CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY MEETING AGENDA

September 16, 2021
6:00 PM

The Mission of the City of Coalinga is to provide for the preservation of the community character by delivering quality, responsive City services, in an efficient and cost-effective manner, and to develop, encourage, and promote a diversified economic base in order to ensure the future financial stability of the City for its citizens.

Notice is hereby given that the City Council will hold a Regular Meeting, on September 16, 2021 in the City Council Chambers, 155 West Durian Avenue, Coalinga, CA. Persons with disabilities who may need assistance should contact the City Clerk at least 24 hours prior to the meeting at 935-1533 x113. Anyone interested in translation services should contact the City Clerk at least 24 hours prior to the meeting at 935-1533 x113. The Meeting will begin at 6:00 p.m. and the Agenda will be as follows:

1. CALL TO ORDER

1. Pledge of Allegiance
2. Changes to the Agenda
3. Council's Approval of Agenda

2. AWARDS, PRESENTATIONS, APPOINTMENTS AND PROCLAMATIONS

1. Active Transportation Overview and Update on Implementation
2. Presentation of Farm Workforce Modernization Act by Manuel Cunha

3. CITIZEN COMMENTS

This section of the agenda allows members of the public to address the City Council on any item within the jurisdiction of the Council. Members of the public, when recognized by the Mayor, should come forward to the lectern, identify themselves and use the microphone. Comments are normally limited to three (3) minutes. In accordance with State Open Meeting Laws, no action will be taken by the City Council this evening and all items will be referred to staff for follow up and a report.

Citizen Comments submitted in writing to the City Clerk by 5:00pm on the day of the City Council meeting shall be distributed to the City Council and included in the record, however they will not be read.

4. PUBLIC HEARINGS (NONE)

5. CONSENT CALENDAR

1. Approve MINUTES - September 2, 2021
2. Authorize Mayor to Sign and Send a Letter of Support for Farm Workforce Modernization Act of 2021 on behalf of the City of Coalinga
3. Consideration and Approval of Bid Award for Fresno Street Rehabilitation
4. Approve the Use of Rubberized Tree Wells as an Alternative Approach to the Use of Conventional Tree Wells for Street Trees
5. Council Update Related to Installing Benches Throughout the City
6. Approve Contract Amendment with IGS Services to Allow Subcontracted Work Subject to City Manager Approval and Further Approving a Task Order to Perform Gas Modeling Services
7. Adopt Resolution No. 4045 Supporting and Implementing the "Timely Use of Funding" as Required by AB1012 for Candidate Federal Transportation Act, Cycle III Projects (STBG/CMAQ)
8. Approve Task Order with Blais and Associates to Develop a Grant Application Under the Bureau of Reclamation WaterSMART and Energy Efficiency Grant Program
9. Authorize City Manager to Execute a Contract Amendment with SWCA Environmental Consultants to Provide Environmental Services Related to the Master Trails Project (ATP Cycle 4 Grant Program)
10. Adopt Airport Hangar Inspection Policy for New Coalinga Municipal Airport
11. Public Works, Utilities & Community Development Monthly Report for August 2021

6. ORDINANCE PRESENTATION, DISCUSSION AND POTENTIAL ACTION ITEMS

1. Council Review and Consideration of the Engineers Report and Direction Related to the Rehabilitation of the Derrick Reservoir

   Sean Brewer, Assistant City Manager

7. ANNOUNCEMENTS

1. City Manager's Announcements
2. Councilmembers' Announcements/Reports
3. Mayor's Announcements

8. FUTURE AGENDA ITEMS

9. CLOSED SESSION (NONE)

10. CLOSED SESSION REPORT

Closed Session: A "Closed" or "Executive" Session of the City Council, Successor Agency, or Public Finance Authority may be held as required for items as follows: personnel matters; labor negotiations; security matters; providing instructions to real property negotiators; legal counsel regarding pending litigation; and protection of records exempt from public disclosure.

Closed session will be held in the Administration Building at 155 W. Durian Avenue and any announcements or discussion will be held at the same location following Closed Session.

11. ADJOURNMENT

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Approve MINUTES - September 2, 2021
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Shannon Jensen, City Clerk

I. RECOMMENDATION:

II. BACKGROUND:

III. DISCUSSION:

IV. ALTERNATIVES:

V. FISCAL IMPACT:

ATTACHMENTS:

File Name	Description
MINUTES_For_Approval_090221.pdf	Minutes - September 2, 2021

MINUTES
CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY MEETING AGENDA
September 2, 2021

1. CALL TO ORDER 6:15PM
Late start due to technical difficulties.

Council Members Present:	Ramsey, Singleton, Adkisson, Ramirez, Horn
Others Present:	City Manager Marissa Trejo, City Attorney Mario Zamora, Chief of Police Darren Blevins, Assistant City Manager Sean Brewer, Financial Services Director Jasmin Bains, Fire Chief Greg DuPuis, Administrative Analyst Mercedes Garcia, Public Works and Utilities Coordinator Larry Miller, and City Clerk Shannon Jensen
Council Members Absent:	None
Others Absent:	City Treasurer Dawn Kahikina
Changes to the Agenda:	City Manager Marissa Trejo announced Item No. 2.1 would be presented at the end of the presentation section, as The CrisCom Company representative is running late. Item No. 6.4 will be pulled from the agenda.

*Motion by Singleton, Second by Ramirez to Approve the Agenda, with changes to move Item No. 2.1 to the end of the presentations and to table Item No. 6.4 for the meeting of September 2, 2021. Motion **Approved** by Roll-Call 5/0 Majority Vote.*

2. AWARDS, PRESENTATIONS, APPOINTMENTS AND PROCLAMATIONS

1. Lobbying Services Update by The CrisCom Company

Renee Missakian of The CrisCom Company gave a brief presentation on the lobbying and economic services they have provided to the City of Coalinga.

2. Grant Services Update by Blais and Associates

Jill Mohler of Blais and Associates gave a brief presentation of the services and successful grants provided to the City of Coalinga.

3. Employee of the Month for August 2021, Account Clerk, Yasmin Gonzalez

Financial Services Director Jasmin Bains presented Account Clerk Yasmin Gonzalez with the Employee of the Month certificate for August 2021.

4. Public Safety Flag Presentation

Chief of Police Darren Blevins and Fire Chief Greg DuPuis presented the Coalinga Police Department and the Coalinga Fire Department flag to the City of Coalinga.

Mayor Ramsey called for a five-minute break at 6:52pm.

Mayor Ramsey resumed the meeting at 7:00pm.

3. CITIZEN COMMENTS

The following individual(s) spoke under Citizen Comments:

Scott Netherton reminded the community of the September 11th Memorial event and asked for volunteers to assist with raising the Garrison Flag at the event. Mr. Netherton went on to speak in favor of approving premium pay for essential employees. (Item No. 6.5)

Robin Scott spoke in opposition of approving premium pay for essential employees. (Item No. 6.5)

4. PUBLIC HEARINGS

None

5. CONSENT CALENDAR

1. Approve MINUTES – August 19, 2021
2. Check Register: 07/01/2021 – 07/31/2021
3. Approve Purchase of Two (2) Pressure Regulating Valves for the Derrick Bypass

Councilman Adkisson pulled Item No. 5.3 for discussion.

Assistant City Manager Sean Brewer gave a brief overview of the item.

4. Consideration of Bid Award for 2021 Rubberized Cape Seal Project
5. Authorize Assistant City Manager to Source and Purchase a Bucket Truck for the Public Works Department
6. Authorization to Source New Vehicles Under the City's Existing Fleet Management Contract with Enterprise
7. Adopt Resolution No. 4044 Establishing the Fire Reserve and Per Diem Pay Scale
8. Approve Lease Agreement with Fresno County Fire Protection District and Staff an Ambulance at Station 93 in Huron

Councilman Ramirez pulled Item No. 5.8 for discussion.

Fire Chief Greg DuPuis gave a brief overview of the item.

*Motion by Adkisson, Second by Horn to Approve Consent Calendar Item Nos. 5.1 through 5.8, along with an additional $1,800 for the purchase of a butterfly valve for the Derrick bypass (Item No. 5.3). Motion **Approved** by Roll-Call 5/0 Majority Vote.*

6. ORDINANCE PRESENTATION, DISCUSSION AND POTENTIAL ACTION ITEMS

1. Discussion, Direction and Potential Action relating to Adding a Crosswalk on Elm Avenue Near Dollar General
   Sean Brewer, Assistant City Manager

Assistant City Manager Sean Brewer stated this was a Future Agenda Item requested by Councilman Ramirez. Mr. Brewer explained that staff is working with Caltrans to include a crosswalk at this location as part of Caltran's Large Complete Streets project scheduled for Elm Avenue from Fifth Street to Cambridge Avenue.

2. Discussion, Direction and Potential Action regarding Reinstating Crossing Guard Positions
   Marissa Trejo, City Manager

City Manager Marissa Trejo gave a brief overview of the item.

Consensus of the Council is for the City Manager to continue discussion with the school district to develop a plan to reinstate crossing guards.

3. Council Approval of Project Scope of Work for Expenditures related to the California Parks Per Capita Program
   Sean Brewer, Assistant City Manager

Assistant City Manager Sean Brewer gave a brief overview of the item.

*Motion by Singleton, Second by Ramirez to Project Scope of Work for Expenditures related to the California Parks Per Capita Program. Motion **Approved** by Roll-Call 5/0 Vote.*

4. Discussion, Direction and Potential Action related to Commercial Cannabis Outdoor/Indoor/Nursery Cultivation Tax Rates and Structure
   Sean Brewer, Assistant City Manager

*Item No. 6.4 was **Pulled** from the Agenda during Changes to the Agenda.*

5. Discussion, Direction and Potential Action regarding American Rescue Plan Act of 2021 (ARPA) Funding Priorities and Allocations
   Marissa Trejo, City Manager

City Manager Marissa Trejo gave a brief overview of the item.

Scott Netherton spoke in favor in favor of approval.

Tom Dominguez spoke in favor of approval.

*Motion by Horn, Second by Ramirez to Approve Premium Pay for Essential Employees up to $12,000 per Employee. Motion **Approved** by Roll-Call 4/1 Vote. Adkisson –Voted No.*

7. ANNOUNCEMENTS

City Manager's Announcements:

City Manager Marissa Trejo reminded the public of Lisa Project that will be in the Council Chambers at City Hall from October 14th – October 20th.

Mrs. Trejo reminded the public of the Breakfast with the Chief that takes place on the first Tuesday of the month at 9:00am at Café 101.

Council Member's Announcements:

None

Mayor's Announcements:

Mayor Ramsey reminded the public of the September 11th memorial event on Saturday, September 11, 2021.

8. FUTURE AGENDA ITEMS

Mayor Ramsey requested that the City Manager receive a new computer, like the ones the Council recently received, for use at the City Council meetings.

9. CLOSED SESSION

1. CONFERENCE WITH LABOR NEGOTIATORS – Government Code Section 54957.6. CITY NEGOTIATORS: City Manager, Marissa Trejo and City Attorney Mario Zamora. EMPLOYEE (ORGANIZATION): General Employees and Nonrepresented Employees

2. CONFERENCE WITH LEGAL COUNSEL – ANTCIPATED LITIGATION under Government Code Section 54956.9(d)(2) – 1 case

10. CLOSED SESSION REPORT

None

11. ADJOURNMENT 7:52 PM

____

Ron Ramsey, Mayor

____

Shannon Jensen, City Clerk

____

Date

From: Joyce Agresta
To: info; Ron Ramsey; Ray Singleton; Adam Adkisson; Jose M. Ramirez; James Horn; manzanitamo.
Subject: To the Mayor and City Councilmen Don"t commit an Egregious Abuse of the Grant Money involving City employees proposal(request to read at City Council meeting 9/2/2021 BY My REP SINGLETON)
Date: Thursday, September 2, 2021 3:04:29 PM

SOME PRETTY GOOD REASONS WHY THE CITY OF COALINGA EMPOYEES SHOULD NOT BE GRANTED THE PREMIUM PAY THEY REQUEST

.(1) Passing The City Employee proposal will prevent equitable distribution(non - compliance) unless you can and will give every essential worker in the citizenry 12000 each.(2:) The proposal prioritizes the city employees premium pay above all infrastructure and everyone else.(3) Does not address infrastructure nor premium pay for lower income workers which should be first on your list (4) This is putting a huge strain on Police community relations.The police and city workers have figured out a way to circumvent the Lower paid essential workers most of whom are Hispanic and Immigrants.rightful place in line it's oppressive."" It is intimidating for all citizens to speak up against the police-. Our fears have proven valid again and again. Our police department has some problems.The Police Dept recently announced they had charged one Former Coalinga Police officer with Kidnapping and rape of a child and we have expetations some more things will come out. (5). The community is not in the mind set to glorify and bonus the Police dept and City employees (.6) When you put only the City employees first it is demoralizing to the community and an assault to the our civil rights..(7) The city employees are acting in a predatory way towards the Citizens of Coalinga...(8) The usual good old boy mentality " lets take some off the top " will not likely hold up to the scrutiny of the treasury and may jeopardize the grant..(9) We can't elect a Mayor in Coalinga because the sitting Mayor wants it that way as he cast the final vote to deny us that right. (10) The Mayors kin and clan will receive many x 12000 dollar payments a windfall in all,.(11) Nepotism is not illegal but it can grow corruption.(12). (94) people want 25% percent of four million dollars off the top (13)The entity of the City of Coalinga Employees have such a unique sense of entitlement they don't seem willing to accept the rules and regulations (14) The lower paid essential workers are in urgent need of premium pay now. Thank you for the opportunity to be heard...Joyce D Agresta... Citizen Coalinga California

From:	Dawn Kahikina
To:	info
Subject:	read during council meeting
Date:	Thursday, September 2, 2021 5:07:48 PM

I believe if their is money for City staff let them have it!! It is not the job of Council to go against the best interest of our City!

