipe so short-circuiting is eliminated.

NSF *Tideflex® Variable Orifice Inlet Nozzles (All Rubber, No Mechanical Parts)*

NSF *Waterflex® Outlet Check Valves (Rubber Membrane, No Mechanical Parts) (Not Required for Tanks With Separate Outlet Pipe)*

Benefits and Features of TMS:

- Extensive CFD and Physical Scale Modeling in every tank style.
- Field validated to achieve complete mixing in every tank style.
- Tideflex® Variable Orifice Nozzles maximize jet velocity, producing rapid mixing.
- No external energy source required.
- Expected life - 30 years, no maintenance.
- Complete custom system design with Mixing Analysis and Water Age Analysis.
- Installed in ANY size and style of tank.
- Only requires one pipe penetration in tank.
- Tideflex® Variable Orifice Nozzles and Waterflex® Outlet Check Valves are NSF 61 Certified.
- For tanks with common or separate inlet and outlet pipes.
- Passive and Active TMS available.

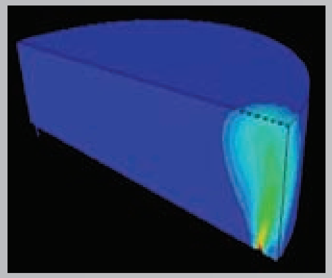
TMS Solves Many Water Quality Problems Including:

- Loss of disinfectant residual.
- Spikes in disinfection by-products (DBP).
- Nitrification in chloraminated systems.
- Bacteria and biofilm growth.
- Variations in pH and dissolved oxygen.
- Ageing water.
- Thermal stratification.
- Ice formation.
- Taste and odor issues.

Limitations of Conventional Tank Design

Conventional tank design typically incorporates a single fixed-diameter inlet pipe. This piping configuration is poor for mixing because it produces low jet velocity and concentrates all of the inflow momentum in one area of the tank. Inflow momentum is the energy responsible for mixing. When concentrated all in one place, a single fixed port will not effectively mix a tank.

Single fixed-diameter inlet pipe - low velocity.



Inlet flow in one location - inhibits mixing.

Problems with water quality are compounded in the summer because the colder water entering the tank is denser and negatively buoyant, causing it to sink. As a result, the water at the bottom of the tank is mixed well, but the water in the upper part of the tank does not mix and gets hotter each consecutive day. This leads to a localized increase in water age inside the tank. Even with an opposing outlet pipe, thermal stratification persists.

A fixed-diameter inlet pipe creates dead zones, short-circuiting, stratification and incomplete mixing, which results in water quality problems.

Stratified tank due to single inlet pipe.

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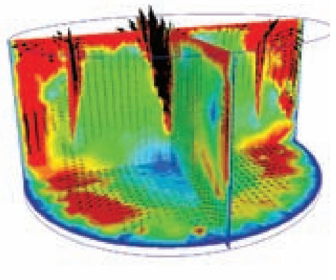
TMS, a Green Solution to Improve Water Quality

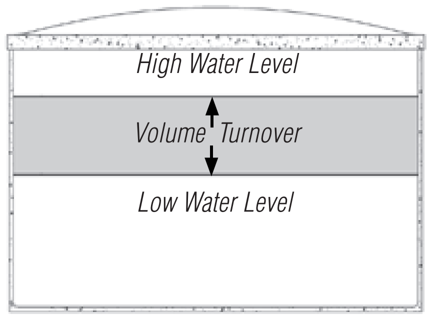


One of the keys to improving water quality in tanks is to ensure that the water is mixed to prevent short-circuiting and dead zones. By design, the distribution system utilizes existing pumps and valves, which then return each tank back to its highwater level. During a fill cycle, fresh water passes through multiple Tideflex® Nozzles, which create a circulation pattern throughout the entire water volume. This rapidly and completely mixes new water throughout the tank. Once the tank is mixed during the fill cycle, it does not "unmix" during the draw cycle.

Unlike mechanical mixers, there is no need to add an additional energy source to mix the water inside the tank. The owner paid for the energy source once when the finished water was pumped to fill the tank back to its high water level. Adding mechanical mixers is paying for energy twice. Having mixers submerged or floating inside the tank also puts an operation and maintenance cost burden on the owner because the motors will need to be replaced every few years, often requiring the tank to be drained. For tanks with minimal or no turnover, mixing 24/7 will not prevent water quality decay, as mechanical mixers just mix continually aging water. TMS is truly a "green" technology!

