STAFF REPORT

To: **Coastside County Water District Board of Directors**

From: **David Dickson, General Manager**

Agenda: **November 13, 2018**

Report Date: November 7, 2013

Subject: **Agreement with Pakpour Consulting Group to Provide Plans and Specifications for the Alves Tank Improvements**

Recommendation:

Authorize the General Manager to enter into a Professional Services Agreement with Pakpour Consulting Group, Inc. to prepare plans and specifications for the Alves Tank Improvements at a time-and-materials cost not to exceed $69,886.

Background:

The District's 2 million-gallon Alves Tank, constructed in 1970, has never been recoated and requires recoating and repair. In preparation for the project, the District retained Cornerstone Structural Engineering Group (Cornerstone) to perform a seismic evaluation of the tank and to recommend a retrofit strategy which will bring the tank up to current seismic standards. Pakpour Consulting Group (Pakpour) coordinated Cornerstone's efforts and assisted with development of retrofit options and cost estimates.

Cornerstone's report, included as Attachment A, concludes that "Due to insufficient freeboard, the Alves water tank is anticipated to be severely damaged, with a potential loss of contents and damage to the roof framing and shell during the design level earthquake." The report identifies several repair/retrofit strategies, with estimated costs ranging from $950,000 to $2.1 million.

The least expensive approach, identified in the Cornerstone report as Option 1, reduces seismic stresses caused by earthquake-induced sloshing in the tank by lowering the water level from 23.0 feet to 17.5 feet. At the lower water level, the seismic wave in the tank will not interact with the roof structure. Lowering the water level to 17.5 feet reduces the tank's capacity from 2 million gallons to about 1.5 million gallons.

Based on discussions with Pakpour and Cornerstone, staff has focused on Option 1 as the best approach. Hydraulic modeling performed by West Yost Associates confirmed that, due to Alves Tank's low elevation relative to other tanks, the tank is not needed to provide water to the distribution system except under extreme conditions that drop system-wide pressure to very low levels. We believe, therefore, that the reduction in storage volume required by Option 1 would be acceptable. In addition, the lower volume mitigates water quality problems resulting from low turnover of the water stored in Alves.

At staff's request, Pakpour has provided a proposal, included as Attachment B, to prepare plans and specifications for the Alves Tank Improvements. The cost for the design is about $70,000 – in line with design costs for previous tank projects. We recommend retaining Pakpour to provide these services.

Fiscal Impact:
Design cost of $70,000. The approved FY19-FY28 CIP includes $2.1 million in funding for this project in FY19 and FY20.

Attachment A

CORNERSTONE structural engineering group

Alves Water Tank

Coastside County Water District
Half Moon Bay, CA

Structural Review and Retrofit Strategy Report

May 29, 2018

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May 29, 2018
2018008

Coastside County Water District
766 Main Street
Half Moon Bay, CA 94019

Attention: David Dickson

Subject: Alves Water Tank
Structural Review and Retrofit Strategy Report

Dear David:

Cornerstone Structural Engineering Group is pleased to present this summary of our structural review and retrofit strategy report. In accordance with our proposal, we have performed a general structural conditional and seismic assessment of the Alves water tank. This report contains an evaluation for the existing 2,000,000 gallon steel water tank located on the Alves Tank site in Half Moon Bay. Originally constructed in approximately 1970, the Alves Tank is approximately 25 feet 6 inches tall by 120 feet in diameter.

The structural provisions of the current California Building Code refer to the ASCE 7-10 standard for determination of design loads for structures designed within California. ASCE 7-10 in turn refers to the AWWA D100-11 standard for analysis and design of welded steel water storage tanks. This report uses those criteria to evaluate the seismic performance of the existing steel water tank. In addition, a general conditional assessment of the water tanks is also included.

We conducted an initial site visit on June 1, 2017 with subsequent site visit on February 14, 2018. Detailed shop drawing plans by Chicago Bridge & Iron Company and an existing soils report by Lowney-Kaldveer Associates for the Alves Tank were made available and reviewed as part of our investigation.

The following report describes the findings of our conditional review and seismic risk assessment to evaluate the performance of the steel water tank when subjected to a current code-level earthquake. Recommendations to address conditional issues and remediate seismic deficiencies are described in the conclusions.

Please feel free to give me a call if you have any additional questions.

Sincerely,
CORNERSTONE STRUCTURAL
ENGINEERING GROUP, INC.

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PART 1: INTRODUCTION

This evaluation represents a general structural conditional and seismic assessment of the existing Alves tank located on Miramontes Point Road in Half Moon Bay, California. The Alves tank is owned, operated, and maintained by Coastside County Water District.

Figure 1: Alves Tank Site Area Photo
(Source: Google Maps)

Figure 2: Alves Tank Site Photo
(Source: Google Earth)

Constructed in approximately 1970, the Alves tank is an unanchored, welded carbon-steel water storage tank with a knuckle roof. The tank has a total shell height of approximately 25.5 feet including the knuckle around the circumference of the tank and is approximately 120 feet in diameter with a nominal capacity of 2.0 million-gallons. The tank provides service to Coastside County Water District in Half Moon Bay. There is a pump house on site that houses equipment that services the Alves Tank (see photo 9 of the Appendix).

An initial site visit was performed on June 1, 2017 to observe the existing exterior structural conditions of the tank. Because the tank was in operation at the time of the initial visit, we were unable to observe the tank interior. Cornerstone performed a subsequent site visit on February 14, 2018 to observe the tank roof, and very limited visual observation of roof framing through the roof access hatch.

The conclusions are limited by the availability of as-built construction documents and by the level of access possible for the observation of the tank. The purpose of this investigation is to provide a summary of conditional issues and seismic assessment for current AWWA level forces for an essential services facility. This report describes the findings of our structural review, and provides recommendations for seismic upgrade and conditional structural repairs as applicable. See part 3 for further discussion regarding observation access and as-built documentation.

PART 2: SEISMIC PERFORMANCE EVALUATION

2.1 *Methodology*

The potential damage to a structure in an earthquake can be evaluated provided that, (1) seismic hazards which affect the structure and site can be estimated and, (2) the vulnerability of the structure to those hazards are known or can be estimated.

Seismic evaluation of the existing welded carbon-steel water tank was conducted using:

- American Water Works Association (AWWA) D100-11 – Welded Carbon Steel Tanks for Water Storage
- American Society of Civil Engineers (ASCE) 7-10 – Minimum Design Loads for Buildings and Other Structures
- Site specific S_S, S_1, S_{DS} and S_{D1} seismic ground motion parameter values approximated by the USGS Seismic Hazard Curves program based off the 2008 NEHRP Maps.

Seismic evaluation of the Alves steel water tank was performed using seismic design forces calculated in accordance with the AWWA D100-11 standard for new welded steel water tank construction.

Design ground motions in AWWA D100-11 standard correlate to a seismic event with a 10 percent probability of exceedance within a 50 year period and are referred to as a 475-year earthquake. Water tanks considered to be essential are designed with an importance factor increase of 1.5 applied to the design ground motions. See below for further discussions.

The methodology used in our assessment uses an importance factor of 1.5 as described in Section 2.2 below, for Seismic Use Group III as documented in the AWWA D100-11 based approach. This Seismic Use Group III is for essential facilities and is essentially equivalent to an occupancy/risk category IV under the 2016 CBC and ASCE 7-10.