I believe take care of those who take care of us!!

I see over and over again the people are always at the bottom of the list when we, employees, and our City should be at the top of the list being that is the job of Council..

I feel it is all a waste if time! They are already talking and they will make a decision before they even meet!!! The people are just entertainment for most of them!!

One person controls the majority and that affects good choices!!

The people need to use their tools to put a end to this mentally ill hate group!! and remove this cancer we have been dealing with!!

The police need to give a no confidence vote and then recall D1...

Our City is always at risk because of this cancer..

I also know the City manager is under attack from this hate group funny before they were given awards..

I find it sick that the one who has been a part of everything and how everything runs now is using their decisions and the situation they created as a tool to get rid of this individual..

That behavior puts our City at risk for legal action and cost and makes for a hostile work place.

A proper way to do things with respect, dignity, morals, and ethics need to be a must.

Also making false pages and sending out the hate group is a shame!!

How can a official be a part of such things and think it is ok for the City they took a oath to serve!!

Their attacks and what they point out is the same MO over and over for 7 years now!!

It is time to say enough is enough!! It is time to make a stand and Rise against this cancer we have been ill with for years...

I say Bleep this cancer!! Rise!!

All part of the hate groups plan to take over the City!!

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Authorize Mayor to Sign and Send a Letter of Support for Farm Workforce Modernization Act of 2021 on behalf of the City of Coalinga
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Shannon Jensen, City Clerk

I. RECOMMENDATION:

Approval of a Letter of Support for the Farm Workforce Modernization Act of 2021.

Future agenda item requested by Mayor Pro-Tem Singleton.

II. BACKGROUND:

Detailed information presented during presentation by Manuel Cunha, Jr., President of the Nisei Farmers League.

III. DISCUSSION:

IV. ALTERNATIVES:

Do not approve.

V. FISCAL IMPACT:

ATTACHMENTS:

File Name	Description
Sample_letter_for_Cities_re_Immigration_Reform_-_Sen._Feinstein.docx	Sample letter for Cities re Immigration Reform- Senator Feinstein
Sample_letter_for_cities_re_Immigration_Reform_-_Sen._Padilla.docx	Sample letter for Cities re Immigration Reform- Senator Padilla

This is a sample letter that can be used to send to U.S. Senator Feinstein

Use City Letterhead

Date:

The Honorable U. S. Senator Dianne Feinstein
331 Senate Hart Office Building
Washington, D. C. 20510

Dear Senator Feinstein,

The City of _______________ greatly appreciates the United States House of Representatives passage of the Farm Workforce Modernization Act of 2021. We have hope that it will pass the Senate, especially since undocumented farmworkers and other agricultural employees have shown how important they are during the COVID-19 pandemic. However, the legislation in its current form leaves out a large segment of our undocumented agricultural workforce, people that work in packing houses and processing plants.

Packing houses and processing plants are a vital economic sector in our community. They provide our residents with good paying jobs. It would be unfair for these workers who are sorting, packing, or processing agriculture commodities to have to resign from these agricultural jobs to seek another that meets the legislation's current definition of *agricultural labor or services*. They too are working long and hours, especially during peak season. Work done whether in the field or in packing houses or processing plants is important to the agricultural industry.

Dreamers must not be forgotten in this push to legalize the agricultural workforce. In our community, many Dreamers have parents who work in agriculture. To not move forward without legislation for Dreamers leaves their future uncertain. A federal district court order enjoined the granting of the initial DACA request. Further court rulings could terminate DACA for those already granted. We will lose teachers, doctors, lawyers, and workers in almost all occupations.

The City of _________________respectfully request that the definition of *agricultural labor or services* in the Farm Workforce Modernization Act of 2021 be modified to include employees who work in packing houses and processing plants and that legislation for Dreamers be passed concurrently.

Sincerely,

This is a sample letter that can be used to send to U.S. Senator Padilla

Use City Letterhead

Date:

The Honorable U. S. Senator Alex Padilla
B03 Russell Senate Office Building
Washington, D. C. 20510

Dear Senator Padilla,

The City of ______________ greatly appreciates the United States House of Representatives passage of the Farm Workforce Modernization Act of 2021. We have hope that it will pass the Senate, especially since undocumented farmworkers and other agricultural employees have shown how important they are during the COVID-19 pandemic. However, the legislation in its current form leaves out a large segment of our undocumented agricultural workforce, people that work in packing houses and processing plants.

Packing houses and processing plants are a vital economic sector in our community. They provide our residents with good paying jobs. It would be unfair for these workers who are sorting, packing, or processing agriculture commodities to have to resign from these agricultural jobs to seek another that meets the legislation's current definition of *agricultural labor or services*. They too are working long and hours, especially during peak season. Work done whether in the field or in packing houses or processing plants is important to the agricultural industry.

Dreamers must not be forgotten in this push to legalize the agricultural workforce. In our community, many Dreamers have parents who work in agriculture. To not move forward without legislation for Dreamers leaves their future uncertain. A federal district court order enjoined the granting of the initial DACA request. Further court rulings could terminate DACA for those already granted. We will lose teachers, doctors, lawyers, and workers in almost all occupations.

The City of ________________ respectfully request that the definition of *agricultural labor or services* in the Farm Workforce Modernization Act of 2021 be modified to include employees who work in packing houses and processing plants and that legislation for Dreamers be passed concurrently.

Sincerely,

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Consideration and Approval of Bid Award for Fresno Street Rehabilitation
Meeting Date:	September 16, 2020
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

It is recommended that the Coalinga City Council award a contract in the amount of $353,973.00 to AJ Excavation, Inc., 514 N. Brawley Avenue, Fresno, CA 93706 for the Fresno Street Rehabilitation Project. It is also recommended that a contingency of 10% ($35,397.30) be included in the Council action to cover any unforeseen incidentals for a total authorization amount of $389,370.30.

II. BACKGROUND:

In November 2020, the Coalinga City Council directed staff to prepare engineering plans and specifications and authorized a call for bids for the Fresno Street Rehabilitation Project. The primary scope of work includes the rehabilitation of Fresno Street in the four-block segment between Washington Street and Harvard Avenue in Coalinga, CA. The work entails construction surveying, demolition of existing concrete improvements, roadway excavation and grading, placement of aggregate base and asphalt concrete pavement sections, construction of concrete curb and gutter, curb ramp, sidewalk, and valley gutter, adjustment of existing utility lids and sewer manholes, and placement of thermoplastic striping and markings.

III. DISCUSSION:

City Staff received and opened five bids for this project on August 31, 2021, at 2:00 p.m. AJ Excavation, Inc., was the apparent low bidder with a total bid proposal of $353,973.00. The Engineer's Estimate was $338,715.00. The entire bid summary is included as Attachment "A". AJ Excavation, Inc., has furnished the required bid bond. If the City Council decides to award the project to AJ Excavation, Inc., and the "Notice to Proceed" is issued, the contractor will have 50 working days to complete the work. The following is a tentative schedule:

Award of Contract:	September 16, 2021
Start of Construction:	October 4, 2019
Completion of Construction:	December 16, 2019

IV. ALTERNATIVES:

The alternative to this council action would be to reject all bids. If all bids are rejected, the City would have to re-advertise or cancel the project. Staff believes that re-advertising the project will not result in lower bids.

V. FISCAL IMPACT:

Total authorization request for this contract is $353,973.00 with an additional 10% contingency of $35,397.30 for a total of $389,370.30. This project is funded by SB1 Street Funds. The FY22 budget appropriated $280,000 for this project but the City is authorized to utilize more funds ahead of future allocations therefore allowing the City to accept the bids and proceed with the contracted amounts. There will be no fiscal impact to the General Fund.

ATTACHMENTS:

	File Name	Description
🗋	2867_Bid_Results.pdf	Fresno Street Bid Results
🗋	2867_Bid_Summary.pdf	Fresno Street Bid Summary

Attachment "B"

Bid Results
City of Coalinga
Fresno Street Rehabilitation
Project No. PW 21-004 / #2867

Bid Date: August 31, 2020
2:00 PM, Tri City Engineering

	Bidder	Base Bid
1	AJ Excavation, Inc.	$ 353,973.00
2	Avison Construction, Inc.	$ 404,243.00
3	Bush Engineering, Inc.	$ 404,614.00
4	D.O.D. Construction	$ 406,010.00
5	R.J. Berry, Jr., Inc.	$ 426,001.40
6	Terra West Construction, Inc.	$ 455,992.00
7		

Sub List

Chrisp Company
ESP Surveying
Madera Concrete
Safety Network

Tri City Engineering
4630 W. Jennifer Ave., #101
Fresno, CA 93722-5415
Tel: 559.447.9075
Fax: 559.447-9074
info@tricityengineering.com

City of Coalinga
155 W. Durian Ave
Coalinga, CA 93210
Tel (559) 935-1533
Fax (559) 935-1184