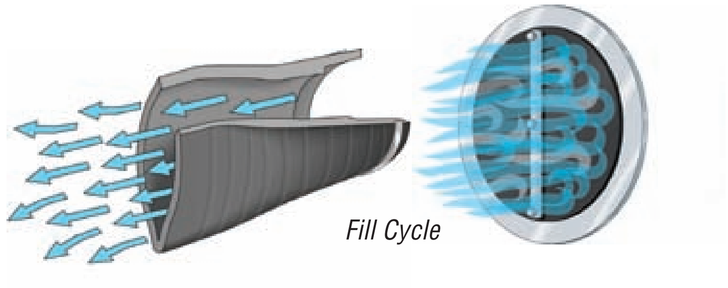
Maximize Volume Turnover to Minimize Water Age

Tanks are designed to have volume turnover and need turnover to minimize water age. A 5% daily volume turnover = 20 day average water age, 10% turnover = 10 day water age, 20% turnover = 5 day water age, and so on. AWWA recommends 20%-30% turnover for 3-5 day water age. Water utilities should operate their system to maximize tank volume turnover, which will minimize water age, resulting in increased disinfectant residuals, reduced DBPs and better water quality.

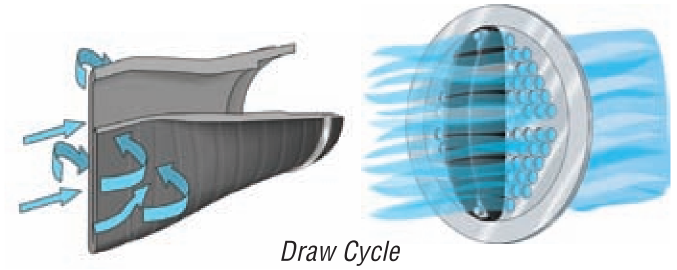


Achieves Complete Mixing, Eliminates Short-Circuiting

TMS Operating Principal - The TMS is a single multiport manifold system comprised of Tideflex® Inlet Nozzles and Waterflex® Outlet Check Valves that have no mechanical parts and operate solely on differential pressure. While the tank is filling, the Waterflex® Valves are closed and the tank fills through the Tideflex® Nozzles, which mix the tank completely. During a draw, the Tideflex® Nozzles are closed and water is drawn from the tank through flow efficient Waterflex® Valves.

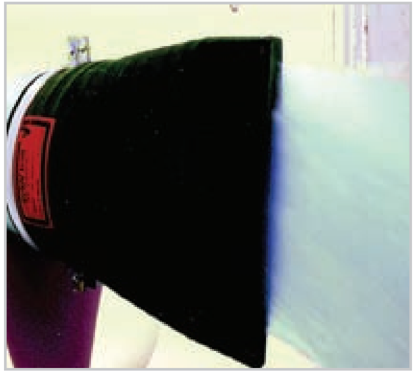


Fill Cycle



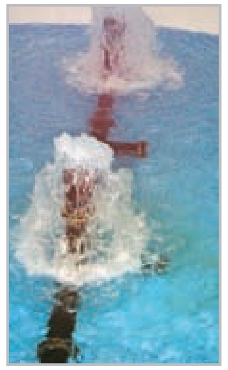
Draw Cycle

Maximized (Non-Linear) Jet Velocity of Tideflex® Nozzles Provides Rapid Mixing



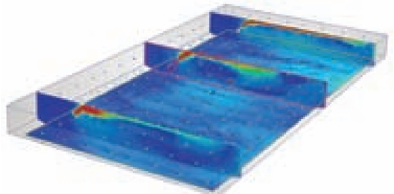
Unlike a fixed-diameter pipe, Tideflex® Nozzles act as a variable orifice. They open and close with increasing and decreasing flow, which maximizes jet velocity at all flow rates with low headloss, which produces rapid mixing.

