CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

August 13, 2020

SUBJECT: REQUEST FOR PROFESSIONAL SERVICES (RFP) FOR DESIGN SERIVES FOR A NEW 4C WELDED STEEL TANK RESERVOIR & REHABILITATION/REPLACEMENT OF A HYDROPNEUMATIC PUMP STATION.

The Camrosa Water District invites your firm to submit a letter proposal for professional services to provide detailed plans and specifications. This project will include the design for a new 1.0 MG (estimated) potable water welded steel tank reservoir and rehabilitation/replacement of an aging hydropneumatic pump station.

NOTE: Both written and electronic submittals are required. Should you have any questions, or require additional information, please contact me at (805) 482-8063.

Sincerely,

Terry Curson

Digitally signed by Terry Curson
DN: cn=Terry Curson, o=Camrosa Water District, ou=Management, email=terryc@camrosa.com, c=US
Date: 2020.08.11 14:08:00 -07'00'

Terry Curson
District Engineer

Attachments

7385 Santa Rosa Road ▪ Camarillo, CA 93012-9284
Phone: (805) 482-4677 ▪ FAX: (805) 987-4797

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

REQUEST FOR PROPOSALS

The District seeks professional consulting engineering services to provide Plans and Specifications for the design of a new 1.0 MG (estimated) potable water welded steel tank reservoir and replacement/rehabilitation of an existing hydropneumatic pump station.

No mandatory pre-proposal conference will be held; however, consultants can call for information and/or request a site visit. The site is located within Camrosa's pressure zone No. 4 and is a residential neighborhood within the Santa Rosa Valley.

A copy of the Request for Proposals can be viewed and downloaded at www.Camrosa.com

Additional information may be obtained by contacting:

Terry Curson,
District Engineer
Camrosa Water District
7385 Santa Rosa Road
Camarillo, CA 93012
(805) 482-8063
terryc@camrosa.com

Two hard and one electronic copy of the Technical Qualifications and a sealed copy of the Cost Proposal must be submitted. All letter proposals must be sealed and submitted at or **before 3:00 p.m., October 1, 2020**, to the following:

Terry Curson,
District Engineer
Camrosa Water District

Deliver or Mail to:

7385 Santa Rosa Road
Camarillo, CA 93012

Note: Please mark the outside of the envelopes (or express shipment envelope, if applicable):

REQUEST FOR PROFESSIONAL SERVICES (RFP) FOR RESERVOIR 4C & HYDROPNEUMATIC PUMP STATION

CAMROSA WATER DISTRICT
REQUEST FOR PROPOSALS FOR

REQUEST FOR PROFESSIONAL SERVICES (RFP) FOR DESIGN OF A NEW 1.0 MG WELDED STEEL TANK AND HYDROPNEUMATIC PUMP STATION.

1.0 Background & Overview

The Camrosa Water District (District) seeks to hire a consultant to provide engineering services to prepare plans, specifications, and other incidentals to bid the construction of a new 1.0 MG welded steel tank and rehabilitation and replacement of and existing hydropneumatics pump station.

The existing site consist of a 1.0 MG welded steel water tank (Appendix A) that was constructed in 1967 that services an area known as Pressure Zone 4C, with both potable water and fire service. In addition, there is a small service area at a slightly higher elevation that is outside of Pressure Zone 4C known as the "hydro-zone." The hydropneumatic pump station (Appendix B) was built in 1975.

The District is interested in the following improvements to be included and/or evaluated:

<u>Reservoir 4C</u>

- Verify size and design a new 1.0 MG (estimated) welded steel potable water tank adjacent to existing tank. Existing reservoir will remain in service during construction. Existing tank will be demolished at completion of new tank.
- New reservoir tank will be above ground welded steel structure with knuckle type roof and located northwest of existing steel tank within existing reservoir property. New reservoir will be approximately 75 feet in diameter. The maximum water depth will be 31 feet and 1.0 MG, respectively.
- New reservoir will have standard appurtenances, such as exterior and interior ladders, exterior ladder cage, roof vent, side access manways (2), roof hatch, partial roof railing, pipe outlets, and either passive and/or active mixing system.
- New yard piping will include inlet and separate outlet with check valve, overflow, reservoir drain, and "doggy" door outlet.
- All interior and exterior piping will be above ground and shall utilize flex tend connectors
- Existing SCE electrical service (100 amps) will be evaluated and most likely upgraded to 200 amps service.
- The existing communication system is at ground level and located in a radio tower shed and antenna mast at the southwest corner of the property. The existing communication system will be maintained at the site and used with new facility. No new communication system between the site and the District's central computer system is to be established.

- Cathodic Protection System (passive type)
- Install new instruments, including pressure gage and water level transmitter. Water level transmitter is to be mounted in lockable cabinet for safety.
- New concrete curb, swales (or gutters) are to be installed for site drainage, if needed and as required
- Interior and exterior tank coating
- New pavement or improved drivable surface
- Security upgrades, including new or repaired fencing, electric gate, etc.
- No new landscaping is to be considered

Hydropneumatics Pump Station Improvements:

- Replace two existing 300 GPM vertical turbine pumps and 25 HP motors with new in kind or as determined in PDR/technical memorandum.
- Remove existing below ground pump discharge piping and valves and replace with new welded steel or ductile iron piping and valves. Replace existing pipe supports.
- Keep existing below ground suction piping. Replace below ground valves.
- Remove existing meter and meter vault. Install new meter above ground on discharge side of pumps.
- Repaint interior and exterior of existing discharge hydropneumatic tank and suction surge tank and reuse with new system.
- Replace existing electrical MCC for the pump station and install new MCC with variable drives.
- Install new electrical and communication conduits as necessary.
- Remove all existing electrical and communication conductors and install new.
- Upsize existing 100 amps service to 200 amps service, or as required.
- Install new control cabinet and local PLC and connect to existing PLC and radio/communication system.
- Paint all new and existing above ground piping, hydro tank, surge tank, and cabinets.
- Install new masonry building to house all electrical switchgear, MCC, and PLC.

2.0 Scope of Work

Phase I. Preliminary Design:

Task 1 – Project Management

1.1 Project Administration

Consultant shall provide Project Administration to direct, coordinate, and monitor the activities of the project with respect to budget, schedule, QA/QC, and tasks identified in the project scope or as otherwise accepted in the consultant's proposal. Any updates will be included as part of periodic coordination meetings.

1.2 Coordination Meetings

Consultant shall provide a periodic update between the Consultant and District personnel to review progress and update the District on project challenges, clarification, progress, and offer the ability to review early technical memorandums or PDRs.

Consultant shall coordinate with District during the preliminary design phase and if required, meet with District staff to review alternatives (either temporary or permanent systems).

Task 2 – Data Gathering

2.1 Kickoff Meeting

Consultant shall initiate a project kickoff meeting. The meeting should include an agenda outlining project overview, necessary data needed from the District, schedule for the project, and list of attendees. This meeting will allow the District the opportunity to discuss preferences and special factors or requirements for the project. The kick-off meeting will also allow for a site visit to allow the Consultant an opportunity to become familiar with the project site, note potential items of concern, and take digital photos for subsequent use.

2.2 Interviews

As part of the kickoff meeting or as a separate meeting, Consultant shall conduct interviews with key District personnel to discuss the particulars of the project scope. Consultant shall make site visits as necessary. The interviews can be conducted individually or as a group. As a minimum, the following should attend:

- District Engineer
- Operations Superintendent
- Senior Inspector

2.3 Collect and Review Current System Data

Consultant shall submit a list of information to be collected, including, but not limited to GIS layers, usage information, and “As-built” information.

Review existing reservoir record drawings to perform search for existing components and utilities. Utilizing new survey map and reservoir record information, prepare a base map showing key/major existing components of reservoir.

Review existing hydropneumatic pump station drawings to perform search for existing components and utilities. Utilizing new survey map and pump station record information, prepare a base map showing key/major existing components of pump station.

The base maps will be used for preparing plans for demolition of existing and design of new facilities.

Task 3 – Site Suitability & Limitations

3.1 Site Suitability

Consultant shall make their own interpretation of determining the necessary tasks to determine overall site suitability and define any limitations related to construction of the proposed facilities.

3.2 Topographic Survey

The District has assumed that the Consultant will provide a topographic site survey and all mapping to evaluate elevations, general grading limits, and cut and fill requirements for evaluating overall design and budget costs for the welded steel tank and hydropneumatic station. No easements or legal descriptions are required.

3.3 Geotechnical Study

It is assumed that a general field exploration would be required to characterize the site materials and determine groundwater levels and potential bedrock depths along with lab testing and evaluation to determine the suitability for the reservoir tank. It is further assumed that the geotechnical report would summarize results of research, field exploration, and testing, geophysical, technical, and seismic data, recommendations for civil and structural design parameters, and pavement requirements.

Task 4 – Preliminary Demolition Plans

4.1 Demolition Plan

Determine demolition requirements for existing reservoir, piping, appurtenances, and general site components and prepare a demolition plan.