City of Coalinga

PW 21-004/#2867 Fresno Street Rehabilitation

ATTACHMENT "A" Bids 1-6

Base Bid Items

					1 A.J. Excavation		2 Avison Construction		3 Bush Engineering		4 DOD Construction		5 R.J Berry Jr., Inc.		6 Terra West Construction	
Item	***Description***	***Unit***	***Qty.***	***Engineer's Est.***	***Unit Price***	***Extension***	***Unit Price***	***Extension***	***Unit Price***	***Extension***	***Unit Price***	***Extension***	***Unit Price***	***Extension***	***Unit Price***	***Extension***
1	MOBILIZATION / GENERAL REQUIREMENTS	LS	1	$ 20,000.00	$ 8,000.00	$ 8,000.00	$ 20,000.00	$ 20,000.00	$ 24,093.00	$ 24,093.00	$ 20,000.00	$ 20,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00
2	WORKER SAFETY	LS	1	$ 1,500.00	$ 1,000.00	$ 1,000.00	$ 500.00	$ 500.00	$ 3,880.00	$ 3,880.00	$ 2,000.00	$ 2,000.00	$ 1,000.00	$ 1,000.00	$ 100.00	$ 100.00
3	TRAFFIC CONTROL	LS	1	$ 3,000.00	$ 6,500.00	$ 6,500.00	$ 3,250.00	$ 3,250.00	$ 11,053.00	$ 11,053.00	$ 3,000.00	$ 3,000.00	$ 5,000.00	$ 5,000.00	$ 20,000.00	$ 20,000.00
4	DUST CONTROL	LS	1	$ 1,760.00	$ 1,000.00	$ 1,000.00	$ 500.00	$ 500.00	$ 6,546.00	$ 6,546.00	$ 1,000.00	$ 1,000.00	$ 2,000.00	$ 2,000.00	$ 1,000.00	$ 1,000.00
5	CONSTRUCTION SURVEYING	LS	1	$ 4,500.00	$ 7,000.000	$ 7,000.00	$ 7,000.00	$ 7,000.00	$ 7,544.00	$ 7,544.00	$ 5,000.00	$ 5,000.00	$ 8,270.00	$ 8,270.00	$ 7,000.00	$ 7,000.00
6	SAWCUTTING	LF	2140	$ 4,280.00	$ 1.500	$ 3,210.00	$ 2.00	$ 4,280.00	$ 1.85	$ 3,959.00	$ 4.00	$ 8,560.00	$ 0.01	$ 21.40	$ 2.50	$ 5,350.00
7	CONCRETE REMOVAL & DISPOSAL	CY	116	$ 17,400.00	$ 125.000	$ 14,500.00	$ 275.00	$ 31,900.00	$ 124.75	$ 14,471.00	$ 110.00	$ 12,760.00	$ 430.00	$ 49,880.00	$ 165.00	$ 19,140.00
8	ROADWAY EXCAVATION AND GRADING	CY	1,514	$ 60,560.00	$ 30.000	$ 45,420.00	$ 30.00	$ 45,420.00	$ 38.50	$ 58,289.00	$ 30.00	$ 45,420.00	$ 70.00	$ 105,980.00	$ 59.00	$ 89,326.00
9	HOT MIX ASPHALT TYPE A (HMA-A)	TON	752	$ 75,200.00	$ 119.000	$ 89,488.00	$ 110.00	$ 82,720.00	$ 102.50	$ 77,080.00	$ 140.00	$ 105,280.00	$ 90.00	$ 67,680.00	$ 100.00	$ 75,200.00
10	AGGREGATE BASE TYPE II	TON	1910	$ 57,300.00	$ 34.000	$ 64,940.00	$ 30.00	$ 57,300.00	$ 35.30	$ 67,423.00	$ 60.00	$ 114,600.00	$ 32.00	$ 61,120.00	$ 44.00	$ 84,040.00
11	ADJUST EXISTING MANHOLE	EA	4	$ 5,000.00	$ 600.000	$ 2,400.00	$ 1,800.00	$ 7,200.00	$ 1,612.00	$ 6,448.00	$ 1,200.00	$ 4,800.00	$ 1,200.00	$ 4,800.00	$ 1,200.00	$ 4,800.00
12	ADJUST EXISTING WATER/GAS VALVE	EA	9	$ 6,750.00	$ 600.000	$ 5,400.00	$ 1,100.00	$ 9,900.00	$ 708.00	$ 6,372.00	$ 400.00	$ 3,600.00	$ 800.00	$ 7,200.00	$ 1,000.00	$ 9,000.00
13	CONCRETE 6" CURB & GUTTER	LF	1618	$ 56,630.00	$ 40.000	$ 64,720.00	$ 56.00	$ 90,608.00	$ 45.50	$ 73,619.00	$ 30.00	$ 48,540.00	$ 35.00	$ 56,630.00	$ 47.00	$ 76,046.00
14	CONCRETE CURB RAMP	SF	165	$ 2,475.00	$ 57.000	$ 9,405.00	$ 35.00	$ 5,775.00	$ 45.00	$ 7,425.00	$ 40.00	$ 6,600.00	$ 20.00	$ 3,300.00	$ 28.00	$ 4,620.00
15	CONCRETE SIDEWALK	SF	370	$ 3,700.00	$ 37.000	$ 13,690.00	$ 17.00	$ 6,290.00	$ 19.00	$ 7,030.00	$ 15.00	$ 5,550.00	$ 8.00	$ 2,960.00	$ 16.00	$ 5,920.00
16	CONCRETE VALLEY GUTTER	SF	1430	$ 17,160.00	$ 10.000	$ 14,300.00	$ 20.00	$ 28,600.00	$ 18.30	$ 26,169.00	$ 10.00	$ 14,300.00	$ 12.00	$ 17,160.00	$ 15.00	$ 21,450.00
17	STRIPING AND MARKINGS	LS	1	$ 1,500.00	$ 3,000.000	$ 3,000.00	$ 3,000.00	$ 3,000.00	$ 3,213.00	$ 3,213.00	$ 5,000.00	$ 5,000.00	$ 3,000.00	$ 3,000.00	$ 3,000.00	$ 3,000.00
	Base Bid Summary			**$ 338,715.00**		**$ 353,973.00**		**$ 404,243.00**		**$ 404,614.00**		**$ 406,010.00**		**$ 426,001.40**		**$ 455,992.00**

F:\Docs\2800's\2867 Fresno Street Repaving Washington to Harvard\Bid Docs\2867 Bid Summary.xlsx
Date Printed: 8/31/2021, 2:36 PM

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Approve the Use of Rubberized Tree Wells as an Alternative Approach to the Use of Conventional Tree Wells for Street Trees
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

Staff is seeking Council's approval to use rubberized tree wells as an alternative approach to the use of conventional tree grates and use this approach on the 7th Street rehabilitation project between Forest and Elm Ave.

II. BACKGROUND:

During the design phase of the 7th street rehabilitation, staff has been looking at alternative methods to traditional metal tree grates. One of the alternatives is the use of rubberized material made from a mixture of recycled tires, washed gravel, and rubber resin and can be poured like concrete. It also serves to mitigate rainwater runoff is with permeable paving that allows water to flow through and be absorbed on site rather than enter the sewer system.

III. DISCUSSION:

Staff is bringing this to the City Council as an alternative to the use of a standard metal grate, that is very difficult to accommodate expanding trucks of trees as they grow over time. With the rubberized material, as the tree grows, crews can cut the material with a jigsaw to accommodate the expanding trunk. This approach also to be found a more cost effective alternative to a typical metal grate. According to the City Engineer, the cost could be approximately $500-$700 per tree well for Porous Pave/Flexi Pave compared to $1500 for a two piece metal tree grate.

Staff has included some information regarding the Porous Pave and Stone Set Tree Surround products that the City would like to consider as a pilot for 7th street rehab project to see how it works. If this serves to be a good option, the City would move to using this a standard for future projects.

In addition to the benefits mentioned above, this alternative provides for a variety of color options to match the surrounding environment or to show civic pride with community based colors. Here is a link to various color options with Porous Pave:

Color Options Link: https://www.porouspaveinc.com/color-options

IV. ALTERNATIVES:

None at this time. Staff is seeking councils direction.

V. FISCAL IMPACT:

According to the City Engineer the cost could be approximately $500-$700 per tree well for Porous Pave/Flexi Pave compared to $1500 for a two piece metal tree grate resulting in a cost savings.

ATTACHMENTS:

File Name	Description
Permeable_Pavement_Grand_Rapids.pdf	Grand Rapids Example
Permeable_Pavement_Protects_Seattle.pdf	Seattle Example
Porous_Pave_Information.pdf	Porous Pave Information

750 Iron Tree Grates in Grand Rapids Replaced with Porous Pave Permeable Paving Material

City improves safety and attractiveness of downtown area by replacing rusted and broken tree grates with Porous Pave, a porous, pour-in-place surfacing material that is a proven solution for green stormwater infrastructure.

March 25, 2015

Named "America's Greenest City" by Fast Company magazine, Grand Rapids. MI has received worldwide recognition for its sustainability efforts. The city's multi-year Sustainability Plan sets more than 200 specific targets in sustainability, energy efficiency, conservation and renewable energy. Progress achieved has reduced energy consumption and greenhouse gas emissions, resulting in significant cost savings and numerous social and environmental benefits.

In its continuing effort to make its downtown more welcoming, and to support its sustainability initiatives, Grand Rapids, MI is completing the replacement of 750 old iron tree grates with Porous Pave XL.

The first phase of the project was completed in September 2014 before the annual ArtPrize event. The city had Porous Pave tree surrounds installed to replace 250 cracked and broken grates that presented the most serious tripping hazard in the three square miles of downtown. An additional 500 grates will be replaced by July 2015.

"Porous Pave allows rainwater and air to get down to the tree roots," said Mark DeClercq, P.E., city engineer. "With its high rubber content and textured surface, Porous Pave is slip resistant and safer when wet than traditional metal tree grates."

"Porous Pave is ADA-compliant," said Dave Ouwinga, president and chief executive officer, Porous Pave, Inc. "In addition to making Porous Pave surfaces slip-resistant, the recycled rubber gives it flexibility, so it withstands freeze-thaw cycles without heaving, cracking or breaking."

An eco-friendly green building product, Porous Pave consists of recycled rubber, stone aggregate and a binder. Made in the U.S.A., Porous Pave XL is a hard, durable material made from 50% recycled rubber chips and 50% stone aggregate with a moisture-cured urethane binding agent. Porous Pave infiltrates stormwater on site, decreases the volume and slows the velocity of runoff flowing into storm drains and storm sewers, improves water quality by reducing erosion and filtering out pollutants, and recharges groundwater. Porous Pave is engineered with 29% void space. Independent testing confirms that Porous Pave allows up to 6,300 gallons of water per hour per square foot to drain directly through its surface, permeate down into a compacted aggregate base, and then slowly filter into the ground

Porous Pave is poured in place at thicknesses of one to two inches atop a compacted aggregate base of two, four or six inches, depending on the application and required compressive strength. Contractors use it in public, commercial and residential installations for loading docks, parking lots, driveways, building entryways and courtyards, walkways and sidewalks, and patios and terraces. The material's porosity, permeability and slip resistance make it ideal for tree surrounds.

Permeable Pavement Protects Seattle's Urban Trees and Makes Streetscape Safer for Pedestrians

June 7, 2018

PAVEMENT
MAINTENANCE & RECONSTRUCTION

As part of its continuing stewardship of the city's urban trees, the Seattle Department of Transportation replaced 38 metal tree grates along the sidewalks of 3rd Avenue with permeable tree surrounds installed with Porous Pave XL.

Running from Space Needle Park to the Smith Tower and Union Station Square, 3rd Avenue is a major thoroughfare with office buildings, high-density housing, retail, and restaurants. A green building product manufactured in the U.S.A., Porous Pave XL is a pour-in-place, permeable paving material, which combines chips of recycled rubber with granite aggregate and a liquid binder.

"Tree roots had pushed the metal grates up from their interior frames in the tree pits," Sherry Graham, arboriculturist, Seattle Department of Transportation says. "Uneven sections and gaps were a tripping hazard."

Porous Pave's recycled rubber content gives it flexibility to withstand freeze-thaw cycles, root expansion and tree growth without cracking or breaking. Metal tree grates are slick and slippery when wet. With its rubber chips and textured surface, the permeable pavement is slip-resistant. Water flows through the openings in metal tree grates, but litter also slips through, making them unsightly and difficult to keep clean. Grates can also get clogged with weeds. The entire surface of Porous Pave is permeable to allow rainwater and air to pass through down to the tree roots. Debris stays on the surface where it can be swept up or power washed away.

"Permeable surrounds with Porous Pave are tree-friendly," says Brian Holers, certified arborist, Root Cause, LLC (Mercer Island, WA.), the urban tree care specialist who is installing permeable tree surrounds at several locations for the City of Seattle. "Installation requires less excavation and minimizes disturbance of the roots. You can spread and fit the material right up against the edges of tree pits and make it conform to the shapes of tree bases. These are significant advantages, since the maples and little leaf lindens along 3rd Avenue are mature trees planted in 1991."

Root Cause installed the new permeable tree surrounds in January 2018. After removing the old grates from their frames, Holers and his crew poured 1.5-in. of Porous Pave XL on a ½- in. base of 5/8 crushed aggregate. The permeable surrounds average 25 square feet in size. The gray color chosen for the project makes the permeable pavement blend in with the adjacent sidewalks.

Porous Pave

PERMEABLE • DURABLE • FLEXIBLE

What is Porous Pave?

Porous Pave is a unique surfacing material made from recycled tires.
It is very durable and highly porous!

Porous Pave is available in two versions:

Porous Pave XL is a hard material made from 50% recycled tires, 50% stone aggregate and a moisture cured urethane binding agent.

Commonly used in pathways, driveways, patios, sidewalks and other areas used for walking or light vehicle traffic.