Multiple Variable Orifice Tideflex® Nozzles



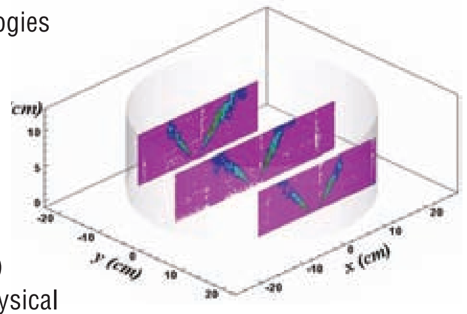
The key to the rapid and complete mixing with the TMS are the multiple Variable Orifice Tideflex® Nozzles that produce a minimum of 75% faster mixing than a single fixed-diameter pipe. In worst case summer conditions (colder inlet water), the multiple Tideflex® Inlet Nozzles have proven to completely mix tanks in comparison to a single inlet where all the flow momentum is in one location, resulting in short-circuiting and stratification.

Computational Fluid Dynamics (CFD) Modeling



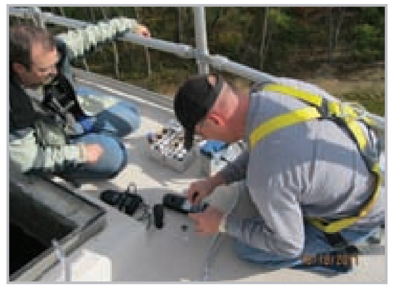
Continuous CFD modeling allows Red Valve's engineering team to optimize TMS designs and configurations. Tideflex® Technologies has conducted hundreds of CFD models for almost every size and style of storage tanks.

Physical Scale Modeling



Tideflex® Technologies partnered with the Georgia Institute of Technology on a Water Research Foundation (WRF) project called "Physical Modeling of Mixing in Water Storage Tanks." Hundreds of experiments were conducted on single and multiple port manifolds to analyze mixing characteristics. Various tank styles were modeled under isothermal, negatively buoyant (colder inlet water) and positively buoyant (warmer inlet water) conditions. The TMS designs are based on the most efficient manifolds discovered in this project. The system has also been validated with independent scale modeling.

Field Validation



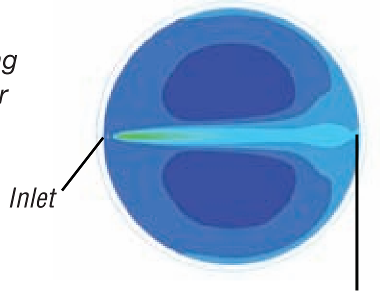
Through owner-conducted water quality sampling at various locations and depths throughout the tank, the TMS has been validated to achieve complete mixing and improve water quality in chlorinated and chloraminated systems in every tank style. The TMS has also been validated with full-scale tracer studies in a circular reservoir and elevated tank.

Custom Designed for Every Tank

Red Valve engineers custom design every TMS based on tank style, material, volume, dimensions, flow rates and volume turnover. Manifold hydraulics, mixing and water age models are run, as well as a jet trajectory analysis, to determine the quantity, size, orientation, elevation and discharge angles of both the Tideflex® Inlet Nozzles and Waterflex® Outlet Valves. A TMS Design Report is provided and includes TMS drawings, specifications, manifold hydraulics and Mixing and Water Age Analysis. The Mixing Analysis shows how much turnover is required to achieve complete mixing. The Water Age Analysis provides the average water age under current or proposed operating conditions.