Determine demolition requirements for existing hydropneumatic pump station facility and prepare a demolition plan.

Task 5 – Preliminary Design and Layout for New Reservoir 4C

5.1 Tank Sizing

The District is currently in the process of completing a hydraulic water model using Innovyze – Info Water and should be completed by November 2020. The existing 1.0 MG tank seems adequately sized; however, the consultant shall utilize the water model and current and expected future demands and determine size adequacy based on demand and the District's fire flow requirements that are outlined in the Water Design and Construction Standards.

5.1 Tank Layout

Determine preliminary location of the new tank. Determine preliminary locations of all major reservoir appurtenances. This will include ring beam, manways, ladders, vent, "doggy door," roof hatches, outlets for inlet-outlet piping, drain and overflow, level target.

Determine preliminary location of site improvements, such as perimeter road, curbs, gutter, fence, and gate.

Task 6 – Soil Foundation, Wave Height and Freeboard Requirements

6.1 Structural and Seismic Requirements

Based on the information presented in the geotechnical report, recommendations will be provided for site excavation and reservoir soil foundation preparation.

Determine sloshing wave height for welded steel reservoir based on the seismic data and AWWA D100. Determine required freeboard based on the calculated wave height. Based on the previous seismic data, it is anticipated that the wave height and associated required freeboard will be significantly large. Develop and evaluate potential solutions for providing smaller freeboard by strengthening roof plates.

Prepare cost different alternatives and provide recommendations (in PDR) to the District for consideration.

Task 7 – Preliminary Design and Layout for Hydropneumatic Pump Station

7.1 Pump Station Layout

Review as-built mechanical and electrical record data. Determine requirements for new pumps and motors based on the characteristics of existing equipment. Coordinate with pump and motor manufacturers to select commercially available equipment suitable for the site and conditions. Existing pump cans will be reused for the design of new pump system, if practical.

Determine new suction and discharge piping, valves and connection locations. Determine requirements for electrical switchgear and MCC and PLC. Existing service is 480/227 wye 100 amp, 75 KVA.

Evaluate requirements for modifying the existing main discharge pipe from the hydropneumatic tank, including installation of any valves based on the operational requirements determined by the District. Include information in PDR.

Prepare an exhibit showing proposed preliminary layout of new components and existing components to be reused.

7.2 Fire Pump & Alternatives

Determine fire pump flow capacity based on the input from District staff. At this point this is assumed to be 1000 GPM.

Evaluate the need for installing a separate 1000 GPM dedicated fire pump or upsize each existing 300 GPM pumps to 600 GPM with VFDs to accommodate average and maximum day demand and fire-flow requirements. Evaluate suction and discharge pipe sizing.

7.3 Evaluate existing Emergency Standby Generator and determine need to upsize/replace to accommodate emergency power for pumps and fire service.

Task 8 – Temporary Water Delivery Pump and Power System During Construction of New Hydropneumatic Pump Station and Electrical Equipment.

8.1 Temporary Service

It is assumed/considered that the new electrical equipment, including MCC and control panel, be installed in a separate location from the existing panels to minimize the need for a temporary pumping system.

Coordinated with the District to determine requirements of temporary water delivery system during construction, including range of flows, time period, operational requirements, SCADA requirements, use of existing communication system and other pertinent information. Determine allowable shutdown period for the existing hydropneumatic pump station for making connections/tie-ins and relatively minor modifications to existing piping and valves.

Develop and evaluate alternative (where feasible) temporary water delivery systems for the following conditions:

1. During replacement of the existing two pumps
2. During switch-over from existing electrical system to new

Develop preliminary plan and evaluation and recommend the most suitable and cost-effective solution to the District, although multiple options could be selected and incorporated in the contract specifications for the contractor to decide.

Task 9 – Develop Preliminary Design Report (PDR)/Technical Memorandum

9.1 Preliminary Design Report/Technical Memorandum

Consultant shall prepare a PDR or detailed technical memorandum summarizing results of analysis, evaluation and preliminary design of major components for the facility. This includes new reservoir, improvements to the existing hydropneumatic pump station, and demolition along with optimal fire service alternatives and any other item included in the project scope tasks.

Wave height, freeboard, and alternative solutions for reducing freeboard with cost analysis will be included in the report for District's consideration.

The proposed temporary pump and power systems to deliver water during construction of the new hydropneumatic pumps and electrical system will be presented with preliminary plan for District's consideration.

The report will include exhibits showing existing site, demolition, new facility layout plant with proposed components and improvements to existing components. It will also include preliminary budget estimates for the alternatives.

Two hard copies and one digital copy of the draft report will be submitted to the District for review.

A meeting will be arranged to discuss the content of the draft PDR and District's comments.

PDR will be revised and finalized and will be the basis for the design.

Phase II. Final Design

Task 10 – Reservoir Structural Analyses and Design:

10.1 Analyses

Perform structural analyses and design for reservoir based on AWWA D100 and site specific geoseismic data and geotechnical design parameters (A PDR report entitled "Steel Reservoir Improvements" by Perliter & Inglasbe, dated July 20, 2017 is included as Appendix D and should be used as the basis for design). This will include, but not limited to, analyses and design of the following major components:

1. Tank and structure for stability, overturning, and sliding
2. Shell/wall
3. Floor plates
4. Annular plates
5. Roof plates
6. Columns
7. Column base plate
8. Roof rafters and joists

It is assumed that the reservoir tank will be required to be anchored to a concrete ring beam. Reservoir anchor bolts will be designed according to the unbalanced seismic forces.

Concrete foundation will be designed for vertical load, torsional forces (if any), and uplift forces due to seismic anchors. Allowable soil bearing pressure will be utilized to determine the required minimum width.

Task 11 – Reservoir Appurtenances and Auxiliary Components:

11.1 Reservoir Appurtenances

Design of reservoir appurtenances and auxiliary components will include:

1. Roof and overflow hatches
2. Platform and railing at hatches
3. Gravity Vent (fiberglass)
4. Exterior ladder System, including ladder, safety door for lower portion of the ladder, and ladder cage.
5. Interior ladders with safety rail
6. Two access manways through shell

7. API style (“doggy door”) cleanout
8. Shell outlets for connecting pressure sending piping for water level transmitter, hose bibs and multiple sample taps.
9. Drip plate at roof level
10. Water level target float
11. Partial railing
12. Fall protection anchors near gravity vent
13. Cathodic protection access ports

Task 12 – Reservoir Yard Piping:

12.1 Inlet Piping

Inlet pipe will be sized based on inflow and designed with aboveground valves, flexible pipe joint air vacuum and release valves. Consultant will also evaluate the use of seismic isolation valves.

12.2 Outlet Piping

Outlet piping will be sized based on outflow and designed with an above ground check valve, isolation valve, flexible joint, and appurtenances.

A separate outlet pipe will be considered. Approximate location of the outlet will be on the opposite side of the inlet pipe. Such configuration will allow increased circulation of water inside the reservoir, that may include internal rotated fittings. Outlet piping will connect to existing piping as required.

12.3 Overflow Pipe and Trough

An overflow pipe and trough will be sized based on the maximum inflow. The pipe will be terminated approximately 12” above the drain box.

12.4 Reservoir Drain

Reservoir drain will be sized as required and designed with aboveground isolation valve and blind flange. The pipe will be terminated at a common exterior drain box used for the overflow pipe.

12.5 “Doggy Door” Drain

To aid with tank cleaning, a “doggy door” flush mounted drain will be installed to discharge at a common exterior drain box.

12.6 Level gauge and interior float

External level target will be installed on tank shell. Location will be located near ladder, roof hatch and other appurtenances for easy maintenance and access.

Task 13 – Reservoir Cathodic Protection

13.1 Cathodic Protection

As required by the District, sacrificial anode type cathodic protection system will be considered and designed. Such system will not require external electrical power. For the purpose of this proposal, it is assumed that the installation of galvanic system is feasible. If galvanic system is not feasible because of soil conditions, other alternatives will be discussed with the District.

Determine requirements of cathodic protection system components, including type, size and location of anodes.

Task 14 – Reservoir Instrumentation, Radios, and Equipment

14.1 Reservoir Instrumentation

Tank level transmitter will be installed and enclosed in a common PLC cabinet or separate cabinet.

Intrusion switch will be installed on roof hatch and ladder door. Connections to the District's existing radios will be included.

Task 15 – Hydropneumatic Pumps, Piping, Valves, Metering, and Air System

15.1 Pumps & Motors

Finalize pump and motor selection design based on PDR and District preference. This includes suction laterals, manifold, valves, and connections.

15.2 Air compressor

Select new air compressor for the existing hydropneumatics and surge tanks. Design new air piping and valve system for the replacement of existing piping. Design air compressor control strategies based on input from the District staff. It is assumed that the air compressor will be controlled based on the water level/pressure transmitters.

15.3 Demolition

Finalize demolition of existing pumps, piping and appurtenances.