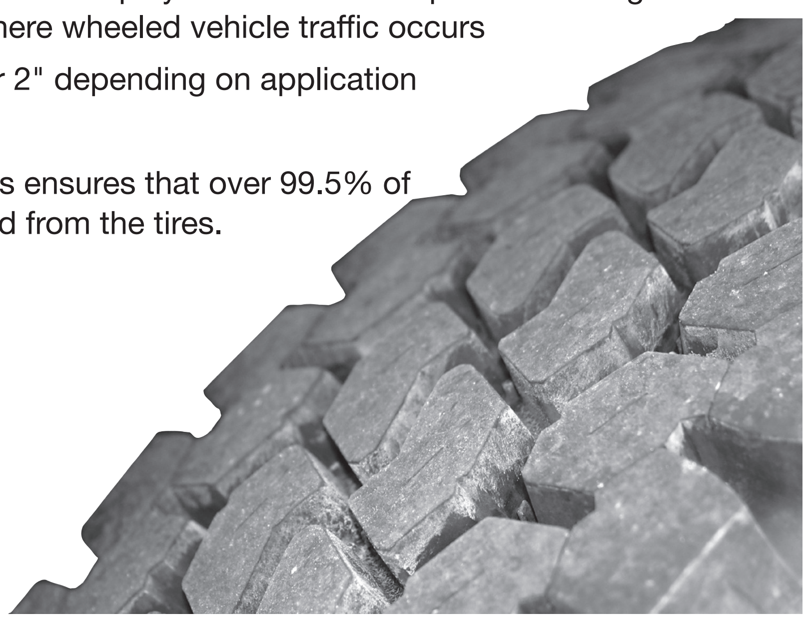
Thickness of install will vary from 1" to 2" thick depending on application

Porous Pave XLS is a softer material made from 100% recycled tires and a softer, more flexible urethane binding agent.

Commonly used in pool surrounds and play areas where a impact absorbing surface is desired. Not for use in areas where wheeled vehicle traffic occurs

Thickness of install will be 1" or 2" depending on application

The unique tire grinding process ensures that over 99.5% of the steel fragments are removed from the tires.



4385 East 110th • Grant, MI 49327
888-448-3873 • Fax 231-834-5537 • www.porouspaveinc.com

Porous Pave
PERMEABLE • DURABLE • FLEXIBLE

Key Sales Features

Highly Porous

One of Porous Pave's biggest features is its highly porous structure. Porous Pave allows large amounts of water to drain through it, thereby minimizing the amount of volume directed to storm drains, basins and other areas of drainage.

- Rainwater is evenly dispersed over the ground and allowed to soak in rather than all of it being directed to storm sewer or retention ponds.
- Erosion and channeling of water is reduced around perimeter of sites not using storm sewers or retention ponds.
- Less run-off results in minimal and in some cases no sub-surface plumbing or catch basins — greatly reducing costs. Also, retention ponds may be reduced in size allowing more usable land for building, parking, etc.
- The non-skid properties of Porous Pave combined with its water storage capacity makes it safer than most other products in similar applications for walkways and parking areas.
- Porous Pave diminishes water run off by allowing water to soak through into the ground.
- Reduces need for separate retention areas and increases usable square footage of site.
- Porous Pave eliminates puddles in low areas.

Environmentally Friendly

- Porous Pave is made from recycled tires. The shredding process removes all steel fragments and produces approximately $^1/_4$" - $^3/_8$" rubber "chips". The use of Porous Pave keeps thousands of tires from going to the landfill. For example, 4500 Lb of scrap tires are used to create 1,000 square feet of 2" porous pavement.
- Porous Pave is mixed on-site and can be applied with little or no damage to existing landscape.

Flexible

- Resists cracking and heaving commonly found on concrete sidewalks. Reduces the chance of slip and fall accidents.
- 50% rubber content allows product to move if sub-base moves.

Porous Pave

PERMEABLE • DURABLE • FLEXIBLE

Key Sales Features *(Continued)*

Frost & Freeze Resistant

- Flexible nature withstands cracking or heaving due to ground movement or frost
- Porous Pave can be applied in temperatures between 40º and 90º F and generally cures in 24 hours, this is a much wider temp range and faster cure time than similar engineered surfaces

Installation Benefits

- Installs in less than half the time of brick pavers
- Low impact installation - no heavy equipment needed, ideal for use in existing landscapes.
- Porous Pave is one large expansion joint eliminating the need for "saw cuts" or expansion strips.
- Entire surface is porous - not just certain areas like brick pavers.

Slip Resistant

- High rubber content ensures good traction even when wet ... lessening the chance of slip and fall accidents.
- Textured surface is not slippery compared to smooth surfaces like concrete.

Strong & Durable

- At only 2" thick, Porous Pave can handle low speed car traffic
- Use at 1$^{1}/_{2}$" thick for bike paths, patios, trails or any other foot and pedestrian traffic
- Use at 1" to overlay existing concrete, asphalt, metal surfaces and wood
- Porous Pave is resistant to oil, chlorine, ozone, UV rays, muratic acid, transmission fluid, gasoline, diesel, hydraulic fluid, salt water and many other hostile materials
- Resistant to snow plow damage

General Specifications

A proven paving product that is durable, flexible and highly porous. It is made from recycled tires, aggregate and a special single component urethane that remains flexible.

Features	***Benefits***
Permeable	Rated at 27% porosity, 5800 GPH permeability
Slip Resistant	Lessons the chance of slip and fall accidents
Flexible	Flexibility of product withstands cracking or heaving
Durable	Resistant to most hostile materials (oil, gas, chlorine, UV, etc.)
Quick Installation	Mix and pour in place application on site
Strong	Can handle low speed traffic at only 2" thick
Environmentally Friendly	Made from recycled tires, every 1000 square feet of Porous Pave saves about 4,100 pounds of tires from the landfill

Installation should be preformed by a Certified Installer

A hard material made from 50% recycled tires, 50% stone aggregate and a moisture cured urethane binding agent. Thickness of install will vary from 1" to 2" thick depending on application. Can be installed from 45° to 95°F temperatures, curing temperature should not drop below 35°F. Fully cured in 24 hours after installation, creating an extremely porous, heavy duty surface.

Substrates for Porous Pave

- At 2" thick a base of 4" crushed stone or similar aggregate with low fines, 3/8" to 3/4" in size, compacted to a density of 95% minimum is needed
- At 1 1/2" thick it is designed for foot traffic only and requires a 2" aggregate base
- At 1" thick it is designed to install over an existing engineered surface (concrete, asphalt, wood, etc.)

Uses

Storm water management, driveways, sidewalks, pathways, patios, pool surrounds, tree surrounds, play grounds, maintenance strips, cart paths, bunker liner, etc.

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Porous Pave

PERMEABLE • DURABLE • FLEXIBLE

Tree Surrounds

Typical Material Install:

2" Porous Pave XL

Typical Base Requirement:

2" Crushed Stone Base

Porous Pave is ideal for use around trees — allows air and water to tree roots while providing a durable, slip resistant surface.

- Reduces maintenance commonly found with metal tree grates
- Can be cut as trees grow larger
- Pour-in-place material can fit any shape or size
- Low cost, durable installations provide years of maintenance free service
- Install as a long term replacement to metal tree grates higher maintenance covering like bark, pea stone, etc.

Color Options

The Porous Pave manufacturing process infuses our recycled rubber chips with rich colors. Porous Pave colors are deep and enduring – not thin outer coatings that flake off or fade away.

Porous Pave's versatility gives you options. We offer eight standard colors. You can mix and match any two of our eight colors to create custom color combinations. Porous Pave is pourable within forms to express creative designs in permeable pavement with distinctive shapes in different colors.

Standard Colors


Black

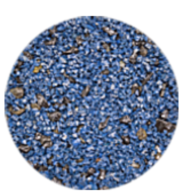

Brown


Cypress


Redwood


Tan


Grey


Blue


Green

Custom Colors

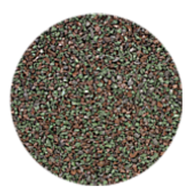

Brown-Tan

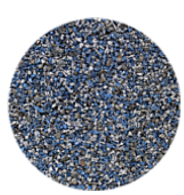

Redwood-Black


Black-Tan


Grey-Black


Cypress - Black


Green-Brown


Blue - Grey


Brown-Black

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Council Update Related to Installing Benches Throughout the City
Meeting Date:	August 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Larry Miller, Public Works and Utilities Coordinator

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I. RECOMMENDATION:

Staff has no formal recommendation at this time. This item is informational only and a proposed map is attached.

II. BACKGROUND:

This was a future agenda item brought forward by Councilman Singleton.

III. DISCUSSION:

Benches located around major thoroughfares can improve quality of life for citizen utilizing those thoroughfares for recreation as well as necessity. Staff has identified locations that they feel would be best suited to this endeavor. These locations are in no way final, but rather selected to represent what we felt were along major paths of travel and within areas that either the City already has the right of way or felt that permission would easily be granted. These places include points of interest such as parks, schools, landscaped areas, and etc. These benches may be an allowable expense of ARPA funds as the promote healthy living, getting community members outdoors and walking.

Staff will bring this item back for discussion at a later date.

Staff asks that, in the meantime, Council review the attached map and be prepared to discuss the locations once this item is brought back for discussion.

IV. ALTERNATIVES:

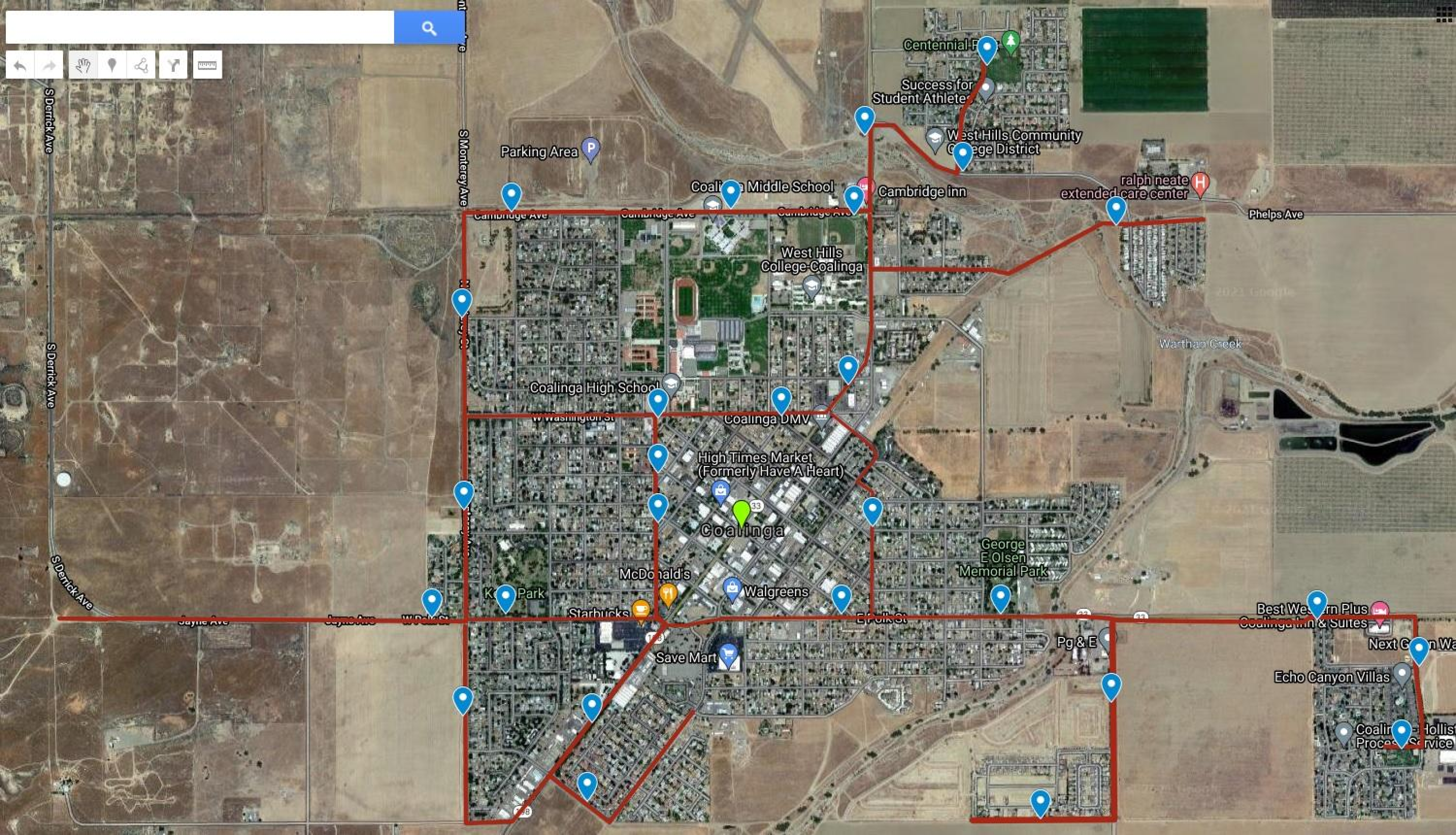
None

V. FISCAL IMPACT:

Prices on park benches can widely vary based on design. Ranging approximately $500.00 for simple designs to $1,000 for more robust designs. Concrete pads and accessibility may be required for each location which will incur an additional cost.