2.2 Seismic Use Group

AWWA D100-11 seismic design identifies three Seismic Use Groups I, II & III and assigns an importance factor, I_E to each group. I_E is a multiplier that is used to calculate lateral load forces applied to structures relative to their community importance to ensure that a structure will sustain less damage in an earthquake. Public water tanks which provide service considered to be essential for post-earthquake recovery, including fire suppression, are sometimes designated as Seismic Use Group III by the owners and are assigned an importance factor, I_E, of 1.5 which is the most stringent codified criteria. As a result, an essential service water tank will normally be designed to withstand 50% more lateral load than a tank considered to be non-essential or redundant.

2.3 Seismic Source

The seismicity in the Bay Area is influenced by several known faults, their potential faulting length, and relative orientation. The San Andreas Fault system, which separates the North American plate from the Pacific plate, is located approximately 6 miles to the northeast of the Alves tank site. The known, nearest-site faults with recorded activity are listed in Table 1, as follows:

Controlling Fault	Estimated MCE (M_W)	Distance to Site (miles)
San Gregorio Fault	7.5	2.0
San Andreas Fault	7.8	6.0
Hayward Fault	7.0	24.0

Table 1: Active Near Source Faults

Based on the California Geologic Survey (CGS) and the United States Geologic System (USGS) mapping, the 475-year peak ground acceleration (PGA) for the Alves Tank site is 0.50g.

In addition to the normal lateral ground motions evaluated for earthquake design, recent earthquakes in Southern and Central California – namely Coalinga, Whittier Narrows, and Northridge – have occurred along blind-thrust faults. These faults do not have readily identifiable surface features and are not extensively mapped. The potential for strong-ground motion to occur due to blind-thrust faulting in Northern California is somewhat in doubt. However, a moderate to large earthquake centered even closer to the site cannot be completely ruled out.

It should be noted that a more thorough explanation of site seismicity and specific faulting hazards could be provided by a geotechnical engineer. The conclusions above rely on general published data for the San Francisco Bay Area.

Furthermore, it should be noted that the Foundation Investigation by Lowney-Kaldveer Associates dated June 15, 1973 discusses site Geology and Seismicity. According to this report, the site is founded on sandstone, siltstone, and claystone of the Purisima Formation and geologic stability is favorable and the danger from fault offset through the site is considered minimal. See Section 3.2 below for further discussion on site classification.

PART 3: WATER TANK EVALUATION

3.1 *Documentation*

- Plans for the Construction of Alves tank prepared by Tudor Engineering Company dated July 1973 were made available for evaluation from the District. These drawings indicated the overall dimensions of the tank, site grading, piping plans and foundation information. It should be noted that these plans use the name "Miramontes Storage Tank". Coastside County Water District has confirmed that the name of the tank is "Alves" and "Miramontes" is the street where the tank is located.
- A Foundation Investigation by Lowney-Kaldveer Associates dated June 15, 1973 was made available for evaluation from the District. This investigation includes site information such as soils, groundwater, and seismicity as well as recommendations including grading, drainage and foundations. Information documented in this report appears to be consistent with the Construction Plans noted above.
- Steel tank shop drawings by Chicago Bridge & Iron Company dated July 7, 1973 were also made available. These documents include tank shell, roof plate, and base plate thicknesses, overflow information, structural framing information, and structural framing connection details. Supporting calculations were also provided.
- An underwater inspection report performed by LiquiVision Technology in January 2008 was also made available. This report provides conditional assessment of the tank interior as well as exterior.

These documents were collectively used to evaluate the existing steel water tank and determine potential retrofits.

3.2 *Evaluation Criteria*

Seismic evaluation of the steel water tank was performed using the AWWA D100-11 standard.

- Alves tank is considered to be essential to maintain water service in the event of an earthquake; therefore, it was evaluated using an importance factor, I_E of 1.5 (essential service).
- Site specific soil classification and seismic parameters were not included in the Foundation Investigation by Lowney-Kaldveer Associates dated June 15, 1973, however description of subsurface conditions and boring logs indicate 3-5 feet of silty clay layer overlaying siltstone with relatively high blow counts. Normally, in the absence of site specific soil classification or seismic parameters, a site classification D is assumed as a default value in seismic assessments.
- According to Table 20.3-1 of ASCE 7-10, the blow counts documented in the available geotechnical report correspond to a site class C and based on the USGS Soil Type and Shaking Hazard in the San Francisco Bay Area Map, the Alves tank site is located within a soil type C. Soil type C (soil profile for very dense soil and soft rock) was determined to be reasonable and was used for the Alves tank. USGS soil type C closely relates to site class C for design with the USGS ground motion data and ASCE 7 requirements. Seismic ground motion parameter values, derived from 2008 USGS hazard data in accordance with ASCE 7-10 (w/ March 2013 errata) for Site Class C, are listed in Table 2.

It should be noted that use of site class D values would result in roughly 15% greater seismic demands. Actual confirmation of site class would need to be provided by a geotechnical professional as the USGS soil type is provided as a general guideline and should not be relied on for final design.

S_S	2.074g
S_1	0.882g
S_{DS}	1.383g
S_{D1}	0.765g

Table 2: Seismic Ground Motion Parameters For Soil Type C

- Alves tank is supported by, but not anchored to, a reinforced concrete ringwall foundation and was therefore evaluated by CSEG as a 'self-anchored' tank to determine seismic vulnerabilities and deficiencies. The AWWA D100-11 response modification factors R_i and R_c used to determine the impulsive and convective design accelerations for self-anchored tanks are 2.5 and 1.5 respectively.

  Evaluation results can be found in section 3.5 "Lateral Load System".

- Alves tank was then evaluated by CSEG with lower Maximum Operating Levels to determine potential retrofit options.

  Evaluation results can be found in Section 3.5 "Lateral Load System".

3.3 *Construction*

The Alves water tank is a flat bottom welded carbon-steel tank, and is 120 feet in diameter. The tank is supported on, but not anchored to, a reinforced concrete ringwall foundation. See Figure 3 below for tank section from the available shop drawings. The information provided below is based on available shop drawings and construction plans for the Alves Tank as well as observations made while visiting the site.

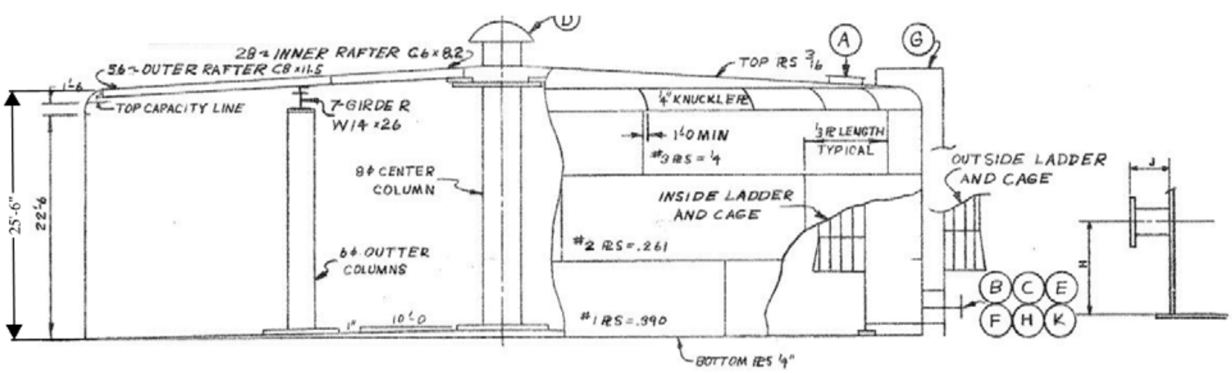

Figure 3: Alves Tank Section
(Source: Alves Tank Shop Drawing)