Caution

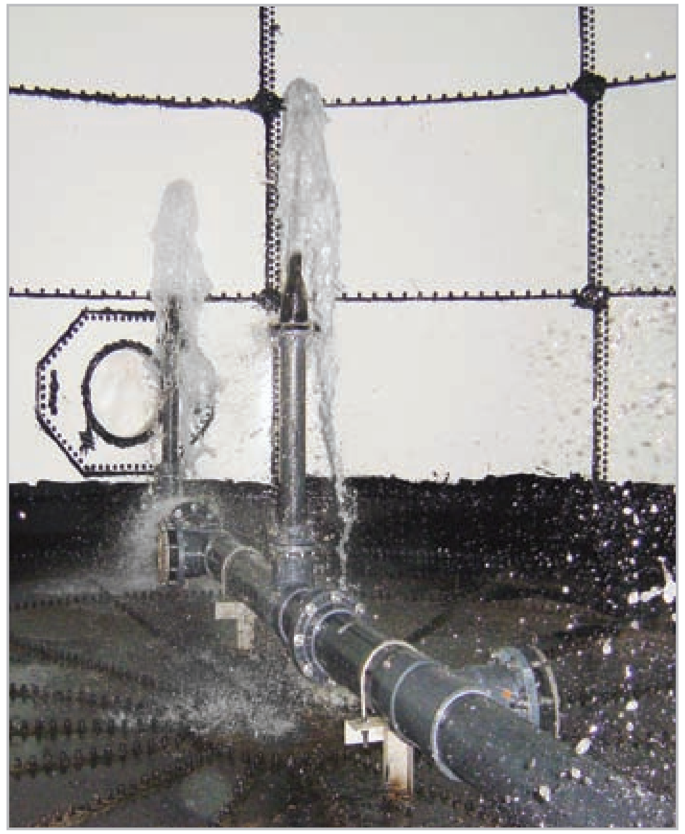
Separating the inlet and outlet pipes will not solve mixing and water quality problems. In almost every case, locating the outlet pipe the furthest distance from the inlet pipe is the wrong place. This will not prevent short-circuiting. A thorough understanding of circulation patterns and mixing is required in order to design a system that will completely mix the tank and eliminate short-circuiting.



Wrong Location of Outlet Pipe

Custom Design for Every Tank Style Based on Size, Volume, Dimensions, Flow Rates and Volume Turnover

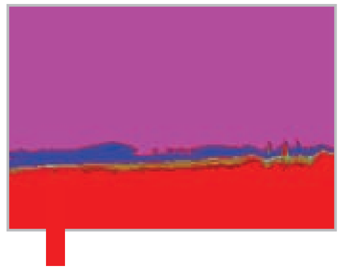
TMS in Circular, Rectangular and Irregular Tanks



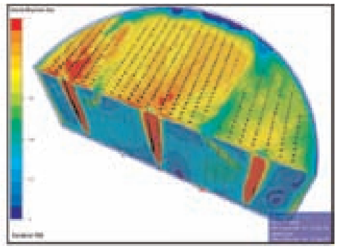
In circular, rectangular and irregularly-shaped reservoirs, the diameter or length is greater than the depth. A single fixed-diameter inlet pipe (common or separate from outlet pipe) results in short-circuiting, poor mixing and dead zones in areas away from the inlet because the momentum is concentrated in one localized area of the tank.

The TMS achieves complete mixing through a horizontal manifold with multiple Tideflex® Inlet Nozzles that distribute the momentum across the tank. The Waterflex® Outlet Valves are strategically located on the manifold to eliminate short-circuiting. For tanks with separate inlet and outlet pipes, the TMS is installed on the inlet pipe.

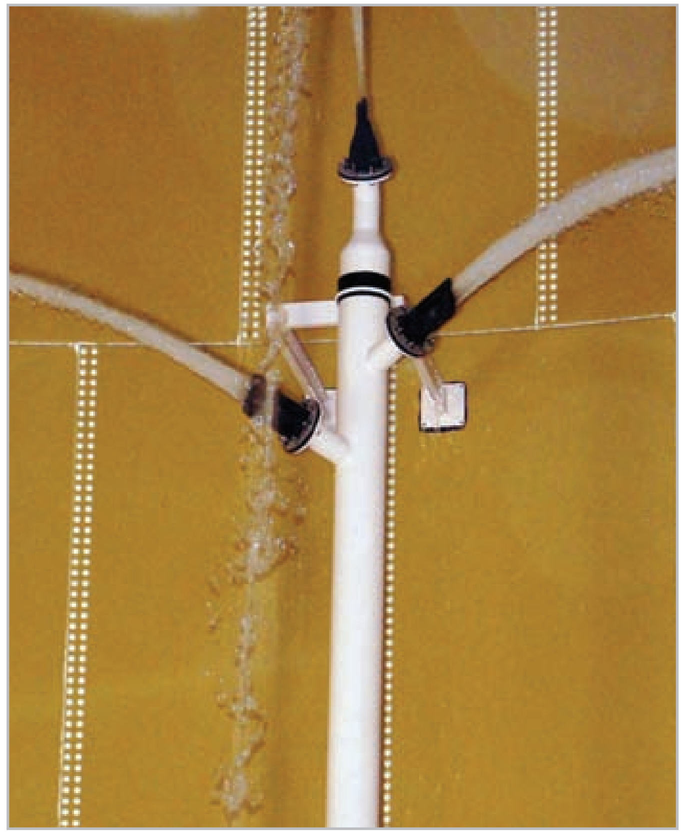
Problem
Poor mixing with a single fixed-diameter inlet pipe results in water quality problems.