ATTACHMENTS:

	File Name	Description
🗋	BenchLocations.jpg	Bench Locations


Centennial P
Success for Student Athletes
West Hills Community College District
Parking Area
Coalinga Middle School
Cambridge inn
ralph neate extended care center
Phelps Ave
Cambridge Ave
West Hills College-Coalinga
Warthan Creek
Coalinga High School
W Washington St
Coalinga DMV
High Times Market (Formerly Have A Heart)
Coalinga
George E Olsen Memorial Park
McDonald's
Walgreens
Starbucks
Jayne Ave
W Polk St
E Polk St
Best Western Plus Coalinga Inn & Suites
Pg & E
Save Mart
Echo Canyon Villas
S Derrick Ave
S Monterey Ave

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Approve Contract Amendment with IGS Services to Allow Subcontracted Work Subject to City Manager Approval and Further Approving a Task Order to Perform Gas Modeling Services
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

Staff is recommending that the City Council approve an amendment to the existing contract with IGS Services to allow for subcontracting and approve a task order to undertake gas system modeling.

II. BACKGROUND:

As the Council may be aware, PG&E has reached a critical point in delivering additional power to larger industrial customers such as cannabis cultivators. Capacity from previous developments have absorbed most of the power available to deliver on these new projects. Staff has been approached by (2) cannabis operators who have approved projects where the lack of power availability by PG&E has delayed their construction timelines as power is not expected to be available for at least two (2) more years when they are scheduled to complete the Jayne/Merced substation upgrades. The locations primarily affected are in the Industrial Park and West Elm south of Polk Street. As a possible solution, these operators have requested that staff allow them to use natural gas generators to provide temporary power to these facilities until permanent power is available. This is a solution that staff is considering for these operators.

III. DISCUSSION:

The city operates and maintains its own natural gas distribution network however, the demand communicated to staff related to these cannabis cultivators who need natural gas to operate their generators is substantial. Preliminary numbers suggest that these two operators could consume as much as two (2) times the natural gas consumed by the entire City in a year. Therefore, in consultation with Dan Bergmann of IGS, the City's gas consultant, has suggested due to the high demand usage, the City would need to undertake some type of gas modeling in order to ensure that the increased usage would not have a negative impact on the City's overall performance and reliability. This is critical infrastructure and heavily regulated, therefore, staff feels that the City has to fully understand the impacts to adding that much demand to an existing system and see how it will perform when demand increases at this level.

The scope of the project described by this proposal includes all work necessary to complete the various tasks associated with the project, as understood at the writing of the proposal, including:

- Development of a computer model of the System;
- Calibration or verification of the resulting model;
- Review the impact of various planned development projects;

- Preparation of the documentation describing the model development, calibration process, and planning review.

In order to undertake this modeling, IGS would need to subcontract the work as the modeling requires additional expertise. Currently, IGS's contract does not allow for subcontracting, however, this is a reasonable request to amend the contract to allow subcontracting as this is a very specialized field and it is critical that IGS be intimately involved in the analysis and oversight of the modeling. Therefore, staff is requesting and subsequently has made the necessary amendments to the existing contract to allow for subcontracting with approval of the City Manager. A redlined version has been attached to this report to see the changes made by staff.

Once the model in complete, the City will be able to fully understand increased demand impacts to the system.

IV. ALTERNATIVES:

- Do not proceed with the natural gas modeling and amendment to the IGS contract.
- Proceed with modeling and determine a level of monetary contribution by the cannabis companies who have requested this energy alternative. Staff would need further direction if Council chooses this alternative.

V. FISCAL IMPACT:

If the council chooses to move forward with this request the Council may choose to proceed with paying the $12,000 from the gas fund as this modeling will have a benefit to the Citywide system as well as possible tax revenue from companies opening sooner than waiting for PG&E to complete their upgrades. If approved it would be a not to exceed $12,000 task order from the professional services account in the Gas Fund.

ATTACHMENTS:

File Name	Description
Agreement_for_Consulting_Services_-_Coalinga-IGS_2021_Amended_-_Subcontract_Language.DOC	IGS Amended Agreement with Subcontract Language
Subcontract_Proposal_for_Gas_System_Modeling.pdf	Gas System Modeling Task Order

AGREEMENT FOR CONSULTING SERVICES

This agreement sets forth the agreement and understanding between City of Coalinga (Coalinga) and Interstate Gas Services, Inc. (also IGS or IGService) for the purpose of IGS providing utility-related consulting services to Coalinga.

SCOPE:

The ongoing scope of services is summarized below by enterprise fund.

Natural Gas Enterprise

- Monthly gas procurement coordination with Shell Trading
- Summer season sale-back of excess Redwood-path pipeline capacity
- Verification of all supplier billing statements
- Monitor revenue and expense of the gas enterprise for rate setting
- Support with PHMSA gas safety compliance

Water Enterprise

- Negotiation and coordination with Westlands and USBR for water costs and volumes
- Negotiation and contract management with wholesale customers
- Annual disclosure reporting for Series 2012 Bonds
- Monitor revenue and expense of the water enterprise regarding rate setting
- Compile and submit monthly volume report to Water Resources Control Board
- Monitor and identify monthly billing detail for errors

Sewer Enterprise

- Annual disclosure reporting for Series 2012 Bonds
- Monitor revenue and expense of the gas enterprise for rate setting

In general, provide ongoing utility technical support to the City Manager, Public Works Director, and staff as requested. Beyond the above-identified areas, this letter agreement is general in nature. All additional work shall be as directed only by the Public Works Director or City Manager and agreed to by Dan Bergmann of IGS.

TERM:

This agreement is effective upon full execution. This agreement supersedes all other agreements in place between IGS and Coalinga. This agreement shall continue until terminated by either party on 30 days written notice, with or without cause.

FEES:

For services provided by IGS:
$185 per hour

For administrative services:
$50 per hour

Lodging:
Actual cost, not to exceed $125 per night

Meals:
Not included

Mileage:
$0.545 per mile (2018), or the highest IRS approved rate

Driving time:
$75 per hour

CONFIDENTIALITY:

IGS and Coalinga recognize and agree that during the term, both will gain access to certain information critical to the ongoing business operations of each entity. This may include, but not be limited to, customers, clients, and supplier identities, transportation arrangements and terms, and conditions of certain contractual arrangements relative to the above. Both parties to this agreement specifically agree to keep any and all such information strictly confidential throughout the term defined hereunder and subsequent to the termination of this Agreement. IGS and Coalinga further agree not to utilize any such information to circumvent such ongoing business activities of each other, either directly and/or through third parties.

WARRANTY:

IGS shall perform all services with due diligence in a good workmanlike manner under generally accepted industry professional standards and, where applicable, standards imposed by law for comparable or similar services. All materials incorporated into services shall be of good quality.

INDEMNIFICATION:

Coalinga agrees to defend, indemnify IGS and save it harmless from all losses, liabilities, or claims including attorneys' fees and costs of court ("Claims"), from any and all persons, arising from or out of claims associated with agreements between Coalinga and entities other than IGS. Coalinga further agrees not to involve IGS in present or future litigation between Coalinga other entities, as a result of Coalinga utilizing IGS work products as evidence. IGS agrees to defend, indemnify Coalinga and save it harmless from all Claims, from any and all persons, arising from or out of the work of IGS hereunder, including but not limited to, the claims of customers, suppliers, and IGS employees.

INDEPENDENT CONTRACTOR:

In performing under this agreement, IGS shall act at all times as an independent contractor. IGS shall not make any commitment or incur any charge or expense in the name of Coalinga.

IGS expressly agrees, acknowledges, and stipulates that neither this Agreement nor the performance of its obligations or duties thereunder shall ever result in IGS, or anyone employed by IGS, being:

A. An employee, agent, servant or representative of Coalinga; or

B. Entitled to any benefits from Coalinga, including, without limitation, pension, profit sharing, accident insurance, or health, medical, life, or disability insurance benefits or coverage, to which employees of Coalinga are entitled.

The sole and only compensation and/or benefit of any nature to which IGS shall be entitled are the payments provided for herein. Coalinga shall have no direction or control of IGS or its employees and agents except in the results to be obtained subject to Coalinga's right to review/inspect the services. The actual performance and supervision of all services shall be by IGS, but the services shall meet the approval of Coalinga.

SOCIAL SECURITY AND WAGE TAX LIABILITY:

IGS agrees to pay timely and to accept exclusive liability for the payroll taxes, contributions for unemployment compensation insurance, old age benefits, social security, and any other payments now or hereafter imposed by the Government of the United States or by any state or political subdivision thereof, which are measured by the ages, salaries or other remuneration paid to IGS's employees. IGS agrees to indemnify Coalinga and save it free and harmless from and against any and all taxes, contributions, and/or payments imposed by law upon IGS.

ASSIGNMENTS AND SUBCONTRACTS:

The parties recognize that a substantial inducement to City for entering into this Agreement is the reputation, experience and competence of IGS. Assignments of any or all rights, duties or obligations of IGS under this Agreement is not permitted. However, IGS shall be permitted to subcontract Services under this Agreement with the express written consent of the City Manager, which will not be unreasonably withheld. If City consents to such subcontract, IGS shall be fully responsible to City for all acts or omissions of the subcontractor. Nothing in this Agreement shall: (1) create any contractual relationship between City and sub contractor; (ii) create any obligation on the part of the City to pay or to see to the payment of any monies due to any such subcontractor; (iii) or relieve IGS of any of its obligations and responsibilities under this Agreement.

PAYMENT:

IGS shall bill Coalinga for work completed on a monthly basis. Payment is due 30 days after receipt of the invoice. Any overdue payments may, at IGS sole discretion, accrue a late charge of 1% per month.

INSURANCE:

IGS shall maintain insurance and shall submit certificates of insurance evidencing that insurance meeting the following requirements is being provided:

1. Errors and Omissions Insurance. If IGS is professionally licensed, IGS shall have such errors and omissions insurance as shall protect City, its officers, directors, employees and agents from claims based on errors or negligent acts or omissions which may arise from IGS' operations or performance under this Agreement, whether claims be made during or subsequent to the term of this Agreement, and whether such operations or performance be by IGS or its employees, Consultants, agents or anyone else directly or indirectly employed by any of the foregoing. The amount of this insurance shall not be less than $1,000,000.

   Said policy shall be continued in full force and effect during the term of this Agreement. In the event of termination of said policy, new coverage shall be obtained for the required period to insure for the prior acts of IGS during the course of performing services under the terms of this Agreement.

2. Workers Compensation. IGS shall carry such insurance as will protect City and IGS from claims under Workers Compensation and Employer's Liability Acts; such insurance to be maintained as to the type and amount in strict compliance with State statutes.

3. General Liability. IGS shall obtain and keep in full force and effect general liability insurance including provisions for contractual liability, personal injury, independent Consultants and broad form property damage coverages. This insurance shall be on a comprehensive occurrence basis form with a stand cross liability clause or endorsement. The limit for this insurance shall be no less than $1,000,000 per occurrence for bodily injury, personal injury and property damage. If commercial General Liability Insurance or other form with a general aggregate limit is used, either the general aggregate limit shall apply separately to this project/location or the general aggregate limit shall be twice the required occurrence limit.

4. Automobile Liability. IGS shall maintain automobile liability insurance with coverage for any vehicle including those owned, leased, rented or borrowed. This insurance shall have a standard cross liability clause or endorsement. The limit amount for this insurance shall be no less than $1,000,000 per occurrence combined single limit for bodily injury and property damage.

5. Within thirty (30) days of the date of this Agreement, IGS shall provide the City with Certificates of Insurance demonstrating compliance with provisions 1 through 4 above.

Said certificates shall specify or endorse to provide that ten (10) days notice shall be given in writing to the City of any cancellations.

NOTICES:

City of Coalinga	City of Coalinga 155 West Durian Coalinga, CA 93210 Attn: City Manager
Interstate Gas Services, Inc.	Dan Bergmann / IGS 15 Shasta Lane Walnut Creek, CA 94597

SIGNATURES:

If the above conditions and terms meet with your approval, please sign below:

______________________________ Signature	____________________ Date
______________________________ Name Printed	
______________________________ Title	
______________________________ Dan Bergmann President Interstate Gas Services, Inc.	____________________ Date

Proposal To Provide:

Coalinga Natural Gas System Model and Analysis

For:

Interstate Gas Services, Inc

September 01, 2021

Prepared By:

B3PE
419 E Columbia Street
Colorado Springs, Colorado
80907
(719) 578 - 9391

This document is formatted to accommodate double sided printing.