- Alves tank is constructed of three courses of plates plus a knuckle for a total shell height of approximately 25.5 feet around the circumference of the tank. Construction of the tank shell was observed to be consistent with the available shop drawings, which indicate continuous butt welds at both the longitudinal and circumferential plate joints. Per the available shop drawings, the tank shell plates are specified as A131A, whereas the roof and bottom plates are specified as A283C. Course plate thicknesses and ASTM designation based on the shop drawings with corresponding yield strengths are shown in Table 3:

Location	Inches	ASTM	Fy (Ksi)
Roof Plate	0.1875	A283C	33.0
Knuckle Plate	0.25	A131A	31.9
Shell Course No. 3	0.25	A131A	31.9
Shell Course No. 2	0.261	A131A	31.9
Shell Course No. 1	0.390	A131A	31.9
Floor Plate	0.25	A283C	33.0

Table 3: As-Built Tank Plate Thicknesses for Alves Tank

- Based on available shop drawings, the roof framing of the tank consists of an inner and outer bay of radial C8x and C6x rafters with an intermediate column supported girder ring. The outer bay of C8x11.5 rafters span approximately 30 feet from the tank shell to an intermediate ring of W14x26 girders. The inner bay of C6x8.2 rafters span from the W14x girders to a central 8 inch diameter column. The W14x intermediate girders are supported by 6 inch diameter interior columns spaced approximately 26 feet apart.

- There are 1-½ inch by 1-½ inch angle stability braces located around the tank at approximate mid span of each rafter. There are also 3½ inch by 3½ inch angle diagonal braces at various locations throughout the tank. Based on discussions with a tank specialist, these diagonal braces were sometimes used to provide additional stability of rafters, particularly against spiraling or rolling.
- The tank bottom plate was observed to extend approximately 2 inches beyond the exterior of the tank shell. The base of the shell is connected to the bottom plate with continuous interior and exterior fillet welds.
- There is a 16-inch diameter inlet/outlet pipe supported by reinforcing plates on both sides of the tank shell that exits the tank through the tank shell near the tank bottom.
- There is a 10-inch diameter interior overflow pipe that exits the tank through the tank shell near the tank bottom.
- There is an approximately 1.5 foot deep by 1 foot wide reinforced concrete ringwall foundation that supports the tank. No anchorage from the tank to the ring walls is shown.
- There is one 24-inch diameter access door and one 36-inch access door located on the tank near the bottom.
- There is an exterior roof access ladder; however there is no interior ladder access.
- There is an approximate 3 foot by 3.5 foot roof access hatch.
- There is a 48" diameter mushroom roof vent with screen in the center of the tank roof.
- The slope of the tank roof is approximately ¾ inch per 12 inches

The Alves tank site also has a pump house that appears to be a masonry building (likely fully grouted and reinforced) with a flexible wood roof diaphragm (see photo 9 of the appendix). A conditional and cursory ASCE 41-13 Tier 1 checklist seismic evaluation for Life Safety was performed on the building to determine any potential seismic deficiencies based on some likely assumptions. See Section 3.5 for findings from this evaluation. As-built plans were not available for the evaluation of the pump house.

3.4 *Conditional Issues*

The tank was in operation during our initial site visit, limiting observation to the exterior of the tank. During a second site visit, roof hatch access of the tank was provided which allowed us to look at the roof framing with a flashlight. Roof framing members near the hatch were visually observed, however measurements could only be taken from the outer bay rafters.

Based on our field visits, the existing tank appears to be in general compliance with the codes and standard construction practices in effect at the time of its construction.

The existing conditions observed during our site visits are as follows:

- Corrosion of the bottom plate is evident in various locations along the perimeter of the tank, see photo 1.
- Corrosion is evident on the exterior tank shell at various locations around the tank, see photo 2.
- Localized areas of minor corrosion are evident on the tank roof, see photo 3.
- The caulking along the top of the footing and the tank bottom plate has degraded and is starting to pull away leaving localized gaps between the footing and bottom plate, see photo 4.
- Corrosion is evident around the perimeter of the roof vent, see photo 5.
- Corrosion is evident on the roof hatch with two small holes visible in the hatch door, see photo 6.

3.5 *Lateral Load System*

Lateral loads for the steel tank structure result primarily from either wind pressure acting upon the exterior tank surface or earthquake induced inertia forces acting on the tank structure and its contents. For our consideration, the seismic forces govern by a significant amount. The lateral-force resisting system consists solely of the cylindrical steel tank shell and floor plate which transfers lateral loads to the base of the tank by a combination of circumferential tension, shear, and vertical tension/compression shell stresses. Tank overturning and sliding forces are resisted with friction by the tank self-weight, including a portion of its contents to resist seismic forces.

Seismic evaluation of the existing tank with no modifications was performed based on a maximum operating water level of 23.0 feet per the direction from the District. The maximum operating level is one foot below the lip of the overflow.

- The existing tank has sufficient self-weight to resist seismic sliding and overturning forces due to the design level earthquake load. The Demand to Capacity (D/C) ratio for seismic sliding is approximately 0.4 and for seismic overturning is approximately 0.5.
- The tank shell thickness is overstressed in circumferential hoop tension stresses due to seismic loads with a maximum Demand to Capacity (D/C) ratio of approximately 1.35.

- The tank has adequate shell thickness to resist longitudinal compression stresses due to design level earthquake loads with a Demand to Capacity (D/C) ratio of 0.21.
- The overturning ratio, “J”, is calculated to be less than 0.785, meaning there is no shell uplift and therefore Alves tank is considered to be considered self-anchored under its own weight.
- The height between bottom of the existing roof rafters at their lowest point and the surface of water at maximum capacity is less than 2 feet (this is the existing freeboard). The calculated freeboard height to accommodate earthquake wave sloshing is 8.5 feet for the Alves tank. At a maximum operating level (MOL) of 23.0 feet, wave sloshing due to earthquake forces will cause significant uplift damage to roof plate, knuckle plate, shell and/or roof framing during the design level earthquake considered for essential service facilities.

<u>Findings for the Pump House Building</u>

Based on the ASCE 41 Tier 1 review, the following items are of significance for the performance of buildings when subjected to strong ground motions during an earthquake. With no as-built drawings, the following items cannot be confirmed without destructive removal of finishes and further testing:

<u>Positive Features</u>

- Foundations show little to no signs of significant settlement or distress.
- Reinforced masonry walls are within allowable shear stress limits (fully grouted assumed).

<u>Negative Features and Unconfirmed Construction Details</u>

- Fully grouted CMU walls: Based on similar buildings constructed in this era, the walls are most likely fully grouted (shear capacity assumed this).
- Roof-to wall ties: Based on similar buildings constructed in this era, the roof-to-wall ties are likely either inadequate or missing entirely. Lack of positive wall anchor ties would rely only on cross grain bending of wood ledgers, which is an inefficient and code prohibited load mechanism.
- Adequate shear transfer from the diaphragm into the shear walls as well as from the wall into the foundation. It is likely that this is moderately deficient.
- Roof construction: it is assumed that the roof diaphragm consists of un-blocked plywood sheathing over 2x roof joists, which would be adequate.