Solution
Multiple Tideflex® Inlet Nozzles circulate water throughout the tank with every fill cycle.



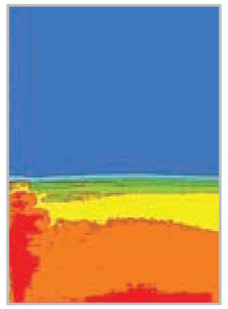
TMS in Standpipes



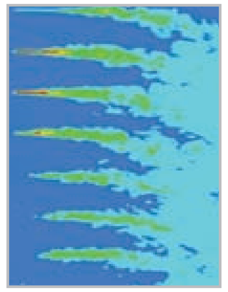
Standpipes are greater in depth than diameter and can exceed 140 feet (43 m) tall. They are extremely prone to short-circuiting, incomplete mixing and water quality decay, especially in summer when colder inlet water sinks, resulting in temperature stratification and increased water quality issues.

The TMS uses a vertical manifold with multiple Tideflex® Inlet Nozzles at various elevations, which distribute momentum throughout the depth of the tank and achieve complete mixing. To eliminate short-circuiting, the Waterflex® Outlet Valves are strategically located on the bottom of the TMS riser. For tanks with separate inlet and outlet pipes, the TMS is installed on the inlet pipe.

Problem
Standpipes are prone to stratification, incomplete mixing and poor water quality.



Solution
Complete mixing is achieved during every cycle by placing Tideflex® Inlet Nozzles vertically in the standpipe.



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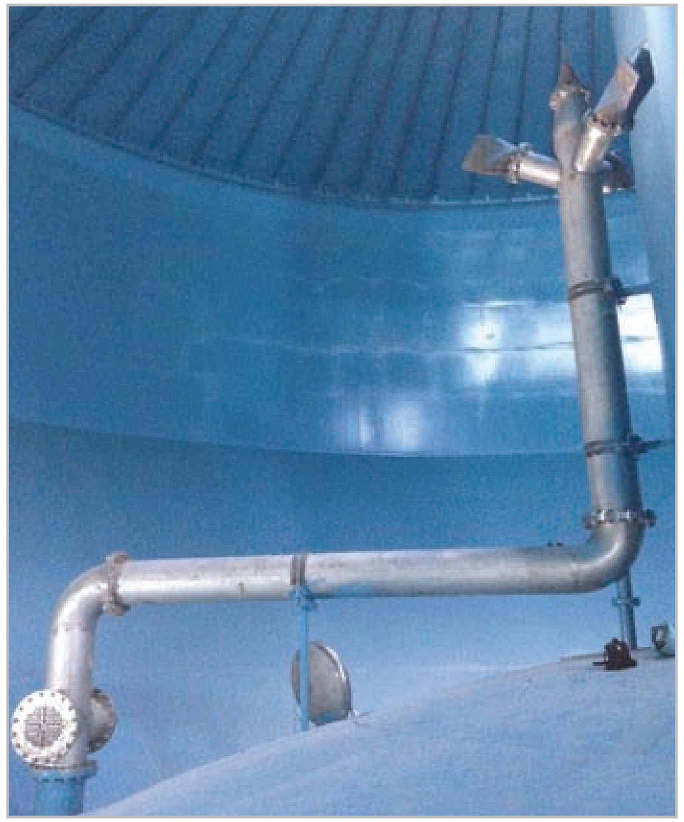
TMS in Dry Riser Elevated Tanks

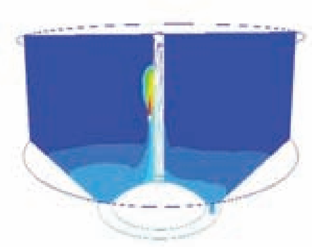


Elevated tanks are prone to poor mixing in summer and icing in winter, due to a large surface area exposed to the sun and the elements. The inlet-outlet pipe of Sphere-Spheroid, Fluted-Column and Composite Elevated Tanks (CET) runs up the pedestal, or dry riser, and penetrates the bottom of the bowl.