PROPOSAL INTRODUCTION

Please find the following proposal in response to a request by Interstate Gas Services, Inc (the Client) to provide various technical services associated with developing a computer model of the existing City of Coalinga (the Owner) gas system (the System), calibrating the resulting model, and reviewing the impact of several proposed new developments on the System's performance. This proposal is submitted by B3PE LLC (B3PE). The proposal describes the various tasks associated with the offered services.

The cost values listed in this proposal are valid for a period of one hundred twenty (120) days from the submission date.

COMPANY BACKGROUND

B3PE (formerly Bradley B Bean PE) is a limited liability company based in Colorado. The company has been supplying exceptional services and software solutions to the natural gas industry since its establishment in 1992. Brad Bean (a partner) will serve as the principal in charge of the activities associated with this proposal. Mr. Bean has an extensive background in the analysis and design of natural gas distribution systems. Bradley B Bean PE is primarily staffed by its partners and a small support staff. Contract labor and professional sub-contractors are used to complete projects requiring additional resources. No additional staff should be required for this project.

PROPOSAL

1.0 Project Scope...

The scope of the project described by this proposal includes all work necessary to complete the various tasks associated with the project, as understood at the writing of the proposal, including:

- Development of a computer model of the System;
- Calibration or verification of the resulting model;
- Review the impact of various planned development projects;
- Preparation of the documentation describing the model development, calibration process, and planning review.

2.0 Task Descriptions...

Each of the tasks required to complete the Project are described in the following tables. Unless otherwise noted, B3PE shall be responsible for completing all items shown in the task descriptions. All liaison with the Owner will be performed by Client.

Task 1	**Model Development**
Scope	A piping hydraulic model will be developed for the System. The piping portion of the model will generally be developed by importing GIS data provided by the Owner, by way of the Client. The assumptions and details associated with the performance of this task are outlined below...
Assumptions & Requirements	1. It is assumed that data for the following will be provided in an acceptable electronic format: a. Main line locations with attributed pipe sizes and materials; b. District regulator station locations (if any); c. Gate station location(s). 2. It is assumed that all data will be in an acceptable coordinate system and that the data will accurately reflect the topology, configuration, connectivity, and nominal pipe sizes and material of the associated piping. 3. It is assumed that the Owner and Client will be available to reconcile conflicting or missing data which may be discovered while developing the piping model. 4. It is assumed that only main line segments will be included in the hydraulic portion

	of the model and that certain short or trivial main segments may be combined or ignored during the model creation. 5. It is assumed that all regulator stations and some piping connections will be generalized in the model. 6. It is assumed that no site visit will be required and that all data transfer will be by electronic means. 7. For this task, in order to test the model for solvability, an arbitrary load value will be assigned to each node. 8. It is assumed that a list of operating pressures and, where required, detail drawings of each regulator station will be provided.
Deliverables	At the completion of this task, a basic working computer model of the hydraulic piping portion of the System, as it is depicted in the provided data, will be created and optionally provided for review.

Task 2	**Customer Assignment**
Scope	Upon completion of Task 1, individual customer locations will be assigned to the hydraulic piping model. The customer portion of the model will be created by importing and geocoding customer (meter) addresses from the Owner's customer billing file. The assumptions and details associated with the performance of this task are outlined below...
Assumptions & Requirements	1. It is assumed that LAC will provide an electronic list, in an acceptable format, of service addresses, unique identifying number, and consumption values for each customer supplied by the System. And that the consumption values will be from at least three recent consecutive cold month periods. The customer locations will be assigned by geocoding the addresses contained in this list. 2. Each customer will be assigned to its supply main based on proximity - for example, assigned to the closest main. Services will be depicted in a generalized form. 3. It is assumed that the Owner and Client will be available to reconcile conflicting or missing data which may be discovered while performing the customer assignments. 4. It is assumed that no site visit will be required and that all data transfer will be by

	electronic means. 5. Individual customer demands will be assigned via an automated routine which matches the unique identifying number values in the customer information list. 6. For this task, the previously assigned arbitrary node loads will be removed and the assigned customer loads will be applied to the model.
Deliverables	At the completion of this task, a basic working computer model (the “Base Model”) of the overall System as it is depicted in the provided data documents will be created and optionally provided for review.

Task 3	**Verify & Calibrate The Computer Model of Existing Gas System**
Scope	Verify the results of the Base Model by comparing the model results with measured and observed field operating values. The operating values will be compared to the overall System model results. If sufficient data is provided, the model will be adjusted (calibrated or tuned) so that the model results generally reflect the values collected from the field. If sufficient operating data is not provided to allow calibration of the model, the model results will be compared with available field data and Owner experience to verify that the model generally reflects the conditions collected from the field. The assumptions and details associated with the performance of this task are listed below...
Assumptions & Requirements	1. It is assumed that various field performance values will be provided, including supply pressure values, system operating pressure, gate station flow rates, large customer meter flow rates (if applicable), and a gas composition analysis for a recent agreed to peak period. 2. It is assumed that if sufficient data is not provided to calibrate the model, that enough data will be provided to verify that the model results are generally reflective of the System’s actual performance. 3. In the event that the model is verified but not calibrated, it is assumed that the Owner and Client will be available to help assess the appropriateness of the model results. 4. It is assumed that no additional site visit will be required, that no testing or monitoring by B3PE will be required, and that all data transfer will be by electronic means.

Deliverables	At the completion of this task, a calibrated or verified computer model of the System as it existed at/during the calibration/verification period (the "Existing System Model") will be created and optionally provided for review.

Task 4	**Planning Study**
Scope	Using the Existing System Model, the impact of various planned developments on the System's performance will be reviewed. The assumptions and details associated with the performance of this task are listed below...
Assumptions & Requirements	1. Before including the new projects in the model, the results of the Existing System Model will be reviewed, any weaknesses identified, and recommended system changes presented. 2. It is assumed that the location, general layout, phasing/timing, and proposed density or land usage for each planned project will be provided. 3. It is assumed that various operating limits and parameters for use as design guidelines for evaluating the impact, and any system changes required to adequately supply the planned developments, will be provided.
Deliverables	At the completion of this task, the general results and conclusions of the various scenarios will be documented and provided for review prior to completing the final project documentation.

Task 5	**Prepare Study Documentation**
Scope	Prepare a summary report of the overall model development process, model and calibration results, and planning study results and recommendation The assumptions and details associated with the performance of this task are listed below...
Assumptions & Requirements	1. It is assumed that the "final" report will be provided in a Portable Document Format (PDF) electronic file. Hard copies of the document will be provided as required. 2. It is assumed that no site visit will be required to review or present the final report.
Deliverables	At the completion of this task, documentation of the model development process, model and calibration results, and planning study results and recommendations will be provided in the required formats.

3.0 Cost Summary...

The costs associated with performing each of the described tasks are summarized in the following table...

Task	Description	Cost
1-5	Model Development, Calibration, Planning Study & Report	$12,000
	Total	$12,000

The above costs do not include the cost of any item that is required to be provided by the Owner, the Client, or by others.

Additional services may be provided, on a negotiated basis, at the rates shown in the Attachments.

Respectfully submitted:

Brad Bean
Managing Member
B3PE LLC

ATTACHMENTS

Effective January 2021

BILLING RATES

Category	Rate($/hour)
Senior Engineer / Subject Matter Expert	$240.00
Project Engineer	$120.00
Engineering Technician	$80.00
Administrative/Clerical	$40.00

Direct Costs	Cost + 10%
Mileage	(TBA = FY IRS Allowance)
Travel Expenses	Actual Cost
Travel Rate	1/4 Listed Hourly Rate

Training (Plus travel and direct expenses)	$240.00

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Adopt Resolution No. 4045 Supporting and Implementing the "Timely Use of Funding" as Required by AB1012 for Candidate Federal Transportation Act, Cycle III Projects (STBG/CMAQ)
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

It is recommended that the Coalinga City Council adopt Resolution No. 4045, supporting and implementing the "Timely Use of Funding" as required by AB 1012, Project Delivery Schedules for the Federal Transportation Act Cycle III Projects in the Surface Transportation Block Grant Program (STBG) and Congestion Mitigation Air Quality (CMAQ) Grant Program.

II. BACKGROUND:

Federal and State Transportation funds for STBG and CMAQ are allocated through a competitive grant process from the Fresno COG every two years. The City of Coalinga is seeking funds for the following projects which we presented to the City Council at their last Council meeting:

- **Paving Various Alleys** - Project cost is estimated around $600,000. Below is a list of alleys being proposed (this list may change based on overall budget)

- **Coalinga East Polk Street Bike/Ped Safety and Connectivity Initiative -** (Partially funded ATP 5 Project. Staff is seeking funding to cover the cost of right-of-way and construction. Fresno COG ATP 5 regional bid awarded the City $218,000 to cover design and partial right-of-way.

- **Phelps Ave Reconstruction from Posa Chanet to City Limits** - This has the lowest PCI of all eligible arterials in the Pavement Management System.

- **Citywide Rubberized Chip and Cape Seal Project** - Various streets determined based on Pavement Condition Index (PCI) from Streetsaver.

III. DISCUSSION:

Grant funding provides an important revenue stream to help offset costs of transportation needs in the City. STBG grants require the city to provide matching funds in the minimum amount of 11.47% of the total project costs. Matching funds will be provided by the City from the various street fund revenues. Tri-City Engineering and the City's Grant writing team (Blais and Associates) are currently developing the grant applications, project cost estimates and construction schedule in anticipation of the October/November application deadline.

IV. ALTERNATIVES:

None - this resolution is required as a condition of funding should the City be awarded STBG and CMAQ funds.

V. FISCAL IMPACT:

There is no initial fiscal impact by adopting this resolution. However, the City will be required to provide matching funds of 11.47% if finding is approved. These funds will be provided by the local street funds.

ATTACHMENTS:

File Name	Description
RESO#4045_Support___Implementation_of_the_Timely_Use_of_Funding_Req_d_by_AB1012_Transportation_Act_Cycle_III_STBG-CMAQ_091621.pdf	Resolution No. 4045 - Timely Use of Funding 2021

RESOLUTION NO. 4045

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF COALINGA SUPPORTING AND IMPLEMENTING THE "TIMELY USE OF FUNDING" AS REQUIRED BY AB1012 FOR CANDIDATE 2021 FEDERAL TRANSPORTATION ACT PROJECTS CMAQ: EAST POLK CONNECTIVITY AND ALLEY PAVING PROJECTS; STBG: PHELPS REHABILITATION AND COALINGA CHIP AND CAPE SEAL PROJECTS

WHERAS, AB 1012 has been enacted into State Law in part to provide for the "timely use" of State and Federal funding; and

WHEREAS, the City of Coalinga is able to apply for and receive Federal and State funding under the Federal Transportation Act; and

WHEREAS, the City desires to ensure that its projects are delivered in a timely manner to preclude the Fresno Region from losing those funds for non-delivery; and

WHEREAS, it is understood by the City that failure for not meeting project delivery dates for any phase of a project may jeopardize federal or state funding to the Region; and

WHEREAS, the City must demonstrate dedicated and available local matching funds; and

NOW THEREFORE BE IT RESOLVED, that the City Council of the City of Coalinga hereby agrees to ensure that all project delivery deadlines for all project phases for Congestion Mitigation and Air Quality and Surface Transportation Block Grant Program projects will be met or exceeded.

BE IT FURTHER RESOLVED, that failure to meet project delivery deadlines may be deemed as sufficient cause for the Fresno Council of Governments Policy Board to terminate an agency's project and reprogram Federal/State funds as deemed necessary.

BE IT FURTHER RESOLVED that the City Council does direct its management and engineering staffs to ensure all projects are carried out in a timely manner as per the requirements of AB 1012 and the directive of the City Council.

PASSED AND ADOPTED, by the City Council of the City of Council at a regularly scheduled meeting held on this **16th day of September, 2021** by the following vote:

AYES:

NOES:

ABSTAIN:

ABSENT:

APPROVED:

____

Ron Ramsey, Mayor

ATTEST:

____

Shannon Jensen, City Clerk

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Approve Task Order with Blais and Associates to Develop a Grant Application Under the Bureau of Reclamation WaterSMART and Energy Efficiency Grant Program
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

Council Approval of a Task Order with Blais and Associates to Develop a Grant Application Under the Bureau of Reclamation WaterSMART and Energy Efficiency Grant Program (WEEG).

II. BACKGROUND:

The BOR WaterSMART and Energy Grant program look for projects that result in quantifiable water savings, implement renewable energy components, and support broader sustainability benefits. These projects conserve and use water more efficiently; increase the production of renewable energy; mitigate conflict risk in areas at a high risk of future water conflict; and accomplish other benefits that contribute to sustainability in the Western United States.