3.6 *Expected Performance*

Due to insufficient freeboard, the Alves water tank is anticipated to be severely damaged, with a potential loss of contents and damage to the roof framing and shell during the design level earthquake. Options for limiting potential damage during an earthquake are discussed in Section 4.3 “Seismic Recommendations”.

The pump house is anticipated to perform below average in comparison to buildings of similar construction when subjected to a design level earthquake due primarily to the assumed inadequate roof-to-wall ties.

PART 4: SUMMARY

Findings within this report provide a general structural conditional and seismic assessment of the Alves water tank located in Half Moon Bay, California. Alves tank is a flat bottomed, welded steel water tank constructed in approximately 1970. The tank has a total shell height of approximately 25.5 feet and is120 feet in diameter with a nominal capacity of 2.0 million gallons.

4.1 *Findings*

Based on our review, the Alves water tank appears to be in general compliance with the codes and standard construction practices in effect at the time of its construction in 1970. However, the Alves water tank is not expected to resist a design level earthquake determined by the AWWA D100-11 criteria for tanks considered necessary for essential services. The following specific deficiencies are as noted:

- Inadequate freeboard height to accommodate earthquake wave sloshing is likely to result in damage to roof plate and/ or roof framing, tank shell, roof framing attachments, and the floor plate at shell to bottom weld and column connections.
- Inadequate shell thickness of bottom two courses to resist circumferential hoop tension stresses caused by the seismic event.

4.2 *General Recommendations for Conditional Issues*

The following recommendations are provided to address issues concerning the general conditions outlined in this report:

- Areas of localized rust and corrosion upon interior framing members, roof plate, and roof hatch should be cleaned and inspected during scheduled painting and maintenance. If more than 10% of the section is lost, then a repair detail should be developed. Roof hatch door should be replaced.
- Areas of localized rust and corrosion on the tank bottom plate should be cut out and patched with new segments of floor plate if corrosion extends inside the tank. Further investigation of the corrosion on the floor slab should be conducted to determine extents.
- Caulking along the top of the footing should be repaired/ replaced as necessary to close off localized gaps between the footing and the bottom plate.

4.3 *Seismic Recommendations*

<u>Water Tank Seismic Recommendations</u>

The following recommendation options are provided to address the seismic deficiency issues related to the water tank as outlined in this report. A variety of water levels have been evaluated to provide the District with potential retrofit options with different water operating levels. A loss of 85,000 gallons in water storage capacity will occur with every foot the water level is lowered:

- Option 1: Provide greater freeboard by lowering the maximum operating level 5.5 feet (MOL) elevation to 17.5 feet so that the seismic wave will not interact with the roof framing, therefore strengthening is not required.
    - o If the Maximum Operating Level (MOL) is lowered from 23.0 feet by 5.5 feet down to 17.5 feet, the calculated freeboard will be greater than the sloshing wave height. This option requires no strengthening of roof framing for seismic wave sloshing. Also, this drop in water level lowers tension stresses at the

bottom of the tank to within acceptable limits. However, this option significantly diminishes the holding capacity of the tank by approximately 470,000 gallons or approximately 25% less than current capacity.

- This option requires door sheet to be cut and re-installed using the existing shell plate and work related to lowering the overflow cone to the required elevation.
- Anchorage to a concrete ring wall foundation is not required for this option.
- Based on our experience with similar tanks, repair/ replacement of roof rafters may be required following blast cleaning and thorough inspection of section loss due to corrosion.
- In addition to structural related items, it appears that the existing tank is due for a complete recoating to extend service life. The recoating of the tank will require extensive surface preparation.

- Option 2: This is an intermediate solution. Provide greater freeboard by lowering the Maximum Operating Level 4 feet (MOL) to 19.0 feet so that the existing shell plates and roof plate are adequate and that the existing roof framing can remain in place and be strengthened.
  - If the Maximum Operating Level (MOL) is lowered from 23.0 feet by 4.0 feet down to 19.0 feet, there will be approximately 6 feet of freeboard height provided. At this water level, the calculated wave sloshing height is approximately 8.0 feet. This will require strengthening of the outer bay roof rafters to resist 2.0 feet of hydrostatic upward pressure. This depth was selected for consideration because it is the highest the operating level that can be achieved without replacement or strengthening of the roof plate and because it would not require strengthening of inner bay rafters.
  - The outer bay roof rafters will require strengthening of bottom flanges by welding on steel plates and bracing the bottom flange with transverse members (See concept Detail A shown in Sketch 1 of the Appendix). The roof plate can adequately resist these forces if the roof plate is welded to the roof rafters or by potentially installing slider clips that would be connected to the underside of the tank roof and hang underneath flanges of existing rafters. According to the available shop drawings, existing roof plate is welded to transverse angle brace and not each rafter. Conditional evaluation after blast cleaning may warrant full replacement of the outer rafters as a more economical solution.
  - The W14x girders will require stability strengthening of bottom flanges by bracing of the bottom flange at mid-span by providing diagonals to outer bay rafter nearest the middle of the girder (See concept Detail B shown in Sketch 2 of the Appendix).
  - The columns would need to be retrofitted to provide a greater resistance to uplift (See concept Detail C shown in Sketch 3 of the Appendix). The existing columns are welded to the bottom plate. This could be achieved by temporarily supporting the existing column and modifying the column base.
  - Anchorage to a concrete ring wall foundation is not required for this option.
  - Based on our experience with similar tanks, strengthening of interior roof rafters may also be required following blast cleaning and thorough inspection of section loss due to corrosion.

    - In addition to structural related items, it appears that the existing tank is due for a complete recoating to extend service life. The recoating of the tank will require extensive surface preparation.

- Option 3: Maintain current 23.0 feet water level elevation
    - Option 3a: Replace the Tank with a new tank designed to the current AWWA D100-11 code.
        - If Maximum Operating Level (MOL) is desired to remain at the current 23.0 foot level, then the tank can be completely replaced with a new tank that will meet the required freeboard. The new tank would be taller than the existing.
        - Existing concrete ring wall foundation may be utilized to support the new tank
        - The plates for the new tank would be shop primed resulting in less surface preparation work compared to re-coating of the existing tank.
    - Option 3b: Maintain current 23.0 feet water level elevation, increase the freeboard and mitigate the tank shell overstress by jacking the existing tank and adding a new lower course shell ring.
        - If Maximum Operating Level (MOL) is desired to remain at the current 23.0 foot level without replacing the tank or roof structure, the existing tank roof would need to be raised. This could be accomplished by jacking the existing tank up and installing a new first shell course and new columns to increase the freeboard of the tank and also provide adequate tensile stress capacity of the tank shell. The new first course ring would be thicker than existing shell plates and approximately 7.0 feet tall for a total tank height of approximately 32.5 feet. The calculated sloshing wave height is 8.5 feet, which is less than the calculated freeboard of approximately 9 feet; therefore strengthening of the roof would not be required. The increase in tank height will need to be reviewed by the District, Planning, and any other governing agencies.
        - Anchorage to a concrete ring wall foundation is not required for this option. Existing concrete ring wall foundation may be utilized to support the new bottom course shell of the altered tank.
        - The Alves tank site appears to be sufficient for the option of jacking the tank shell, with reasonable access around the perimeter of the tank.
        - Based on our experience with similar tanks, repair/ replacement of roof rafters may be required following blast cleaning and thorough inspection of section loss due to corrosion.
        - In addition to structural related items, it appears that the existing tank is due for a complete recoating to extend service life. The new bottom course will be shop primed, however the rest of the tank would require surface preparation in the field.