15.4 Meter Station

Relocate existing metering vault and replace with new above ground meter on discharge of station.

Task 16 – Hydropneumatic Pump Station Electrical Equipment, Instrumentation, and Controls:

16.1 Electrical Service

Evaluate and upgrade, if necessary, existing 480/277 wye 100 amp, 75KVA service. Design new electrical equipment based on needed power. Design MCC and control sections, including metering main circuit breaker, test blocks, pump circuit breakers, starters, compressor starter, including automatic transfer switch.

16.2 Miscellaneous Electrical

Design new instruments for pump station, including gauges, water level transmitters, pressure switches, and sensors. This also includes all controls, conduits, conductors and radio communication.

Task 17 – Building

17.1 Building

As part of Task 7, evaluate the cost and feasibility of constructing a building to house the electrical, controls, and other equipment.

Task 18 – Fire Pump

18.1 Fire Pump

As an option for the District, evaluate the use of either a diesel or electrical driven separate fire pump to meet fire service within the zone served by the Hydropneumatic pump station and include as part of Task 9.

Task 19 – Site Electrical System:

19.1 Site Electrical

The existing Edison series consists of 480/277 wye with a 100-amp 75KVA service. At a minimum a new 200-amp service will be considered, and the design will include any necessary upgrades or refurbishment. Any upgrades will be adequate for both existing and new components, including instruments, lights, PLC, compressor, pumps, motors, controls and communication.

Task 20 – Site Communication and SCADA:

20.1 Site Communication & SCADA

Existing PLC and communication system are at ground level and located in the hydropneumatics PLC, radio tower building on the southwest corner of the property. The existing communication system will be maintained in place and reused. No new communication devices between the site and District's SCADA are to be considered.

20.2 All existing and new signals will be integrated with the new local PLC. Local PLC will be connected to the existing PLC for communication to the District's SCADA.

Task 21 – Site Earthwork, Grading and Drainage and Miscellaneous Improvements:

21.1 Earthwork

Determine required earthwork, including excavation, over-excavation, and backfill within the reservoir sites based on the geotechnical report. No major excavation, cut slopes, or embankment installation are considered because of available existing flat pad.

21.2 Drainage Improvements

Determine fine grading for site pavement and drainage and determine requirements of concrete curbs, gutters, and swales.

21.3 Catch Basins and Piping

Design catch basin and rain pipe as required. Existing drainage discharge system/pipe will be used to connect the new drainpipe. No off-site drainage system is considered.

Task 22 – Site Demolition and Improvements and Security:

22.1 Tank Demolition

Finalize demolition of steel tank facility, including tank, foundation, tank piping, tank appurtenance, instrumentation, electrical, and sub-soil.

22.2 Security Fencing

Evaluate existing fencing and include provisions for partial repairs and/or replacement. Include replacement of swing gates and include new automatic gate opener and man-gate.

22.3 Site Demolition

Demolish existing asphalt pavement for reservoir access and perimeter road and replace with new.

Task 23 – Temporary Water Delivery Pump and Power System:

23.1 Temporary Facilities

Finalize design of temporary system involving electric pumps and electrical power and controls. Finalize design of temporary system involving diesel operated pump system and controls. Design temporary auxiliary components and appurtenances including modifications to suction and discharge piping.

Task 24 – Design Drawings:

24.1 Contract Design Drawings

Design drawings will be prepared using AutoCAD. Design drawings will be prepared with adequate information to show plans, profiles, sections, details and general and special notes.

24.2 Drawings Review (Draft)

One 24” x 36” copy of design drawings will be submitted at 60%, 90%, and 100% completion stages to the District for review and comment. Design drawings at each completion stage will include the revisions as per District’s review comments from previous submittals a project meetings.

24.3 Drawings Review (Final)

The final plans will be printed on vellums for reproduction. The final plans will also be provided in PDF in both full and half-size.

Task 24 – Specifications:

24.1 Specifications (Draft)

Front in documents will be provided by the District. Sections such as Notice Inviting Bids, Proposal, Special conditions, etc. will be revised and custom tailored to the project. Technical specifications will be prepared in CSI format and will include all divisions applicable to the project. One copy of the specifications will be submitted to the District for review at each stage per 24.2.

24.2 Specifications (Final)

The final specifications will be provided in Word and PDF format as requested by the District.

Task 25 – Cost Estimate:

25.1 Cost Estimate

Prepare a preliminary budget estimate as part of Task 9 of the technical memorandum and update at 90% and 100%.

Task 26 – Coordination and Review Meetings During Design:

26.1 Meetings

Attend a kick-off meeting and a secondary meeting to discuss project components and review comments from the District.

Task 27 – Optional Scope:

27.1 Optional Scope

The Consultant has the option of including additional tasks that they feel are necessary to complete the project. These optional tasks should be included in the proposal and cost assigned in the cost proposal portion.

3.0 Selection Process

The District Engineer shall designate an evaluation team comprising of District personnel. Each proposal will be independently reviewed by each member of the team and scored accordingly based on the below criteria and points. Once complete, the team will meet and confer their finding to determine the ranking.

The ranking will be made on the basis of the following criteria:

- Project Understanding (10)
- Project Team Individual Experience/Qualifications (10)
- Firm's Experience, Qualifications and References (10)
- Quality/Responsiveness of Proposal (10)
- Knowledge and Exp. W/Similar Projects (10)
- Approach to Performing the Work (15)
- Scope of Services/Enhanced or Optional Scope (10)
- Fee Schedule (15)
- Schedule of Services/Start Date and Design Period (10)
- Willingness to Comply with Standard Agreement (yes/no)

4.0 Deliverables

Consultant shall provide a letter proposal outlining and detailing the above scope of work. The proposal should include costs for each work item (task). In the event the Consultant feels that additional work tasks should be included, these tasks should be included as a separate line item with an explanation of its need. The proposal should also include an estimated time schedule. Fee schedules should be included in a separate envelope. Also, Consultant should include an acknowledgement statement that they accept the terms of the attached professional services agreement in Appendix C.

Proposals need to be submitted no later than **October 1, 2020 by 3:00 PM** to be considered.

For questions, please contact Mr. Terry Curson, District Engineer at (805) 482-8063 or Terryc@camrosa.com

APPENDIX A

(Reservoir 4C Tank & Site)

APPENDIX B

(Hydropneumatic Pump Station)

APPENDIX C

(Professional Services Agreement)

APPENDIX D

(Seismic Study Report)

Camrosa Water District
7385 Santa Rosa Rd.
Camarillo, CA 93012
Telephone (805) 482-4677 - FAX (805) 987-4797

Some of the important terms of this agreement are printed on pages 2 through 3. For your protection, make sure that you read and understand all provisions before signing. The terms on Page 2 through XX are incorporated in this document and will constitute a part of the agreement between the parties when signed.

TO: DATE:

Agreement No.:

The undersigned Consultant offers to furnish the following:

Contract price $:

Contract Term:

Instructions: Sign and return original. Upon acceptance by Camrosa Water District, a copy will be signed by its authorized representative and promptly returned to you. Insert below the names of your authorized representative(s).

Accepted: Camrosa Water District Consultant:

By: _____ By: _____

Title: Title:

Date: _____ Date: _____

Other authorized representative(s): Other authorized representative(s):

. _____ _____

Consultant agrees with Camrosa Water District (District) that:

a. **Indemnification:** To the extent permitted by law, Consultant shall hold harmless, defend at its own expense, and indemnify the District, its directors, officers, employees, and authorized volunteers, against any and all liability, claims, losses, damages, or expenses, including reasonable attorney's fees and costs, arising from negligent acts, errors or omissions of Consultant or its officers, agents, or employees in rendering services under this contract; excluding, however, such liability, claims, losses, damages or expenses arising from the District's sole negligence or willful acts.

b. **Minimum Insurance Requirements:** Consultant shall procure and maintain for the duration of the contract insurance against claims for injuries or death to persons or damages to property which may arise from or in connection with the performance of the work hereunder and the results of that work by the Consultant, his agents, representatives, employees or subcontractors.

c. **Coverage:** Coverage shall be at least as broad as the following:

   1. **Commercial General Liability (CGL) -** Insurance Services Office (ISO) Commercial General Liability Coverage (Occurrence Form CG 00 01) including products and completed operations, property damage, bodily injury, personal and advertising injury with limit of at least two million dollars ($2,000,000) per occurrence or the full per occurrence limits of the policies available, whichever is greater. If a general aggregate limit applies, either the general aggregate limit shall apply separately to this project/location (coverage as broad as the ISO CG 25 03, or ISO CG 25 04 endorsement provided to the District) or the general aggregate limit shall be twice the required occurrence limit.

   2. **Automobile Liability -** (If applicable) Insurance Services Office (ISO) Business Auto Coverage (Form CA 00 01), covering Symbol 1 (any auto) or if Consultant has no owned autos, Symbol 8 (hired) and 9 (non-owned) with limit of one million dollars ($1,000,000) for bodily injury and property damage each accident.