Examples include:

- Water Conservation
- Canal Lining/Piping
- Municipal Metering
- Irrigation Flow Measurement
- Supervisory Control and Data Acquisition and Automation (SCADA)
- Landscape Irrigation Measures (including turf removal)
- High-Efficiency Indoor Appliance and Fixtures
- Commercial Cooling Systems

Applications for this grant program are due by November 3, 2021.

III. DISCUSSION:

After reviewing the criteria and scope of projects eligible for funding, staff has discussed internally and based on need, is recommending that the City proceed with an application that has the following components:

Advanced Metering Infrastructure (AMI) – Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers.

AMI meters provide many desirable benefits such as:

- The design of the meter is more resilient to accuracy degradation
- Allow the City to collect actionable data such as usage/leak trends
- Allow citizens to monitor and become alerted to their own usage.

These functionalities work in concert to produce an overall increase in water use efficiency. To achieve this, the City would purchase the necessary meters, endpoints, and equipment required to send and receive the data as required.

This grant program requires a 50% match; however, it is staff's approach to utilize an "in kind" methodology. This allows City staff to claim their labor costs as their matching amount. Staff does not foresee meeting this amount to be an issue, as it will require: Public Works staff time to install the meter, Utility Billing staff time to input new meter information, and support staff time to develop messaging to garner a high end-user rate of the "Eye on Water" application. No in-depth analysis has been conducted to ensure this, but should subsequent information reveal that "in kind" matching is inadequate, an item will be brought directly to council for consideration and use of Water Enterprise Funds.

IV. ALTERNATIVES:

Do not direct staff to proceed with the grant application - staff does not recommend.

V. FISCAL IMPACT:

The cost of the grant development by Blais and Associated is a not to exceed amount of $10,015.00. Grant writing services are budgeted in the FY22 budget to cover this cost from the water enterprise fund (Fund 501-503-88130 and 501-508-88130) .

ATTACHMENTS:

File Name	Description
Q_Coalinga_BOR_WEEG_Grant_110321.pdf	Grant Development Quote for BOR WaterSMART Application

Quote Prepared by:
Andrea Owen
(949) 525-5674
aowen@blaisassoc.com

B&A | Professional Grant Consulting

7545 Irvine Center Drive
Irvine Business Center, Suite 200
Irvine, CA 92618
www.blaisassoc.com

Grant Development Quote

Client Name	**City of Coalinga**
Client Contact	**Sean Brewer, Assistant City Manager**
Client Copy:	
Grant Program / Proposal	**Bureau of Reclamation WaterSMART: Water and Energy Efficiency Grant Program**
Proposal Due	**November 3, 2021**
Project Name (if known)	**Turf Removal/Replacement with Sustainable Landscaping**
Date Prepared	August 30, 2021
Grant/Revenue Potential	$500,000 or $2,000,000
Grant Development Cost	$10,015.00
Cost to Develop Grant as % of Revenue Potential	TBD
Hourly Rate	$105

Activity	**Hours**	**Total Cost**
Preparation activities including review Guidelines, develop e-filing system, develop hard copy notebook, internal set up calls, develop timeline and checklist, lead kick-off conference call with client, attend to follow-up action items. Confirmation of valid SAM.gov and grants.gov accounts.	5	$ 525.00
Develop application content including the Standard Form 424, Assurance Documents, Budget Standard Form 424B, create a cover page/title page, create a table of contents, develop the technical proposal which includes an Executive Summary, Background Data, Technical Project Description, and Evaluation Criteria, develop performance measures, develop the environmental compliance narrative including required permits and approvals, write the funding plan, prepare and help circulate letters of support (up to 5 maximum), complete the budget forms and write a budget narrative, develop the mandatory Resolution (client will circulate through City Council). ******The application cannot exceed 50 pages maximum.*** ***Resolution may be submitted 30 days after the grant deadline.******	70	$ 7,350.00
Develop 80% draft and 100% final. Circulate to client for review and feedback. Allowance for internal strategy calls and quality control reviews. Allowance for conference calls with client. Collate final documents and upload to funding agency via www.grants.gov. Follow-up with funding agency to ensure successful submission.	20	$ 2,100.00
SUBTOTAL	*95*	*$ 9,975.00*
Total Labor Cost Per Application	***$ 9,975.00***	***$ 9,975.00***
Direct Costs (charged at cost, no mark-up)		
Client Files (Flash Drive), if desired.	$ 40.00	$ 40.00
Reproduction and Supplies, if needed.	$ -	$ -
Express Delivery Mail or Courier Services, if needed.	$ -	$ -
SUBTOTAL Direct Costs Per Application	*$ 40.00*	*$ 40.00*
Grand Total	**$ 10,015.00**	**$ 10,015.00**

Work performed by B&A that is outside of the scope of this estimate will be billed at $105 per hour.

Please see "notes and assumptions."

Quote Prepared by:
Andrea Owen
(949) 525-5674
aowen@blaisassoc.com

B&A Professional Grant Consulting

7545 Irvine Center Drive
Irvine Business Center, Suite 200
Irvine, CA 92618
www.blaisassoc.com

Notes and Assumptions
1) Local match is 50% and the maximum funding for Group 1 projects is $500,000 per project and for Group 2 is $2 million. Group 1 projects must be completed within two years and Group 2 projects must be completed within three years. No more than $1.5 million will be awarded to any one applicant. Costs dating back to July 1, 2021, may be submitted as project costs in the budget but these costs must be counted toward the applicant's match.
2) An authorizing Resolution must be submitted within 30 days after the grant deadline.
3) This grant assumes the Client is registered with www.grants.gov and is current. If the Client would like B&A to assist with registration, this quote will need to be amended.
4) Client will provide a day-to-day contact with expertise in the proposed project and will be available during the duration of this grant writing assignment.

Please note that this quote is an estimate for services based on current conditions and understandings. Many factors often change during the development of a grant application that may or may not increase the amount of labor and materials necessary to perform the services successfully. If during the course of work, B&A believes the work is taking longer than originally estimated, B&A will immediately notify the contract point of contact and either mutually agree to a change order or discuss alternatives. Additionally, B&A only charges for actual work performed. The total cost to perform the tasks may be less than quoted herein.

Signature Approving Costs and Authorizing Notice to Proceed

Printed Name

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Authorize City Manager to Execute a Contract Amendment with SWCA Environmental Consultants to Provide Environmental Services Related to the Master Trails Project (ATP Cycle 4 Grant Program)
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

Council Authorizing the City Manager to Execute an Amendment to the Professional Services Agreement with SWCA Environmental Consultants to Provide Environmental Services Related to the Master Trails Project (ATP Cycle 4 Grant Program).

II. BACKGROUND:

The City received ATP Cycle 4 funding allocation for the design and implementation of segments 3 (portion), 4 (portion), and 9 (portion) of the Trails Master Plan. The funding included preparation of the necessary environmental documentation in accordance with State and Federal Law.

On August 6, 2020 the City Council approved a professional services agreement with SWCA to provide the necessary environmental consulting services to satisfy the NEPA and CEQA requirements as part of the ATP Cycle 4 grant funding.

SWCA, Incorporated, dba SWCA Environmental Consultants (SWCA), submitted a contract amendment to provide additional environmental services for the City of Coalinga Trails Master Plan Segments 3, 4, and 9 (project). SWCA has prepared a memorandum (attached) to summarize the differences between the original scope and budget submitted in May 2020 and the revised scope and budget which include additional tasks requested by the California Department of Transportation (Caltrans) in their Preliminary Environmental Study form and letter dated October 23, 2020.

III. DISCUSSION:

SWCA, Incorporated, dba SWCA Environmental Consultants (SWCA), submitted a contract amendment to provide additional environmental services for the City of Coalinga Trails Master Plan Segments 3, 4, and 9 (project). SWCA has prepared a memorandum to summarize the differences between the original scope and budget submitted in May 2020 and the revised scope and budget which include additional tasks requested by the California Department of Transportation (Caltrans) in their Preliminary Environmental Study form and letter dated October 23, 2020.

SWCA's original proposal, dated May 29, 2020, included a budget totaling $74,810 which was approved by the City Council on August 6, 2020. Revisions to this original proposal had been made by SWCA to include preparation of a Jurisdictional Delineation and a Biological Assessment as required by Caltrans.

During the process of revising their cost estimate for the City to include the additional tasks requested by Caltrans, SWCA accounting staff were tasked with preparation of a revised 10-H form as required under the grant It was discovered that there was an error in their accounting which did not include costs for all of the labor categories that were listed. This error resulted in the total revised budget being reduced to $61,729.27.

SWCA has made the necessary corrections and prepared the updated 10-H form that has been submitted to Staff. Specific changes include the incorporation of 8 labor hours by the Environmental Specialist VII labor category and the incorporation of raw wages for all previously missing labor categories. These changes resulted in an increase of Subtotal Direct Labor Costs from $20,985.32 to $27,891.80. SWCA also included a correction to Other Direct Costs, which have been corrected to accurately match the specified costs in the proposed budget. Therefore, the revised budget reflects a total of $84,412.77. Staff has been in conversation with SWCA about these budgetary changes and increased costs related to the project and find that all are accurate and justified.

IV. ALTERNATIVES:

- Do not authorize the City Manager to execute Amendment #1 with SWCA Consultants. - this is not recommended by staff.

V. FISCAL IMPACT:

The contract amendment increases the contract amount to a not to exceed amount of $84,412.77. This contract is funded by the ATP Cycle 4 grant. The budgeted amount in the grant for environmental services was $100,000.00, so the increase in budget will still be within the grant amount for environmental.

ATTACHMENTS:

File Name	Description
Coalinga_TMP_Env_Svcs_Contract_Amendment_9-3-21.pdf	Memo Dated 9-3-2021 SWCA
Fully_executed_COC-SWCA_Services_Agreement_Trails_Master_Plan_-_CURRENT.pdf	Original Agreement SWCA and COC
Amendment_#1_to_Professional_Services_Agreement_signed.pdf	Amendment #1 to Professional Services Agreement

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www.swca.com

September 3, 2021

Sean Brewer, Assistant City Manager
City of Coalinga
155 West Durian Avenue
Coalinga, CA 93210

Submitted via email: sbrewer@coalinga.com

Re: City of Coalinga Trails Master Plan Segments 3, 4, and 9 Environmental Services (NEPA/CEQA) / Contract Amendment

Dear Mr. Brewer:

SWCA, Incorporated, dba **SWCA Environmental Consultants (SWCA)**, appreciates the opportunity to submit our contract amendment to provide additional environmental services for the City of Coalinga Trails Master Plan Segments 3, 4, and 9 (project). SWCA has prepared this memorandum to summarize the differences between the original scope and budget submitted in May 2020 and the revised scope and budget which include additional tasks requested by the California Department of Transportation (Caltrans) in their Preliminary Environmental Study form and letter dated October 23, 2020.

SWCA's original proposal, dated May 29th, 2020, included a budget totaling $74,810 (copies of the original proposal and corresponding 10-H form have been provided). Revisions to this original proposal have been made by SWCA to include preparation of a Jurisdictional Delineation and a Biological Assessment, if determined necessary following the fieldwork conducted during preparation of the Natural Environment Study – Minimal Impacts (NES-MI). The scope associated with these tasks is included on the following pages of this memorandum. With these additional tasks included, our budget increased by $16,977, totaling $91,787, to account for the additional field work and technical studies.

During the process of revising our cost estimate for the City to include the additional tasks requested by Caltrans, SWCA accounting staff were tasked with preparation of the 10-H form (which includes raw wages for personnel). Due to SWCA's internal policy to keep raw wages confidential from SWCA project-level staff, the budget was sent directly from SWCA accounting staff to the City without additional internal review. What resulted from this process was an error where our accounting staff did not include costs for all of the labor categories that were listed. Specifically, our accounting staff failed to populate hourly rates for labor categories where the names of project personnel we identified with "TBD". While this is common practice to include "TBD" for labor categories, our accounting staff should have included the corresponding rates. This error by our accounting staff resulted in the total revised budget value and executed contract value being $61,729.27, which is approximately $30,058 less than what our revised budget should have been ($91,787).