          Issues considered that could affect jacking operations include access restrictions, material handling, and construction methods:

1. The new shell ring could be provided in standard lengths based on the site access available.
2. A jacking system would be temporarily installed around the tank circumference and be sized for the weight of the tank. In addition, each column on the interior of the tank would require a separate jack. Final determination would be made after detailed inspection of the structural configuration if the jacking option is selected.
3. The jacking process could potentially take several weeks, as horizontal welds will need to be applied by hand around the circumference of the tank instead of using an automated weld process normally used in new tank construction.
4. Existing manholes in the bottom shell could be left in place or removed and sealed with cover plates. New manholes would be built into the new bottom course.

- Option 3c: Maintain current 23.0 feet water level elevation, strengthen the roof framing and mitigate the tank shell overstress by installing a new external roof system and shell reinforcing plate at bottom two courses.
  - If Maximum Operating Level (MOL) is desired to remain at the current 23.0 foot level without replacing or jacking of the existing tank, the roof will need to be strengthened. Various tank manufacturers offer external roof systems that provide significant strength and resistance to wave pressures.
  - If tank dimensions and water level are left unchanged, strengthening plates would need to be provided around the bottom two shell courses where analysis indicates that shell plates are overstressed due to circumferential hoop tension. Since the tank is overstressed in the bottom two courses and a new bottom course is not being added, it was determined that this alternative is not economical compared to alternatives 3a and 3b.

Pump House Seismic Recommendations

The following recommendations are provided to address the seismic deficiency issues outlined in this report related to the pump house. These recommendations are based on assumptions made regarding the as-built condition of the roof framing. Assumptions should be confirmed with exploratory demolition of finishes and investigation of the roof framing and wall components prior to beginning retrofit work.

Based on our Tier 1 investigation summarized in section 3.5 above, it is likely that the roof-to-wall ties are either missing or are inadequate for the current seismic design codes. Removal and reinstallation of the ceiling will be required to install the new ties. Roof to wall ties will consist of tension tie rods drilled and epoxied through the existing masonry walls with holdown anchors installed on the sides of the roof joists. At locations where walls are parallel to the roof framing tension tie rods shall be installed through blocking in the outer 3 bays of framing with metal straps installed on top of the roof. Enhanced nailing on the roof sheathing will be required at the location of the tie rods. Removal and reinstallation of the roofing and ceiling has been included in the cost estimate as rough order of magnitude costs. Additional work to the roof diaphragm (plywood sheathing, additional nailing) may be required depending on what type of roof sheathing exists on the pump house roof (plywood sheathing, straight/diagonal sheathing). These scope items are included in the structural cost estimates in section 4.5 below.

4.4 *Painting*

Based on observation of Alves Tank, it appears that the tank is due for recoating and general maintenance. This report includes recommendations of structural items only, however it is noted that recoating of the interior and exterior of the tank will increase the expected life span and generally help prevent further corrosion. Please note that in order to provide a more accurate comparison between the options noted, the costs for paint have been included as part of the cost estimates shown in Section 4.5 below. These costs are general estimates and the District should consult tank manufacturers for final costs.

4.5 *Cost Estimate*

Although Alves Tank has performed adequately for the past 45 years, we recommend that the tank be repaired to remedy existing conditional issues. The District can evaluate the options outlined below to increase survivability of a code level earthquake or replaced with a new tank. The following cost estimates for tank rehabilitation were provided by Cornerstone and developed jointly with a tank specialist and Pakpour Consulting Group. **Estimates for all retrofit options include Interior and Exterior complete stripe and recoating of the tank.** Cost estimate as include scope items related to the pump house building strengthening as noted in section 4.3 above. These costs are for structural costs only and do not include planning, engineering, or special inspections.

Option 1 (Lower overflow to 17.5')

This option includes cutting a door sheet in the tank for access and material handling, labor and equipment necessary to lower the overflow elevation to the specified level. Radiography and re-installation of the door panel is included. Based on our experience with similar tanks in this general area, a separate line item for roof rafter replacement has been added assuming the entire roof rafter system will need to be replaced due to extensive corrosion that may be evident following blast cleaning.

Pump House Strengthening	
Roof-to-Wall Ties & Reroofing	$58,000
20% contingency	$12,000
Pump House Strengthening Subtotal	$70,000
Seismic Retrofit of Tank	
Overflow Retrofit	$40,000
Recoating with 3 part epoxy system	$690,000
20% contingency	$150,000
Seismic retrofit of Tank Subtotal	$880,000
Total	**$950,000**
Additional costs to replace rafters	$200,000
Additional 20% Contingency	$50,000
Total w/ rafter replacement	**$1,200,000**

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Option 2 (Lower overflow to 19.0’ and seismically retrofit the tank)

This option includes cutting a door sheet in the tank for access and material handling, labor and equipment necessary to lower the overflow elevation to the specified level, material, fabrication, and installation of roof structure reinforcing components, including bottom flange strengthening plate on outer bay rafters, stiffener plates, lateral bracing, diagonal bracing, welding, and column strengthening. Radiography and re-installation of the door panel is included. Based on our experience with similar tanks in this general area, a separate line item for strengthen/ replace roof rafters has been added assuming the entire roof rafter system will need to be replaced due to extensive corrosion that may be evident following blast cleaning. Note that if extensive corrosion is evident, rafters could be replaced with heavier rafters deigned to accommodate the seismic wave force.

Pump House Strengthening	
Roof-to-Wall Ties & Reroofing	$58,000
20% contingency	$12,000
Pump House Strengthening Subtotal	$70,000
Seismic Retrofit of Tank	
Strengthen/ Replace Rafters and Connections	$700,000
Recoating with 3 part epoxy system	$690,000
20% contingency	$280,000
Seismic retrofit of tank Subtotal	$1,670,000
Total	**$1,740,000**

Option 3 (Leave Normal Operating Level at 23’)

This option includes leaving the normal operating level at 23 feet if Coastside County Water District cannot lose any existing capacity due to daily usage and excess capacity for fire suppression. This option is broken down into three alternatives:

Option 3a – Replace existing tank with a new tank of similar capacity designed to the current AWWA Standard

Option 3b – Retrofit existing tank by jacking the tank and adding a new bottom shell course

Option 3c – Replace existing roof with a new external rafter roof system and retrofit the tank shell with strengthening plates. Estimates for this option have not been included as it was determined to be non-economical.

Cost information for each of the options is shown below.

Option 3a (New 2.0 MG, 120’D x 30’H + 3’ knuckle (23.0’ MOL) Tank)

As a comparison to the retrofit options noted in this seismic evaluations, costs have also been provided for replacement of the existing tank with a new tank, designed to the current AWWA standard. Costs for replacing the existing Alves tank with a new tank of similar size is provided below. The following cost estimates were provided jointly a tank specialist and Pakpour Consulting Group. **Estimates for all retrofit options include Interior**

and Exterior complete stripe and recoating of the tank. Estimate for the replacement option includes finish coating of the interior and exterior of the tank. These costs are for structural costs only and do not include planning or engineering, or special inspections.