   3. **Workers' Compensation Insurance -** as required by the State of California, with Statutory Limits, and Employer's Liability Insurance with limit of no less than $1,000,000 per accident for bodily injury or disease.

   4. **Waiver of Subrogation:** The insurer(s) named above agree to waive all rights of subrogation against the District, its directors, officers, employees, and authorized volunteers for losses paid under the terms of this policy which arise from work performed by the Named Insured for the District; but this provision applies regardless of whether or not the District has received a waiver of subrogation from the insurer.

   5. **Professional Liability** - (also known as Errors & Omission) Insurance appropriates to the Consultant profession, with limits no less than $1,000,000 per occurrence or claim, and $2,000,000 policy aggregate.

d. **If Claims Made Policies:**

   1. The Retroactive Date must be shown and must be before the date of the contract or the beginning of contract work.

   2. Insurance must be maintained and evidence of insurance must be provided **for at least five (5) years after completion of the contract of work.**

   3. If coverage is canceled or non-renewed, and not replaced with another claims-made policy form with a Retroactive Date prior to the contract effective date, the Consultant must purchase "extended reporting" coverage for a minimum of five (5) years after completion of contract work.

If the Consultant maintains broader coverage and/or higher limits than the minimums shown above, the District requires and shall be entitled to the broader coverage and/or higher limits maintained by the Consultant. Any available insurance proceeds in excess of the specified minimum limits of insurance and coverage shall be available to the District.

Other Required Provisions: The general liability policy must contain, or be endorsed to contain, the following provisions:

a. **Additional Insured Status:** The District, its directors, officers, employees, and authorized volunteers are to be given insured status (at least as broad as ISO Form CG 20 10 10 01), with respect to liability arising out of work or operations performed by or on behalf of the Consultant including materials, parts, or equipment furnished in connection with such work or operations.

b. **Primary Coverage:** For any claims related to this project, the Consultant's insurance coverage shall be primary at least as broad as ISO CG 20 01 04 13 as respects to the District, its directors, officers, employees, and authorized volunteers. Any insurance or self-insurance maintained by the District, its directors, officers, employees, and authorized volunteers shall be excess of the Consultant's insurance and shall not contribute with it.

Notice of Cancellation: Each insurance policy required above shall provide that coverage shall not be canceled, except with notice to the District.

Self-Insured Retentions: Self-insured retentions must be declared to and approved by the District. The District may require the Consultant to provide proof of ability to pay losses and related investigations, claim administration, and defense expenses within the retention. The policy language shall provide, or be endorsed to provide, that the self-insured retention may be satisfied by either the named insured or the District.

Acceptability of Insurers: Insurance is to be placed with insurers having a current A.M. Best rating of no less than A:VII or as otherwise approved by the District.

Verification of Coverage: Consultant shall furnish the District with certificates and amendatory endorsements or copies of the applicable policy language effecting coverage required by this clause. All certificates and endorsements are to be received and approved by the District before work commences. However, failure to obtain the required documents prior to the work beginning shall not waive the Consultant's obligation to provide them. The District reserves the right to require complete, certified copies of all required insurance policies, including policy Declaration and Endorsements pages listing all policy endorsements. If any of the required coverages expire during the term of this agreement, the Consultant shall deliver the renewal certificate(s) including the general liability additional insured endorsement to the District at least ten (10) days prior to the expiration date.

Subcontractors: Consultant shall require and verify that all subcontractors maintain insurance meeting all the requirements stated herein, and Consultant shall ensure that the District, its directors, officers, employees, and authorized volunteers are an additional insured on Commercial General Liability Coverage.

Other Requirements:

a. Consultant shall not accept direction or orders from any person other than the General Manager or the person(s) whose name(s) is (are) inserted on Page 1 as "other authorized representative(s)."

b. Payment, unless otherwise specified on Page 1, is to be 30 days after acceptance by the District.

c. Permits required by governmental authorities will be obtained at Consultant's expense, and Consultant will comply with applicable local, state, and federal regulations and statutes including Cal/OSHA requirements.

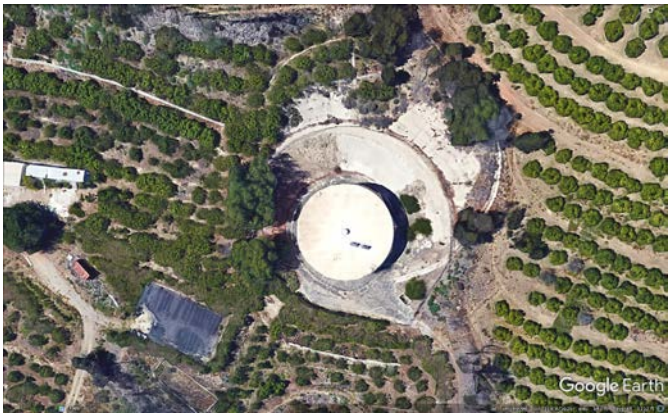
d. Any change in the scope of the professional services to be done, method of performance, nature of materials or price thereof, or to any other matter materially affecting the performance or nature of the professional services will not be paid for or accepted unless such change, addition or deletion is approved in advance, in writing by the District. Consultant's "other authorized representative(s)" has/have the authority to execute such written change for Consultant.

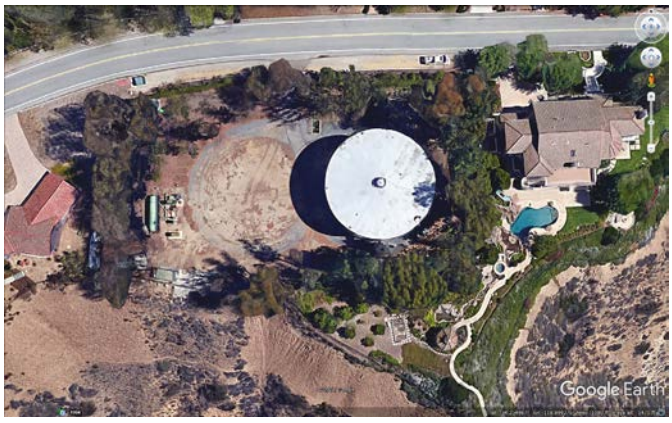
The District may terminate this Agreement at any time, with or without cause, giving written notice to Consultant, specifying the effective date of termination.

CAMROSA WATER DISTRICT

Preliminary Design Report

Steel Reservoir Improvements





Perliter & Ingalsbe
Consulting Engineers
430 W. Colorado Street
Glendale, CA 91204
(818) 500-8921

July 20, 2017

PERLITER & INGALSBE
CONSULTING ENGINEERS

- Investigations
- Designs
- Construction Services

July 20, 2017

Mr. Terry Curson
Camrosa Water District
7385 Santa Rosa Road
Camarillo, CA 93012

SUBJECT: Steel Tank Improvements
Final Preliminary Design Report (PDR)

Dear Terry:

We are pleased to submit the final Preliminary Design Report for the Steel Tank Improvements project. This report summarizes our analyses and evaluation and includes our conclusions and recommendations for the District's consideration.

If you have any questions, please do not hesitate to call me.

Sincerely,

PERLITER & INGALSBE

Amar Shah

430 West Colorado Street, Glendale, California 91204
Telephone (818) 500-8921 Facsimile: (818) 500-8925

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

1.01 General:

Camrosa Water District has eleven steel reservoirs that serve potable and recycled water systems. These reservoirs are known as 1A, 1B, 2A, 2B, 3A, 3B, 3C, 3D, 4A, 4B, and 4C. All reservoirs were built between 1966 and 1968, except 1A, which was constructed in 1977.

Out of eleven reservoirs, four reservoirs, 1A, 1B, 2A, and 3D, have been improved and retrofitted in early 2000s. The District wants to implement steel reservoir improvement projects for the remaining seven reservoirs, 2B, 3A through 3C, and 4A through 4C. As the initial part of the improvement project(s), the District wants to determine required improvements for each of the seven steel reservoir structures and sites. As an extension to this task, the District also wants to determine required site and reservoir coating system improvements for the four reservoirs that were retrofitted earlier.

After required improvements are identified through this project for each facility, the final design and construction of the steel reservoirs improvements will be performed over a few years based on the priority, available funding, and as determined by the District.

1.02 General Scope of Work: (See Note 1 on Page 1-2)

The scope of work included the following major tasks.

A. Review record data.

B. Perform reservoir structural analysis and evaluation.

C. Determine required/recommended reservoir structural improvements.

D. Determine required piping improvements.

E. Perform site inspection and evaluation for required improvements for reservoir appurtenances and site.

F. Review reservoir inspection report and determine required pertinent improvements.

G. Prepare cost estimate for potential improvements.

H. Prepare construction priority.

I. Prepare exhibits and report.

Structural, piping, coating, and site improvements are to be considered for seven reservoirs 2B, 3A, 3B, 3C, 4A, 4B, and 4C. For the remaining four reservoirs 1A, 1B, 2A, and 3D site improvements are to be considered.