For tanks with common inlet-outlet pipes, the TMS is a vertical manifold with Waterflex® Outlet Valves near the bottom of the bowl. This separates the inlet and outlet and eliminates short-circuiting. Multiple Tideflex® Inlet Nozzles are located at various elevations and discharge angles along the vertical riser to achieve complete mixing and will minimize the possibility of icing. For tanks with a separate outlet pipe, the TMS manifold is installed on the inlet pipe.

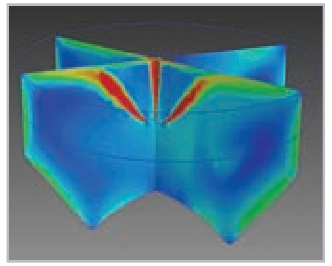
Problem

With so much of its area exposed to the elements, elevated tanks are prone to problems of poor mixing, stratification and water quality degradation.



Solution

Multiple Tideflex® Inlet Nozzles at multiple angles and elevations completely mix the tank.



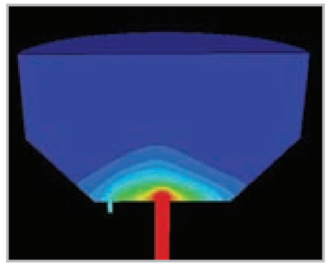
TMS in Wet Riser Elevated Tanks

Multi-column or multi-leg tanks are highly prone to water quality issues. Often the wet riser is 3-12 feet in diameter, running from ground level to the bottom of the tank, where it enters the bowl. At ground level, the inlet-outlet pipe penetrates the bottom of the wet riser and is significantly smaller in diameter than the wet riser. As a result, water velocity is severely reduced when it enters the wet riser from the inlet-outlet pipe. This drastically reduced velocity is not sufficient for mixing, making these tanks highly prone to thermal stratification and short-circuiting in warmer months when inlet water is colder. The colder water is denser and remains at the bottom of the tank during the fill cycle and the momentum of the inflow of the wet riser is almost always too low to provide complete mixing.

To achieve complete mixing, the Tideflex® Inlet Nozzles are located up in the bowl or vertical riser. Waterflex® Outlet Valves are located at the bottom of the wet riser, near ground level.

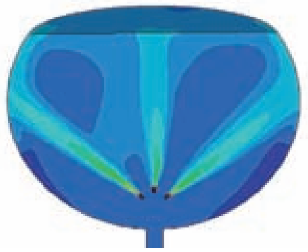
Problem

With a fixed-diameter inlet pipe at the bottom of the tank, only the water at the very bottom gets mixed.



Solution

The entire tank is mixed through Tideflex® Inlet Nozzles placed up in the bowl. This configuration prevents icing and other water quality problems.



A Smarter Way to Achieve Active Mixing and Chemical Injection

The maintenance-free Passive TMS has proven to mix tanks and mitigate icing problems with as little as 5% volume turnover, while using the inherent energy source of the fill and draw cycles.