Pump House Strengthening	
Roof-to-Wall Ties & Reroofing	$58,000
20% contingency	$12,000
Pump House Strengthening Subtotal	$70,000
New Tank Construction	
Remove existing tank	$65,000
Construct new tank	$1,060,000
Painting with 3 part epoxy system	$375,000
20% contingency	$300,000
New Tank Construction Subtotal	$1,800,000
Total	**$1,870,000**
Additional costs to replace roof with external roof rafter system	$220,000
Additional 20% Contingency	$40,000
Total w/ optional external roof system	**$2,130,000**

Option 3b (Increase tank height to 32.5' by jacking the tank and keep MOL at (E) 23')

This option includes labor and equipment necessary to jack the tanks, material, fabrication, installation of new first course ring, installation/ modification of columns, and pre-blasting all weld joints. Based on our experience with similar tanks in this general area, a separate line item for roof rafter replacement has been added assuming the entire roof rafter system will need to be replaced due to extensive corrosion that may be evident following blast cleaning.

Pump House Strengthening	
Roof-to-Wall Ties & Reroofing	$58,000
20% contingency	$12,000
Pump House Strengthening Subtotal	$70,000
Seismic Retrofit of Tank	
Tank Jacking, New Bottom Course & Columns	$425,000
Recoating with 3 part epoxy system	$690,000
20% contingency	$235,000
Seismic retrofit of the tank Subtotal	$1,350,000
Total	**$ 1,420,000**
Additional costs to replace rafters	$200,000
Additional 20% Contingency	$50,000
Total w/ rafter replacement	**$1,670,000**

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4.6 *Summary*

Table 4 below summarizes the seismic retrofit options as described above in Sections 4.3 through 4.5. See these sections for more detail regarding each option recommendations and cost. Note that the current overflow elevation is approximately at 24 feet above the base of the tank.

Retrofit Option	Operating Level (ft)	Tank Capacity (gallons)	Scope of Work/Recommendations	Cost Estimate
Option 1	17.5	1.53MG	1. Retrofit Overflow 2. Paint Water Tank 3. Replace Rafters (as req'd)	**$950,000 (w/o rafter replacement)** **$1,200,000 (w/ rafter replacement)**
Option 2	19.0	1.66MG	1. Retrofit Overflow 2. Strengthen/ Replace roof rafters 3. Paint Water Tank	**$1,740,000**
Option 3a	23.0	2.0MG	1. Demolish existing tank 2. construct new tank 3. Paint new tank 4. New external rafter system (optional)	**$1,870,000 (w/o exterior rafter system)** **$2,130,000 (w/ exterior rafter system)**
Option 3b	23.0	2.0MG	1. Jack tank 2. Install new columns and bottom shell course 3. Paint Water Tank 4. Replace rafters (as req'd)	**$1,420,000 (w/o rafter replacement)** **$1,670,000 (w/ rafter replacement)**

Table 4: Summary of Seismic Retrofit Options for Steel Tank

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PART 5: APPENDIX

Photo 1: Corroded Tank Bottom Plate

Photo 2: Corrosion on Tank Shell Plate

Photo 3: Corrosion on Tank Roof Plate

Photo 4: Degraded Caulking along Perimeter of Bottom Plate

Photo 5: Corrosion around Perimeter of Roof Vent

Photo 6: Corrosion on Roof Hatch

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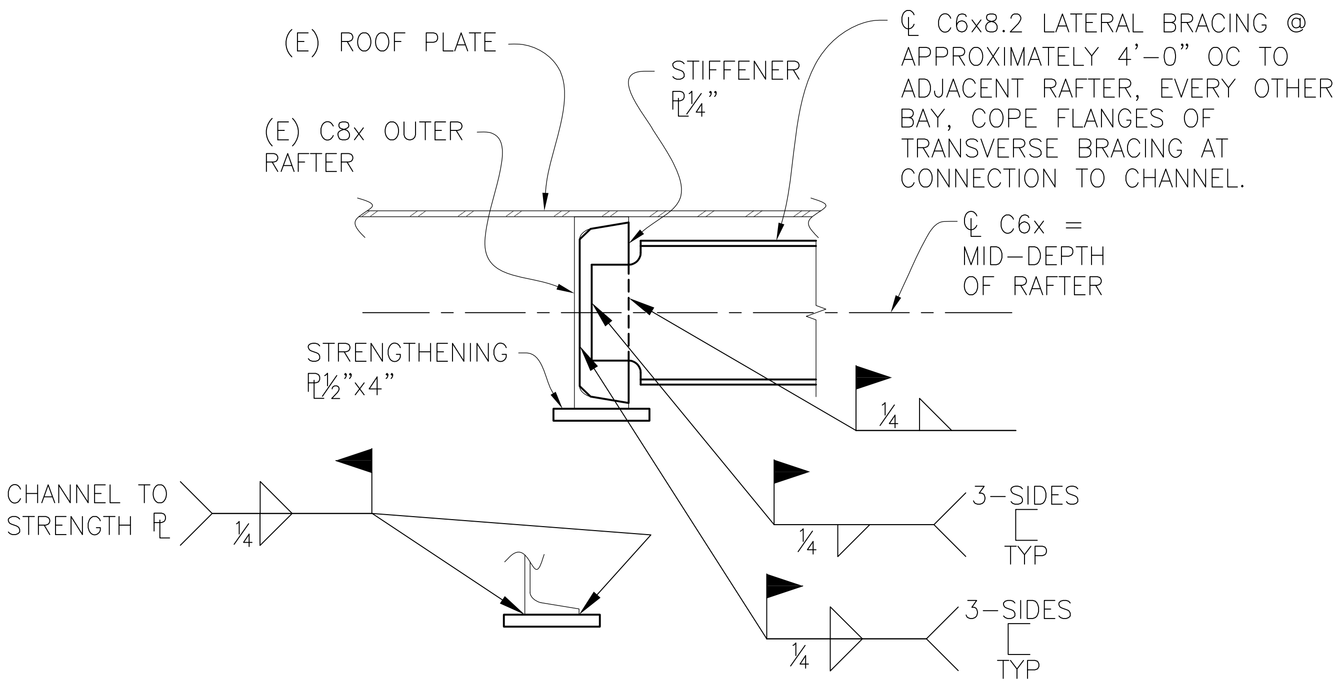
Photo 7: Condition of Existing Exterior Rafters