1.03 Existing Steel Reservoir Locations:

A. Exhibit 1-A on the following page shows approximate locations of all existing steel reservoirs owned by the District.

B. Exhibit 1-B shows locations of all steel reservoirs on Google aerial map.

C. Figures 1.1 through 1.6 show aerial close-up plan for each reservoir.

1.04 References:

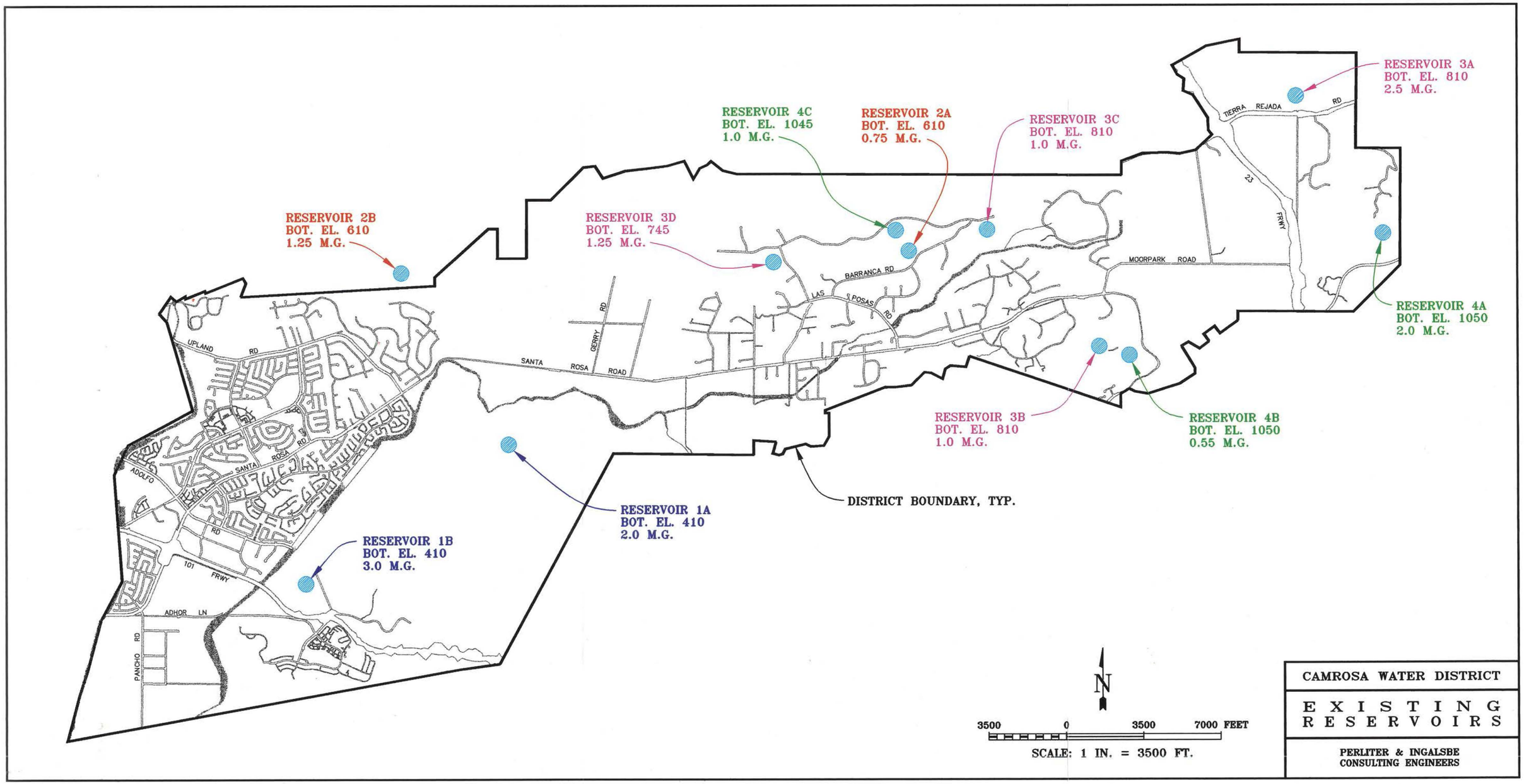
A. Engineering Report, Analyses of Steel Reservoirs for Earthquake Safety, May 1999 by Perliter & Ingalsbe.

B. American Water Works Association (AWWA) Standard D 100 – 11, Welded Carbon Steel Reservoirs for Water Storage.

Notes:

1. Several tasks considered in the original scope of work were not performed based on the results of the structural analyses and evaluation of each steel reservoir and subsequent decision of replacing the reservoir structures with new and not performing retrofit work. Refer to Sections 2 and 3 for detailed information.

EXHIBIT 1-A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BOT. EL. 810
2.5 M.G.
RESERVOIR 4C
BOT. EL. 1045
1.0 M.G.
RESERVOIR 2A
BOT. EL. 610
0.75 M.G.
RESERVOIR 3C
BOT. EL. 810
1.0 M.G.
RESERVOIR 2B
BOT. EL. 610
1.25 M.G.
RESERVOIR 3D
BOT. EL. 745
1.25 M.G.
RESERVOIR 4A
BOT. EL. 1050
2.0 M.G.
RESERVOIR 3B
BOT. EL. 810
1.0 M.G.
RESERVOIR 4B
BOT. EL. 1050
0.55 M.G.
RESERVOIR 1A
BOT. EL. 410
2.0 M.G.
RESERVOIR 1B
BOT. EL. 410
3.0 M.G.
DISTRICT BOUNDARY, TYP.
TIERRA REJADA RD
23 FRWY
MOORPARK ROAD
BARRANCA RD
LAS POSAS RD
SANTA ROSA ROAD
GERRY RD
UPLAND RD
SANTA ROSA RD
ADOLFO RD
101 FRWY
ADHOR LN
PANCHO RD
N
3500 0 3500 7000 FEET
SCALE: 1 IN. = 3500 FT.
CAMROSA WATER DISTRICT
EXISTING RESERVOIRS
PERLITER & INGALSBE
CONSULTING ENGINEERS

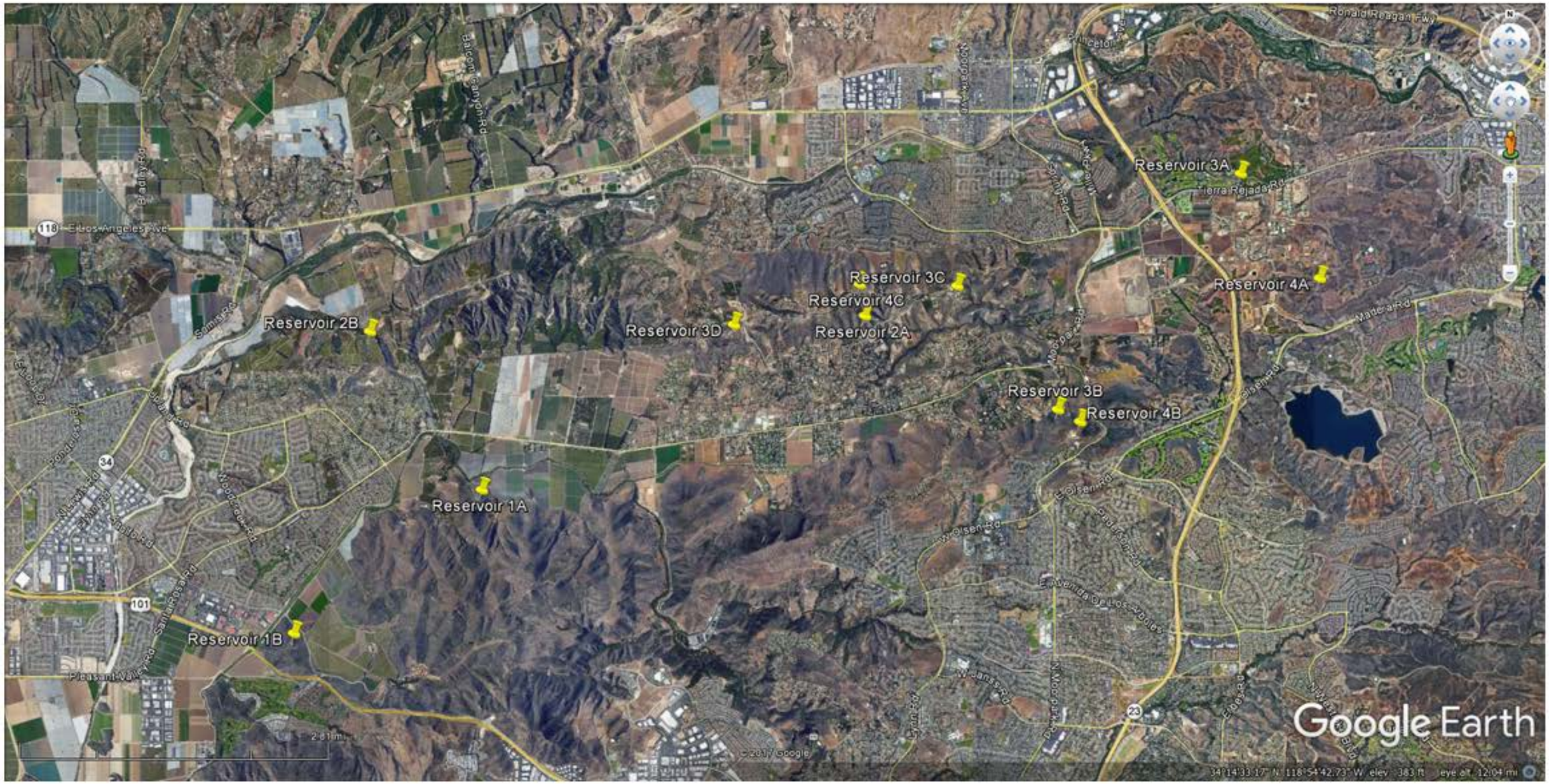
Reservoir 3A
Reservoir 3C
Reservoir 4C
Reservoir 2A
Reservoir 4A
Reservoir 2B
Reservoir 3D
Reservoir 3B
Reservoir 4B
Reservoir 1A
Reservoir 1B
Ronald Reagan Fwy
Moorpark Ave
Tierra Rejada Rd
Los Angeles Ave
Bradley Rd
Santa Rosa Rd
Pleasant Valley Rd
Madera Rd
Olsen Rd
Google Earth