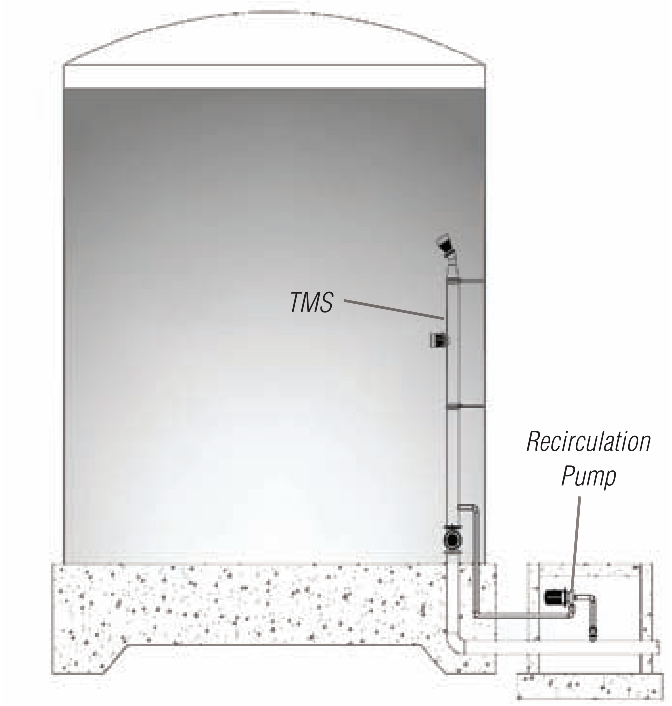
Active 24/7 mixing is almost never required. Installing floating or submerged mechanical mixers inside of storage tanks forces the owner to pay for an additional energy source, when the power has already been paid for once. It puts additional operational and maintenance costs on the owner, especially because mechanical mixers require maintenance and can be difficult to access.

For tanks with very low turnover or in extremely cold climates, the Passive TMS is easily made into an Active TMS using a recirculation pump, creating the Pass-Active TMS. This item can be utilized seasonally, as needed.

With the Pass-Active TMS, the passive TMS is installed in the tank, where it does not need maintenance. The recirculation pump is installed in the valve vault or an adjacent structure, where mechanical parts are easily inspected and maintained. The pump is low flow, head and energy because it pulls water from the tank and puts it back into the tank. Red Valve engineers size the recirculation pump and provide a Mixing Analysis.

Caution

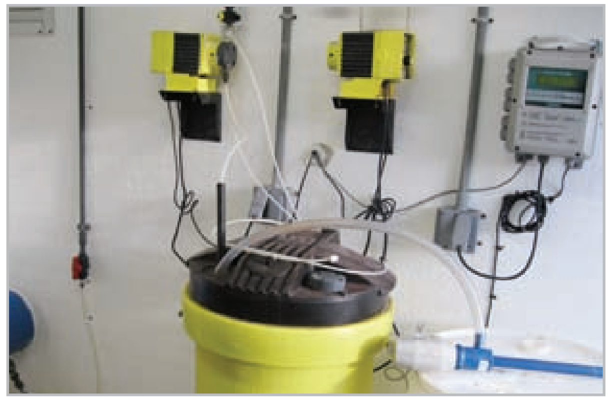
Mixing a tank 24/7 will not reduce water age. The Pass-Active TMS can also be used for forced drawdown where the pump discharges back into the distribution system to force the tank to draw down. Once the pump is called off, the tank refills and mixes through the passive TMS. Both mixing and water age are addressed with the forced drawdown scenario.



Pass-Active TMS keeps the pump outside the tank, for easy access and maintenance.

Safer, Easier Chemical Injection

The Pass-Active TMS can also be used for chemical injection to boost chlorine in free chlorine systems or chlorine and ammonia for systems on chloramines. Used in this way, the chemicals are completely mixed within the tank. This system eliminates the need to climb to the top of the tank to add chemicals. It ensures that water of a more consistent quality is leaving the tank.



A Secure, Reliable Choice for Overflow and Drain Pipes

Municipalities are challenged with protecting water storage tanks against contamination. Insects, rodents, birds, or tampering can cause serious health risks. Tideflex® Check Valves provide a reliable, cost-effective and maintenance-free solution compared to screens and flap valves.

Either flanged, or clamped onto the end of an overflow pipe, Tideflex® Valves are very reliable for overflow pipe protection. The all-rubber construction of Tideflex® Valves prevent rust, corrosion, and mechanical failure. Because they are non-mechanical, Tideflex® Overflow Valves do not require maintenance and will drain completely after an overflow event.

Tideflex® Valves are virtually impossible for rodents, birds and insects to penetrate. Unlike mesh screens and flapgate valves, Tideflex® Check Valves will not corrode, dislodge, freeze open or shut.