Photo 8: Existing Roof Framing

Photo 9: Pump House Building

Attachment A

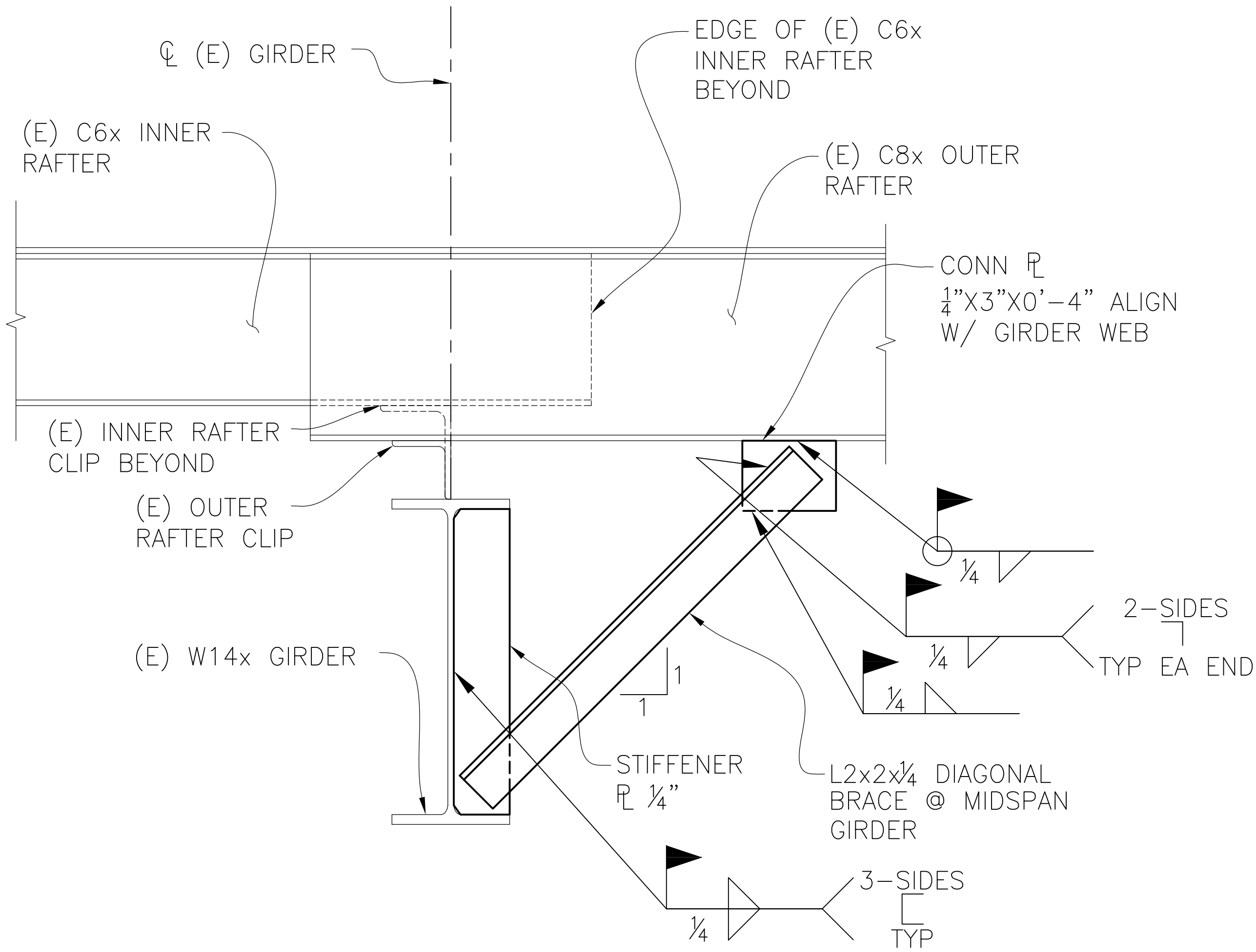


OUTER BAY RAFTER STRENGTHENING

A
SK-1

1 1/2"=1'-0"

CORNERSTONE structural engineering group 40 Federal Street San Francisco, California 94107 415.369.9100 fax 415.369.9101	DESIGNED BY: CDI DRAWN BY: CDI CHECKED BY: DGL SCALE: AS NOTED	ALVES TANK SEISMIC ASSESSMENT HALF MOON BAY, CA OUTER RAFTER STRENGTHENING	SK-1 PROJECT No: 2018008 DATE: 04/02/18



GIRDER BRACING

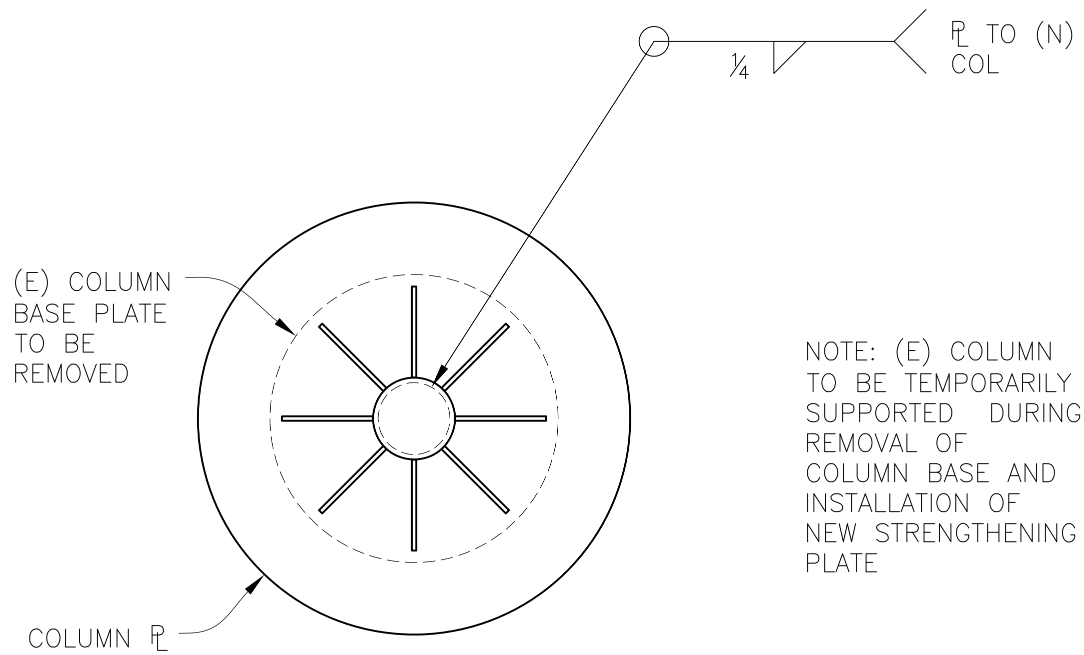
1 1/2"=1'-0"