FIGURE 1.1

RESERVOIR 1A

RESERVOIR 1B

FIGURE 1.2

RESERVOIR 2A

RESERVOIR 2B

FIGURE 1.3

RESERVOIR 3A

RESERVOIR 3B

FIGURE 1.4

RESERVOIR 3C

RESERVOIR 3D

FIGURE 1.5

RESERVOIR 4A

RESERVOIR 4B

FIGURE 1.6

RESERVOIR 4C

SECTION 2

EXISTING STEEL RESERVOIR STRUCTURAL ANALYSES AND EVALUATION

2.01 Criteria and Notes for Structural Analyses:

A. Analyses are performed based on AWWA D100-11.

B. Deterioration of existing steel plates or welded connections is not considered.

C. Analyses for roof beams and steel columns are not performed under this Section.

D. Geotechnical data, including soil data and soil bearing pressures, are derived from the geotechnical report prepared by Converse Consultants, Inc. in 1990. Soil classifications are estimated based on the values of allowable soil bearing pressures. In general, assigned soil classification for majority of the reservoir sites may represent better soil than actually exists. This approximation provides less conservative results of stresses and deficiencies.

2.02 Major Components of Structural Analyses:

Each reservoir has been analyzed for the following major components:

A. Shell Hoop Stresses:

a. Hydrostatic Shell Hoop Stresses: The shell plates (reservoir walls) experience hoop stress (tensile stress) because of hydrostatic force. These forces are directly proportional to the depth of water in the reservoir. The maximum hydrostatic forces are at the base of the shell plates.

b. Dynamic Shell Hoop Stresses: These stresses on the shell plates are caused by both the horizontal and the vertical forces generated during an earthquake event. The magnitude of these forces depends upon the intensity of ground movements, the weight of reservoir components and its content (water). These forces and related stresses on the shell are in addition to those caused by the hydrostatic forces.

c. Combined Hydrostatic and Dynamic Shell Hoop Stresses: These stresses are resultant hoop stresses experienced by the shell due to static and dynamic forces during an earthquake event.

d. Per AWWA D100-11, allowable hydrostatic hoop stress in steel plates is 15,000 psi regardless of the steel type and yield strength. This is approximately 42% to 55% of the yield strength of steel used for the reservoir.

e. Allowable combined hydrostatic and dynamic hoop stress in steel plate is 19,950 psi (33% higher) for all steel. This equals to approximately 56% to 73% of the steel yield strength.

f. If actual stresses are less than steel yield strength, steel deformation will be elastic and steel plate will return to its original state. If stresses are higher than or close to steel yield strength, steel plates will deform permanently (plastic deformation). With increased stresses in plastic deformation stage, steel plates and the reservoir structure may experience major failure.

B. Reservoir Overturning: This analysis determines the potential overturning of a reservoir due to seismic forces. In general, reservoirs having a higher ratio of height to diameter experience greater overturning forces. If resisting forces against overturning are less than the overturning forces, the reservoir should be anchored. Per AWWA D100, if the overturning ratio (overturning moment divided by resisting moment) is less than 0.785, the shell will not uplift. If the ratio is between 0.785 and 1.54, the shell will uplift, but the reservoir may be stable if shell compression stresses are within allowable limits. If the ratio is more than 1.54, the reservoir is not stable and needs to be anchored.

C. Reservoir Sliding: Horizontal seismic forces may cause the reservoir to slide off its foundation. A small shift might shear the reservoir inlet-outlet, drain and overflow piping passing through the floor of the reservoir. The sliding forces are resisted by the friction force between the reservoir bottom and foundation soils. The resisting force shall be greater than the sliding horizontal seismic force.

D. Shell Buckling/Compression Stresses: When the reservoir is resisting overturning forces, high compression forces are concentrated in the shell at the foot of the reservoir, which acts as a pivot point. Similarly on the opposite side, tensile forces will be trying to lift the reservoir from its base or separate the connection of the shell to the bottom plate. As the earthquake continues, these stresses will shift side-to-side in a rolling fashion. Failures by this mode generally result in outward shell buckling around the base of the reservoir, normally referred to as an "elephant foot" and, in some cases, cause the rupture of piping connections to the reservoir. Shell compression stresses shall be less than allowable. The allowable stresses vary with numerous factors such as diameter of reservoir, thickness of shell, and others.

E. Wave Height and Freeboard: During an earthquake event, waves are generated at water surface. Height of wave depends on many factors, such as reservoir diameter, reservoir height and seismic forces. Wave height defines the required/desired freeboard. If freeboard is less than the wave height, it will impose hydraulic load on the roof structure and may damage it.

2.03 Results of Structural Analyses:

A. Key physical features and results of analyses for seven reservoirs are provided in Tables 2.1 through 2.7.

B. Values shown in red font do not meet AWWA D100-11 requirements.

C. Values shown in magenta font represents permanent deformation in steel and potential cause of major failure.

2.04 Discussion and Evaluation on Results of Structural Analyses:

A. Shell Hoop Stresses:

a. As seen in the Tables 2.1 through 2.7, hoop stresses on the bottom two courses of all reservoirs exceed the allowable stresses by 25% to 92%. With the exception of Reservoir 4B, hoop stresses of the third course from the bottom for all reservoirs exceed allowable stresses by 18% to 100%. With the exception of Reservoir 3A, hoop stresses of the top courses of all reservoirs are within the allowable limits.

b. With the exception of Reservoirs 2B and 4B, hoop stresses of one or multiple shell courses of all reservoirs (3A, 3B, 3C, 4A, and 4C) exceed or are very close to yield strength of steel. Steel plates with such excessive stresses will experience permanent deformation and are susceptible to failure.

c. In general, shell hoop stresses on multiple steel courses for all reservoirs exceed allowable, mainly because of thinner thicknesses of steel plates. Except Reservoirs 2B and 4B, all reservoirs are considered to have major deficiencies in steel plate thicknesses for one or multiple courses.

B. Reservoir Overturning:

a. With the exception of Reservoirs 3A and 4A, reservoir overturning ratios for all reservoirs exceed 1.54, which means that they are not stable. These reservoirs require anchorage and associated concrete ring beam foundation.

b. Reservoir overturning ratios for Reservoirs 3A and 4A are approximately 1.3 or more, which means that the reservoirs are marginally stable. However, considering high shell compression stresses and associated high soil bearing pressures, concrete ring beams and reservoir anchorage are recommended for these two reservoirs also.

C. Reservoir Sliding: All reservoirs are safe against horizontal sliding.

D. Shell Buckling/Compression Stresses:

   a. Shell buckling/compression stresses for Reservoirs 2B, 3A, and 4A are within the allowable limits after they are anchored to new concrete ring beam.

   b. Shell buckling/compression stresses for Reservoirs 3B, 3C, 4B, and 4C exceed the allowable stresses even after they are anchored to new concrete ring beams. This is attributed to thinner steel plate for the bottom course of the shell. With excessive hoop stresses combined with excessive buckling stresses, the existing bottom courses of these reservoirs are likely to experience major deformation.

E. Wave Height and Freeboard:

   a. Calculated wave heights range from 4.92 feet to 9.42 feet, all of which exceed the available freeboard of approximately 1.5 feet.

   b. Because of relatively large wave heights, roof plates, rafters, and areas near shell and roof connections might get damaged and distorted.

F. Collective Structural Deficiencies:

   a. Collective structural deficiencies for each steel reservoir are considered to be significant.

   b. Even after installation of concrete ring beam and reservoir anchorage, existing shell courses will experience excessive stresses and in many instances permanent deformation and associated failures.