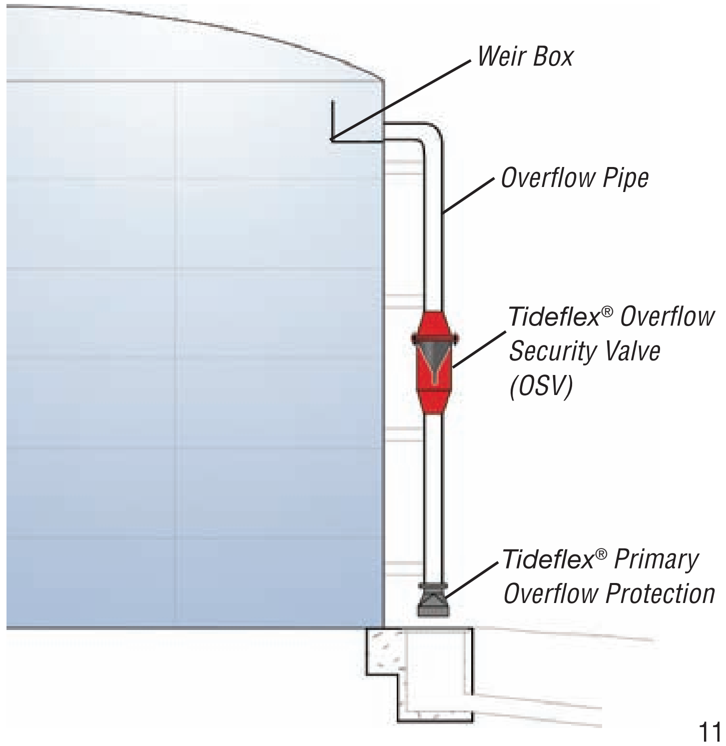
Tideflex® Valve still discharging water at -35° F.

Overflow Security Valve (OSV)

After 9/11, Red Valve Company's engineering team developed the Overflow Security Valve (OSV) to help our water utility customers address the increased need to secure their water supply from a potential terrorist attack. The OSV assembly incorporates a Tideflex® Series 37 Valve and is either welded or flanged to the overflow pipe with tamper-proof bolts.

With the OSV installed above the end of an overflow, you achieve two deterrents; the Tideflex® Series 37 cannot be seen, and it is extremely difficult to access, manipulate or damage.

Red Valve engineers provide a detailed Overflow Pipe Hydraulic Analysis to size and locate the Tideflex® Valve and/or OSV, based on tank dimensions, overflow pipe size and material, air gap distance and peak flow rate.



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Field Validation and Water Quality Sampling Equipment

The Tideflex® Mixing System (TMS) has been installed in thousands of tanks and reservoirs as small as 2,000 gallons, to over 150.0 million gallons. The TMS has been field validated in every tank style with sampling and monitoring studies conducted by water utilities, proving it improves storage tank water quality.

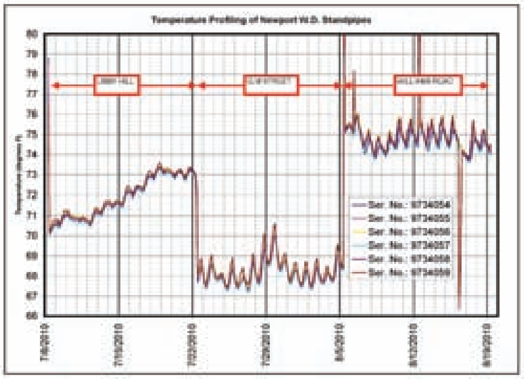
Whether you would like to determine if your tanks are stratified, or if you have mixing systems and want to confirm the tanks are mixed, Tideflex® Technologies has water quality sampling equipment available to sample your tank water quality throughout the depth.

The available monitoring equipment and services include:

- Temperature Data Logger (TDL) Strings that continuously monitor temperature within your tank for an extended period of time. The Data Loggers are pre-programmed for deployment.
- Depth Samplers that obtain grab samples at various depths within your tank for water quality analysis.
- Pocket Colorimeters that can be used to obtain free and total chlorine residuals.

Once the equipment is returned, the data is downloaded and analyzed. A report with the data is compiled and provided to the customer.

Contact Tideflex® Technologies for more information about these services.



Temperature Profiling Chart

Temperature Data Logger String

Depth Sampler

Colorimeter

The products contained in this brochure are covered under one of the following patent numbers:

US 7,104,279 (US),
US 6,016,839 (USA),
CA 2,409,009 (Canada).

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