B
SK-2

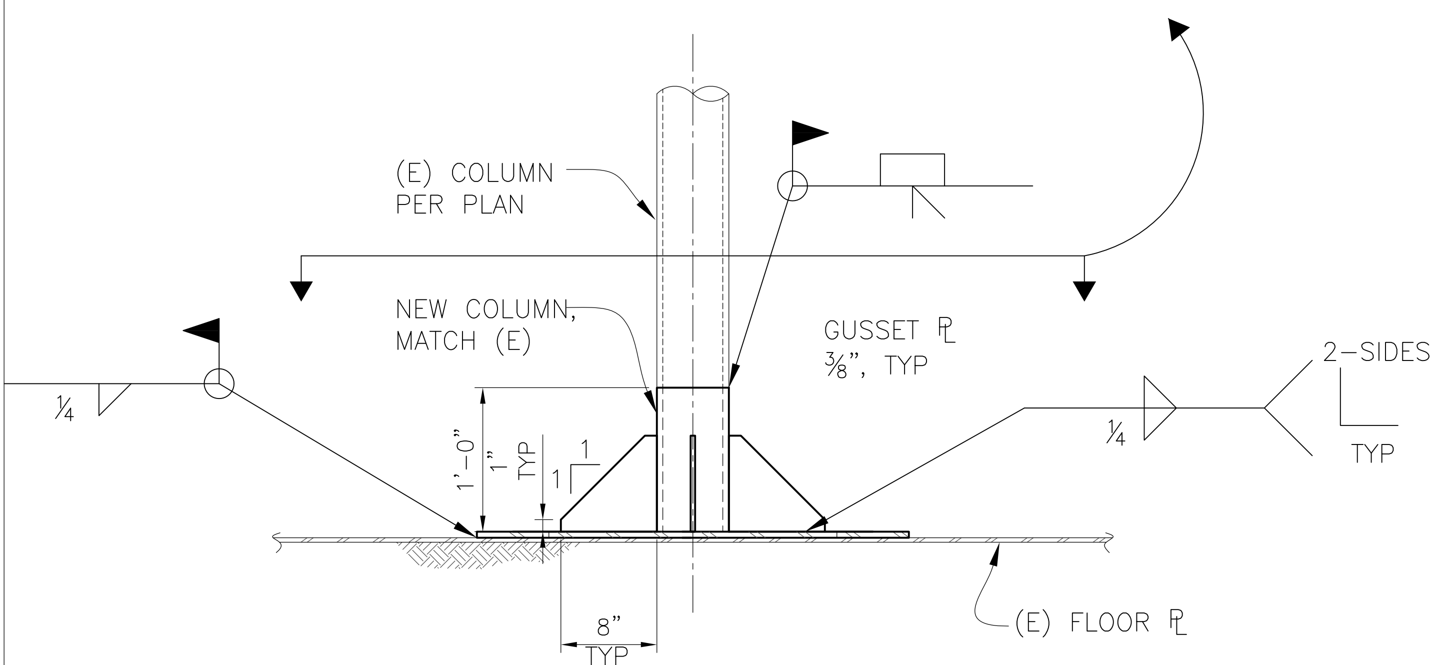
CORNERSTONE structural engineering group

40 Federal Street
San Francisco, California 94107
415.369.9100
fax 415.369.9101

DESIGNED BY: CDI	ALVES TANK SEISMIC ASSESSMENT HALF MOON BAY, CA	SK-2
DRAWN BY: CDI		
CHECKED BY: DGL		PROJECT No: 2018008
SCALE: AS NOTED	GIRDER BRACING	DATE: 04/02/18



PLAN



COLUMN PLATE

3/4"=1'-0"

C
SK-3

CORNERSTONE structural engineering group 40 Federal Street San Francisco, California 94107 415.369.9100 fax 415.369.9101	DESIGNED BY: CDI DRAWN BY: CDI CHECKED BY: DGL SCALE: AS NOTED	ALVES TANK SEISMIC ASSESSMENT HALF MOON BAY, CA COLUMN STRENGTHENING	SK-3 PROJECT No: 2018008 DATE: 03/06/18

Pakpour Consulting Group, Inc.

September 25, 2018 **_10034.08_**

David R. Dickson
General Manager
Coastside County Water District
766 Main Street
Half Moon Bay, CA. 94019

Subject: **Proposal to Provide Plans, Specifications, Estimate for the Alves Tank Improvements Coastside County Water District**

Dear David,

Pakpour Consulting Group (PCG) is pleased to provide a proposal to prepare plans, specifications, and cost estimate for the Alves Tank Improvements. We based our proposal on the recommendations found in the "*Structural Review and Retrofit Strategy Report*", as prepared by *Cornerstone Structural Engineering Group* (CSEG), dated May 18, 2018, and discussions with the District.

The anticipated tank work will include a full recoat of the tank interior and exterior, appurtenance retrofits/replacements and rafter replacement. This scope of work assumes we will not be able to conduct an "out-of-service" tank inspection of the interior. Therefore, the structural work on the tank will assume full rafter replacement along with minor repair details should the rafters prove to be in good condition following the initial blast during construction.

Scope of Work

Task 1.0 - Various Meetings (Field / Design) / Project Management

Our Team will schedule and attend a kickoff / field meeting with District operation personnel to visit the tank site and identify appurtenance replacements/additions the District desires. This task also includes design review meetings in addition to various project management duties throughout the project.

Deliverables: Meeting minutes as necessary

Task 2.0 – 65% Plans, Specifications and Cost Estimate

Upon verifying the scope of work during the initial field meeting, our Team will prepare the 65% PS&E. Exhibit type plans (11x17) will be developed with sufficient detail to delineate work to be performed along with structural repair/retrofit details. The design drawings will be prepared in AutoCAD Civil 3D 2017. This submittal will also include a preliminary cost estimate based on our experience with recent tank improvement projects. The preliminary plans, specifications and cost estimate will be submitted to the District for review with our Team fully participating in the review process.

Deliverables: 65% plans, specifications and cost estimate

Task 3.0 – 95% Plans, Specifications and Cost Estimate
The 65% plans will be carried to 95% completion by adding details, additional notes, and addressing District and other agency comments along with preparing 95% technical specifications and cost estimate. The specifications will be in Microsoft Word format and will be incorporated into the District's "boilerplate" to produce final bid documents. Bid quantities will be estimated for each item of work and a cost estimate prepared based on unit prices for each item. Unit prices will be determined based on recent bid tabulations from similar projects, job cost media such as Means, and discussions with local contractors.

Deliverables: 95% plans, specifications and cost estimate

Task 4.0 – Final Plans, Specifications and Cost Estimate
Upon receiving 95% review comments, each comment will be reviewed, discussed, and addressed. Appropriate modifications will be made to the plans, technical specifications, and cost estimates. The plans (22x34) and specifications will be finalized for the project including all notes/details and incorporating all comments received.

Deliverables: Final plans, specifications and cost estimate for bid purposes

Task 5.0 – Advertise and Award Period
Our Team will provide technical assistance to District staff during the advertising period which will include up to five written responses to bidder's inquiries. This includes preparing contract addenda and attending a pre-bid conference and site visit.

Deliverables: Written responses to inquires and addenda

<u>Budget</u>

TASK	DESCRIPTION	Principal		Project Engineer II		TOTALS	
		HR	COST	HR	COST	HRS	COST
	Hourly Rate:		$190.00		$145.00		
1.0	Various Meetings (Field / Design) / Project Management	4	$760	40	$5,800	44	$6,560
2.0	65% PS&E	4	$760	80	$11,600	84	$12,360
3.0	95% PS&E	4	$760	60	$8,700	64	$9,460
4.0	Final PS&E	2	$380	20	$2,900	22	$3,280
5.0	Advertise & Award Period	4	$760	20	$2,900	24	$3,660
Total Labor		18	$3,420	220	$31,900	238	$35,320
Coating Subconsultant (DB Gaya)							$3,300
Structural Subconsultant (CSEG)							$27,500
Contractor Consultation							$2,000
5% Direct Expense Fee (Mileage, Copies, Plots, Etc)							$1,766
Total Budget							*$69,886*

Schedule

Task 1.0	Various Meetings	Throughout the project
Task 2.0	65% PS&E	Within 40 working days of the Notice to Proceed
Task 3.0	95% PS&E	Within 20 working days of the District's 65% review
Task 4.0	Final PS&E	Within 10 working days of the District's 95% review
Task 5.0	Advertise / Award Period	As needed

Thank you for the opportunity to assist the District on this project, should you have any questions please do not hesitate to contact me.

Very truly yours,

Pakpour Consulting Group, Inc.

Brandon Laurie, P.E.
Project Engineer

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