TABLE 2.1: RESERVOIR 2B PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	1.25 MG
Type	Welded Steel
Year Built	1967
Site Soil Classification	C-Very Dense Soil and Soft Rock
Diameter	85'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A283-C
Tank Shell 2nd Course	0.25", A36
Tank Shell 3rd Course	0.322", A36
Tank shell Bottom Course	0.4375", A36
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	1.83			
Anchorage Requirement	Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	1.92			
Sloshing Wave Height	8.6'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	0.63			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	0.75	1.41	1.56	1.43
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.5	0.79	0.86	0.79
Required Shell Plate Thickness for Static Forces only (in)	0.14	0.26	0.4	0.54
Required Shell Plate Thick. Seismic (in)	0.19	0.35	0.5	0.63
Existing Shell Plate Thickness (in)	0.25	0.25	0.322	0.4375

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

TABLE 2.2: RESERVOIR 3A PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	2.5 MG
Type	Welded Steel
Year Built	1966
Site Soil Classification	C-Very Dense Soil and Soft Rock
Diameter	120'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A131-A
Tank Shell 2nd Course	0.25", A131-A
Tank Shell 3rd Course	0.375", A131-A
Tank shell Bottom Course	0.5", A36
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	1.39			
Anchorage Requirement	Not Required but Recommended -Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	2.5			
Sloshing Wave Height	9.42'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	0.54			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	1.1	2.04	1.92	1.79
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.65	1.2	1.12	1
Required Shell Plate Thickness for Static Forces only (in)	0.17	0.37	0.56	0.76
Required Shell Plate Thick. Seismic (in)	0.27	0.51	0.72	0.9
Existing Shell Plate Thickness (in)	0.25	0.25	0.375	0.5

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

TABLE 2.3: RESERVOIR 3B PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	1.0 MG
Type	Welded Steel
Year Built	1968
Site Soil Classification	B - Rock
Diameter	75'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A131-A
Tank Shell 2nd Course	0.25", A131-A
Tank Shell 3rd Course	0.25", A131-A
Tank shell Bottom Course	0.313", A131-A
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	1.76			
Anchorage Requirement	Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	2.02			
Sloshing Wave Height	5.63'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	1.02			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	0.6	1.18	1.67	1.69
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.35	0.69	0.99	0.99
Required Shell Plate Thickness for Static Forces only (in)	0.11	0.23	0.35	0.47
Required Shell Plate Thick. Seismic (in)	0.15	0.29	0.42	0.53
Existing Shell Plate Thickness (in)	0.25	0.25	0.25	0.3125

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

TABLE 2.4: RESERVOIR 3C PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	1.0 MG
Type	Welded Steel
Year Built	1967
Site Soil Classification	C - Very Dense Soil and Soft Rock
Diameter	75'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A131-A
Tank Shell 2nd Course	0.25", A131-A
Tank Shell 3rd Course	0.25", A131-A
Tank shell Bottom Course	0.313", A131-A
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	1.98			
Anchorage Requirement	Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	1.82			
Sloshing Wave Height	7.95'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	1.14			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	0.64	1.22	1.72	1.75
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.37	0.71	1.02	1.02
Required Shell Plate Thickness for Static Forces only (in)	0.11	0.23	0.35	0.47
Required Shell Plate Thick. Seismic (in)	0.16	0.31	0.43	0.54
Existing Shell Plate Thickness (in)	0.25	0.25	0.25	0.3125

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

TABLE 2.5: RESERVOIR 4A PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	2.0 MG
Type	Welded Steel
Year Built	1968
Site Soil Classification	B - Rock
Diameter	110'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A131-A
Tank Shell 2nd Course	0.25", A131-A
Tank Shell 3rd Course	0.344", A131-A
Tank shell Bottom Course	0.469", A131-A
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	1.3			
Anchorage Requirement	Not Required but Recommended -Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	2.66			
Sloshing Wave Height	6.58'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	0.53			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	0.92	1.79	1.82	1.69
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.54	1.04	1.08	0.99
Required Shell Plate Thickness for Static Forces only (in)	0.16	0.34	0.52	0.7
Required Shell Plate Thick. Seismic (in)	0.23	0.44	0.63	0.79
Existing Shell Plate Thickness (in)	0.25	0.25	0.344	0.469

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

TABLE 2.6: RESERVOIR 4B PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	0.55 MG
Type	Welded Steel
Year Built	1968
Site Soil Classification	B - Rock
Diameter	55'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A131-A
Tank Shell 2nd Course	0.25", A131-A
Tank Shell 3rd Course	0.25", A131-A
Tank shell Bottom Course	0.25", A131-A
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	2.34			
Anchorage Requirement	Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	1.67			
Sloshing Wave Height	4.92'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	1.43			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	0.47	0.88	1.25	1.56
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.28	0.52	0.73	0.92
Required Shell Plate Thickness for Static Forces only (in)	0.09	0.17	0.26	0.35
Required Shell Plate Thick. Seismic (in)	0.11	0.21	0.3	0.38
Existing Shell Plate Thickness (in)	0.25	0.25	0.25	0.25

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

TABLE 2.7: RESERVOIR 4C PHYSICAL FEATURES AND SEISMIC ANALYSES RESULTS

PHYSICAL FEATURES	
Capacity	1.0 MG
Type	Welded Steel
Year Built	1967
Site Soil Classification	C - Very Dense Soil and Soft Rock
Diameter	75'-0"
Height	32'-0"
Max. Water Height	31'-0"
Tank Shell Top Course	0.25", A131-A
Tank Shell 2nd Course	0.25", A131-A
Tank Shell 3rd Course	0.25", A131-A
Tank shell Bottom Course	0.313", A131-A
Floor Plate	0.3125", A283-C
Roof Plate	0.1875", A283-C
Type of Roof	Cone Roof
Type of Foundation	Steel Retainer, 6" Sand Cushion

SEISMIC ANALYSES RESULTS				
Design Basis	AWWA D100-11			
Overturning Ratio	2.01			
Anchorage Requirement	Yes			
Ring Beam Requirement	Yes			
Safety Factor Against Sliding	1.79			
Sloshing Wave Height	8.08'			
Ratio of Max. Long. Shell Compression Stress to Seismic Allowable Long. Shell Compression Stress	1.15			
Tank Shell	Top Course	2nd Course	3rd Course	Bottom Course
Ratio of Combined Hoop Tensile Stress to Allowable Design Stress in Tension	0.72	1.3	1.82	1.79
Ratio of Combined Hoop Tensile Stress to Reduced Minimum Specified Yield Strength (2)	0.42	0.76	1.06	1.05
Required Shell Plate Thickness for Static Forces only (in)	0.11	0.23	0.35	0.47
Required Shell Plate Thick. Seismic (in)	0.16	0.31	0.44	0.55
Existing Shell Plate Thickness (in)	0.25	0.25	0.25	0.313

NOTES:

1. Items in red do not meet AWWA D100-11 requirements.
2. If ratio of actual stress to yield strength is greater than or close to 1.0, steel plate will deform permanently and may experience plastic behavior with major failure.
3. Tank shell stresses are calculated based on assumption (Requirement) that the tank will be anchored. If not then the stresses will be higher than shown here.

SECTION 3

CONCLUSIONS AND RECOMMENDATIONS

3.01 Conclusions and Recommendations:

A. Based on the results of structural analyses and evaluation discussed in Section 2, it is considered that the existing reservoirs have significant structural deficiencies. Existing shell plates are relatively too thin to withstand anticipated seismic forces.

B. Construction of new concrete ring beam, reservoir anchors, and strengthening of rafters and columns as originally considered will not address major deficiencies of the shell plate thicknesses.

C. Existing reservoir structures and sites also require other improvements, including removal and replacement of portions of inlet-outlet piping, drain piping, and overflow piping, replacement of existing paint system with new, spot repairs of roof and floor plates, replacement of central air-vent with new, asphalt repair due to concrete ring beam construction, site improvements, etc.

D. Retrofitting cost of steel reservoir structures (without strengthening or replacing shell plates) and site improvements are estimated to be to be $0.80 to $0.90 per gallon of storage capacity, which is considered to be significant. Reservoir structures will not meet the current AWWA D100 requirements after retrofitting because shell courses will not be retrofitted.

E. Considering relatively short remaining useful life of these 50 +/- year-old reservoir structures and significant retrofitting cost, it is recommended that the District consider replacing existing steel reservoir facilities with new. Construction cost of new facilities is estimated to be approximately $1.50 per gallon of storage. Reservoir 2B may be retrofitted because structural deficiencies are the least and marginally acceptable with assumed risk.

3.02 Reservoir Replacement Priority:

A. Based on the structural deficiencies for each reservoir and estimate of potential inundation damage, reservoir replacement priority is presented in the last column of Table 3.1. This table also provides a comprehensive summary of results of analyses and evaluation of all seven reservoirs.

B. Estimate of potential inundation damage as noted in Table 3.1 is developed with the help of District staff and is based on aerial map and data submitted in the P&I 1999 Engineering Report.

3.03 District Adopted Plan:

A. After review of the results of the structural analyses and evaluation, District staff is considering replacement of the existing steel reservoir structures with new.

3.04 Deletion of Engineering Tasks:

A. Because existing reservoir facilities are recommended to be removed and replaced with new, other engineering tasks as originally planned (refer to Section 1) are not required and not performed as requested by the District.

Table 3.1

Summary of Key Results of Steel Reservoir Analyses per AWWA D100-11

Reservoir Name	Size (MG)	Tank's Ability to Resist Overturning[1]	New Concrete Ring Beam and Tank Anchors are Required/ Recommended[2]	Meets Allowable Longitudinal Shell Compression Stress (EF)[3]	Shell Courses Hoop Stresses % Overstressed above Allowable AWWA				Shell Courses Hoop Stresses % Overstressed above Yield Strength of Steel (Elastic vs. Plastic Deformation)[4]				Potential[5] Inundation Damage based on Location	Priority Refurbish or Replace[8]
					Top	2nd	3rd	Bottom	Top	2nd	3rd	Bottom		
2B	1.25	**No**	Yes	Yes	0	**41**	**56**	**43**	Elastic	Elastic	Elastic	Elastic	Low	6
3A	2.50	Marginally Yes	Yes	Yes	**10**	**100**	**92**	**79**	Elastic	**Plastic (20%)**	**Plastic (12%)**	**Plastic (close to yield stress)**	Moderate	2
3B	1.00	**No**	Yes	**No**	0	**18**	**67**	**69**	Elastic	Elastic	**Plastic (close to yield stress)**	**Plastic (close to yield stress)**	Moderate	4
3C	1.00	**No**	Yes	**No**	0	**22**	**72**	**75**	Elastic	Elastic	**Plastic (2%)**	**Plastic (2%)**	Moderate	5
4A	2.00	Marginally Yes	Yes	Yes	0	**79**	**82**	**69**	Elastic	**Plastic (4%)**	**Plastic (8%)**	**Plastic (close to yield stress)**	Low	3
4B	0.55	**No**	Yes	**No**	0	0	**25**	**56**	Elastic	Elastic	Elastic	Elastic	Moderate	7
4C	1.00	**No**	Yes	**No**	0	**30**	**82**	**79**	Elastic	Elastic	**Plastic (6%)**	**Plastic (5%)**	High	1

1. Tank's ability to resist overturning during earthquake.
2. If tank is not capable to resist overturning, concrete ring beam and anchors are required.
3. AWWA allowable longitude shell stress for compression failure as a result of excessive tank overturning forces (Elephant's Foot).
4. Shell courses with potential plastic deformation (shown in Red) may experience steel plate failure leading to major or complete failure of the tank structure.
5. Potential inundation or likelihood of property damage is determined based on its vicinity to housing developments or populated area and 1999 P&I Report, Table 9 – Priority Evaluation Matrix.
6. Structural analyses do not consider effect of steel plate corrosion if exists.
7. All tanks are required to have their existing interior & exterior paint system removed and replaced with new.
8. Priority for refurbishment or replacement is determined based on structural deficiencies and potential inundation damage.

APPENDIX A

Board Memorandum

June 22, 2017

Tank Seismic Upgrade Analysis

CAMROSA WATER DISTRICT
BUILDING WATER SELF-RELIANCE

Board Memorandum

June 22, 2017

To: General Manager

From: Terry Curson, Project Engineer

Subject: **Tank Seismic Upgrade Analysis**

Objective: Provide results from the structural and seismic analysis for several steel potable water tanks based on current American Water Works Association (AWWA) standards.

Action Required: No action necessary; for information only.

Discussion: The seismic analysis has been completed for seven of the District's eleven potable water tanks. The analysis provides guidance in evaluating the condition of the tanks and how they compare to current AWWA standards.

Following the 1971 and 1994 Sylmar and Northridge earthquakes, respectively, more attention has been given to seismic risk for virtually all types of structures. AWWA updated its D100 (Steel Tanks for Water Storage) Standards in 1984 and again in 1996, in response to improving reliability and public safety for these types of facilities. Prior to the 1984 update, seismic forces were taken into consideration by most engineers in the design of hydraulic structures, but these forces and the procedures of seismic design were not as complex or elaborate as those today. The majority of the District's water tanks were designed and constructed between 1966 and 1968, when few guidelines existed.

In 1999, a seismic evaluation was done on the District's eleven steel water storage tanks that evaluated the ability for the tanks to withstand specific seismic forces, overall structural integrity, and the condition of the existing interior and exterior coatings. The evaluation was based on the most current standards at that time (AWWA D100-96).

Between 1999 and present, four of the eleven tanks have been retrofitted in accordance with the earlier standards: tanks 1A, 1B, 2A, and 3D. In March 2017, the Board awarded a contract to Perliter & Ingalsbe (P&I) to seismically evaluate the seven remaining tanks in accordance with the most current AWWA standards (D100-11).

Findings and Alternatives

As part of the contract, P&I completed structural and seismic analyses of seven tanks on May 17, 2017. Since the AWWA standards are only guidelines, P&I looked at utilizing different load factors and joint efficiencies to offer staff some comparison and flexibility in evaluating and determining the limits and/or need for structural retrofitting.

The first portion of the analysis looked at each tank's ability to resist overturning during a seismic event. With the exception of tanks 3A and 4A, the remaining tanks do not meet the recommended safety ratio against overturning and require concrete ring beams and anchoring systems to keep them stable during a seismic event.

Secondly, P&I looked at the longitudinal shell compression stresses (buckling stresses). During a seismic event, the bottom shell or boundary area between the tank's wall and floor is susceptible to an elastic-plastic instability failure. This failure mode is commonly known as "elephant's foot buckling" as the boundary layer tends to permanently bulge out. Installing a concrete ring beam and anchoring the tank will help to prevent the tank buckling but may not completely eliminate potential damage resulting from axial forces and other related stresses. Tanks 2B, 3A, and 4A meet the standards for allowable longitudinal stresses while the other four remaining tanks exceed those limits.

The last critical area of analysis looked at the shell hoop stress for each shell course from top to bottom. P&I compared shell hoop stresses for all four courses of each tank with the allowable stresses provided in AWWA standards. Hoop stresses on the bottom two courses of all tanks exceed the allowable stresses by 25 to 92 percent. With the exception of Tank 4B, hoop stresses of the third course from the bottom for all tanks exceed allowable stresses by 18 to 100 percent. With the exception of Tank 3A, hoop stresses of the top course of all tanks are within the allowable limits. Although hoop stresses may exceed AWWA standards, the deformation of the shell will be within the elastic region and it will rebound to its original shape if stresses are below steel's yield strength. However, if hoop stresses are close to the steel's yield strength or higher, the shell will experience plastic deformation leading to potential failure.

Until the project definition and direction are better defined, preliminary budget costs have not been determined. A generally accepted cost guideline for direct costs associated with new tank construction (including site work) is approximately $1.50/gallon. Tank retrofitting costs can vary significantly based on the amount of work needed, but generally range between $0.80/gallon to $0.90/gallon. Currently, the District has a proposed fiscal year 2017-18 budget amount of $3,942,000 for tank seismic retrofitting.

Exhibit A (attached) summarizes the analysis results. The areas noted in red identify tank deficiencies based on current standards, although some areas shown in red could be considered marginal and may be fully or partially mitigated through seismic retrofitting. The last column in the exhibit identifies potential inundation or likelihood of property damage based on its vicinity to housing developments or populated areas. Since it is expected that any retrofitting or replacement will take several years to complete, a preliminary prioritization schedule is shown in the attached exhibit.

Staff recommends using the existing available funds to replace Tank 4C and Tank 3C, and to build the cost of replacing the remaining tanks into the rate study.

EXHIBIT A

Summary of Key Results of Steel Tank Analyses per AWWA D100-11

Reservoir Name	Size (MG)	Tank's Ability to Resist Overturning[1]	New Concrete Ring Beam and Tank Anchors are Required/ Recommended[2]	Meets Allowable Longitudinal Shell Compression Stress (EF)[3]	Shell Courses Hoop Stresses % Overstressed above Allowable AWWA				Shell Courses Hoop Stresses % Overstressed above Yield Strength of Steel (Elastic vs. Plastic Deformation)[4]				Potential[5] Inundation Damage based on Location	Priority Refurbish or Replace[8]
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1. Tank's ability to resist overturning during earthquake.
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5. Potential inundation or likelihood of property damage is determined based on its vicinity to housing developments or populated area and 1999 P&I Report, Table 9 – Priority Evaluation Matrix.
6. Structural analyses do not consider effect of steel plate corrosion if exists.
7. All tanks are required to have their existing interior & exterior paint system removed and replaced with new.
8. Priority for refurbishment or replacement is determined based on structural deficiencies, and potential inundation damage.