Our accounting staff have made the necessary corrections and prepared the updated 10-H form that we have submitted to the City. Specific changes include the incorporation of 8 labor hours by the Environmental Specialist VII labor category and the incorporation of raw wages for all previously missing labor categories. These changes results in an increase of Subtotal Direct Labor Costs from $20,985.32 to $27,891.80. SWCA also included a correction to Other Direct Costs, which have been corrected to accurately match the specified costs in the proposed budget. The revised 10-H reflects a total of $84,412.77. The difference between our budget total of $91,787 and the 10-H total of

$84,412.77 is due to our budget using standard rates and the 10-H using built-up rates. Therefore, we are requesting a contract amendment in the amount of $22,683.50, to account for the difference between our executed contract amount ($61,729.27) and our revised 10-H total ($84,412.77). We are grateful the City is willing to take these revisions into consideration.

If you have any questions regarding this memorandum, please feel free to contact SWCA Project Manager and Primary Contact Jacqueline Markley at (916) 234-5522, or jacqueline.markley@swca.com.

Sincerely,

Jacqueline Markley

Jacqueline Markley, AICP
Project Manager / Environmental Planner

Bill Henry, AICP
Director

SCOPE OF SERVICES

The following scope of services identifies the additional tasks SWCA will complete in response to Caltrans recommendations included in the PES and corresponding letter dated October 23, 2020. SWCA anticipates the need for the following additional technical studies will be determined depending on the results of the fieldwork conducted during preparation of the NES-MI (Task 3.1 in SWCA's original proposal submitted in May 2020).

Task 1: Jurisdictional Delineation Report

Due to the proximity to potentially jurisdictional drainages and surface water resources, preparation of a Jurisdictional Delineation Report (JDR) may be necessary. During the field survey conducted for the NES-MI (Task 3.1), an SWCA biologist will survey and assess the proposed work areas for wetland and other surface water resources to determine the need to prepare a JDR. If resources are identified within or in close proximity to proposed work areas, the SWCA biologist will collect all necessary field data during the same survey effort. SWCA will prepare a JDR to be included as an appendix to the NES-MI. The JDR will include a delineation of potential federal jurisdictional Waters of the United States (i.e., wetland and other waters) and Waters of the State (i.e., State wetlands and non-wetland Waters of the State). The JDR will be prepared following the standards of the 1987 *Corps of Engineers Wetlands Delineation Manual*, the 2008 *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0)*, the 2008 *A Field Guide to the Identification of the Ordinary High Water Mark (OHWM) in the Arid West Region of the Western United States: A Delineation Manual*, and the new *State Wetland Definition and Procedures for Discharges of Dredged or Fill Material to Waters of the State*, which came into effect in 2020.

Task 2: Biological Assessment

If, during preparation of the NES-MI, SWCA determines the project has the potential to result in adverse effects to a federally listed species or critical habitat that necessitate mitigation, preparation of a Biological Assessment will be required. A BA shall be prepared to evaluate the potential impacts to species that are listed as threatened, endangered, or candidate species under the Federal Endangered Species Act (FESA). The BA shall be prepared in accordance with the legal requirement founds in Section 7(a)(2) of the FESA (16 United States Code 1536(c). The BA shall follow the latest template in the Caltrans SER.

ANTICIPATED BUDGET

SWCA has prepared our budget based on our approach to the project, identified key assumptions, consultation with our technical experts, and our experience with similar projects. SWCA's 10-H and 10-K forms are included as separate documents that have been submitted to the City.

Table 1. Cost Estimate

TASK	ESTIMATED COST
Task 1: Jurisdictional Delineation Report	$9,358
Task 2: Biological Assessment	$7,619
Contract Amendment Total	**$16,977**
PROJECT TOTAL (NOT INCLUDING ADDITIONAL TASKS)	**$74,810**
PROJECT TOTAL (INCLUDING ADDITIONAL TASKS)	**$91,787**
CURRENT EXECUTED CONTRACT TOTAL (INCORRECT)	**$61,729.27**
CORRECTED 10-H TOTAL (BASED ON RAW BUILT-UP RATES)	**$84,412.77**

ASSUMPTIONS

For budgeting purposes, we are making the following assumptions because some of these items are beyond SWCA's control and because these factors could significantly affect project schedule and cost:

1. SWCA assumes all copies of report submittals will be electronic.
2. SWCA assumes presence at in-person meetings will not be necessary for this project.
3. SWCA assumes the City will provide all background materials, including any partial design plans and requested information, prior to SWCA commencing field work or preparation of technical studies.
4. SWCA assumes two rounds of review by the City and/or Caltrans for each deliverable.

AGREEMENT FOR PROFESSIONAL SERVICES FOR THE CITY OF COALINGA TRAILS MASTER PLAN SEGMENTS 3, 4, AND 9 ENVIRONMENTAL SERVICES (NEPA/CEQA)

This Agreement for Professional Services ("Agreement") is made and entered into this __6th____ day of __August 2020_______, by and between the City of Coalinga, a Municipal Corporation ("City"), and SWCA, Incorporated, dba SWCA Environmental Consultants ("Provider").

RECITALS

A. Provider represents to City that they are specially trained, experienced, licensed and competent to perform the services which will be required by this Agreement; and

B. Provider represents to City that they possess the skill, experience, ability, background, certification and knowledge to provide the services described in this Agreement on the terms and conditions described herein.

C. City desires to retain Provider to render the services as set forth in this Agreement, as Exhibit 1.

NOW THEREFORE, in consideration of the mutual covenants set forth herein for such other good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, the parties hereto agree as follows:

1. **Retention of Provider**. Subject to the terms and conditions set forth herein, City retains Provider to perform the services identified in this Agreement, as an independent contractor and Provider hereby accepts this independent contractor appointment.

2. **Scope of Services**. The Provider shall perform professional services, in accordance with all the provisions of this Agreement. The Scope of Work is attached hereto as Exhibit 1. Provider shall correct any and all errors and/or omissions, which arise out of Provider's negligence or intentional misconduct, in the performance of the Services and any documents resulting therefrom even though City has accepted said Services or documents. Provider shall make such corrections upon City's request and at no cost or expense to City.

3. **Time of Performance**. This agreement shall remain in effect until May 1, 2021. Contract time of completion for individual projects will be agreed upon before assignment of each project to Provider. Services designated in the scope of work shall be completed on agreed date unless prior written approval for a time extension has been granted by Sean Brewer, Assistant City Manager.

4. **Compensation**. Compensation to be paid to Provider shall be no more than $61,729.27 in accordance with scope of work and budget located in Exhibit 1.

5. **Method of Payment**. Provider shall submit monthly billings to City describing the work performed during the preceding month. Provider's bills shall include a brief description of the Services performed and the date the Services were performed the number of hours spent and by

whom, and a description of any reimbursable expenditures. City shall pay Provider no later than 30 days after the date of submittal of a complete invoice for completed tasks and approval of the invoice by City staff.

6. **Extra Work.** At any time during the term of this Agreement, City may request that Provider perform Extra Work. As used herein, "Extra Work" means any work which is determined by City to be necessary for the proper completion of the Services, but which the parties did not include in the Scope of Work. Extra work will be performed on an hourly basis under the Provider's most current hourly fee schedule. Provider shall not perform, nor be compensated for Extra Work without written authorization from City.

7. **Termination**. This Agreement may be terminated by the City immediately and without notice for cause or by City without cause upon ten (10) days' written notice of termination to Provider. Upon termination, Provider shall be entitled to compensation for Services performed up to the effective date of termination, unless this Agreement is terminated for cause, in which case, City may withhold compensation due Provider in order to reimburse City for any losses, damages or expenses caused by Provider's default under this Agreement.

8. **Equal Opportunity Employment**. Provider represents that it is an equal opportunity employer and it shall not discriminate against any sub provider, employee or applicant for employment because of race, religion, color, national origin, handicap, ancestry, sex or age. Such non-discrimination shall include, but not be limited to, all activities related to initial employment, upgrading, demotion, transfer, recruitment or recruitment advertising, layoff or termination. Provider shall also comply with all relevant provisions of City's programs or guidelines currently in effect as identified and provided to Provider by City.

9. **Insurance Requirements**.

a. Provider, at Provider's own cost and expense, shall procure and maintain, for the duration of this Agreement, the following insurance policies.

i. Workers Compensation Coverage. As required by the State of California, with Statutory Limits, and Employer's Liability Insurance with a limit of no less than ONE MILLION AND NO/100 DOLLARS ($1,000,000) per accident for bodily injury or disease.

ii. General Liability Coverage. Insurance Services Office (ISO) Form CG 0001, including products and completed operations, with limits of no less than ONE MILLION AND NO/100 DOLLARS ($1,000,000) per occurrence for bodily injury, personal injury, and property damage. If a general aggregate limit applies, either the general aggregate limit shall apply separately to this project/location or the general aggregate limit shall be TWO MILLION AND NO/100 DOLLARS ($2,000,000), twice the required occurrence limit.

iii. Automobile Liability Coverage. ISO Form Number CA 0001 covering any auto (Code 1), with a limit no less than ONE MILLION AND NO/100 DOLLARS ($1,000,000) per accident for bodily injury and property damage.

iv. Professional Liability Coverage. Contractor will maintain Professional Liability coverage with limits no less than ONE MILLION AND NO/100 DOLLARS

($1,000,000) per occurrence or claim, and TWO MILLION AND NO/100 DOLLARS ($2,000,000) policy aggregate.

If Provider maintains higher limits than the minimums shown above, the City requires and shall be entitled to coverage for the higher limits maintained by Provider.

Provider's insurance policies shall be "occurrence" policies and not "claims-made" coverage except for Professional Liability Coverage.

Provider may maintain an Umbrella policy in conjunction with the insurance policies referenced above. In such case, Provider shall be deemed to have satisfied the insurance requirements of this contract as long as: (i) the coverage limits of the Umbrella policy and of the underlying liability policy(ies), when combined, satisfy each of the per occurrence and aggregate requirements identified in this subsection a.; and (ii) coverage under the Umbrella policy is as broad as and includes all incidents and events covered by the underlying insurance that it supplements.

Any deductibles or self-insured retentions must be declared to and approved by the City. The City may require Provider to purchase coverage with a lower deductible or retention or provide proof of ability to pay losses and related investigations, claim administration, and defense expenses within the retention. Alternatively, the City may require Provider to provide a financial guarantee satisfactory to the City guaranteeing payment of losses and related investigations, claim administration, and defense expenses within the retention.

The policies are to contain, or be endorsed to contain, the following provisions:

i. The City and its officers, officials, employees, and volunteers are to be covered as additional insureds on the CGL and automobile liability policies with respect to liability arising out of work or operations performed by or on behalf of Provider including materials, parts, or equipment furnished in connection with such work or operations; products used by Provider; or automobiles owned, leased, hired or borrowed by Provider. General liability coverage can be provided in the form of an endorsement to Provider's insurance at least as broad as ISO Form CG 20 10 11 85 or if not available, through the addition of both CG 20 10 and CG 20 37 if a later edition is used. The coverage shall contain no special limitations on the scope of protection afforded to the City, its officers, officials, employees or volunteers.

ii. For any claims related to this contract, Provider's insurance coverage shall be primary insurance as respects the City and its officers, officials, employees, and volunteers. Any insurance or self-insurance maintained by the City and/or its officers, officials, employees, or volunteers shall be in excess of Provider's insurance and shall be non-contributory.

iii. Each insurance policy required above shall provide that coverage shall not be canceled, except with notice to the City.

Insurance is to be placed with insurers with a current A.M. Best's rating of no less than A:VII.

Provider shall furnish the City with original 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 City before work commences. However, failure to obtain the required documents prior to the work beginning shall not waive the Provider's obligation to provide them. The City reserves the right to require complete, certified copies of all required insurance policies, including endorsements required by these specifications, at any time.

Provider hereby grants to City and its officers, officials, employees, and volunteers a waiver of any right to subrogation which any insurer of Provider may acquire against the City and/or its officers, officials, employees, and volunteers by virtue of the payment of any loss under such insurance. Provider agrees to obtain endorsements necessary to effect this waiver of subrogation, but this provision applies regardless of whether or not the City has received a waiver of subrogation endorsement from the insurer.

The City reserves the right to modify the insurance requirements contained in this contract, including, without limitation, coverage limits, based on the nature of the risk, prior experience, insurer, coverage, or other special circumstances.

10. **Indemnification**. To the fullest extent allowable by law, Provider agrees to indemnify, defend and hold harmless the City and its officials, officers, employees, agents and volunteers from and against all claims, demands, actions, injuries, liabilities, losses, costs or damages, direct or indirect, and any and all attorneys' fees and other expenses which City or its officials, officers, employees, agents or volunteers may sustain or incur as a consequence of or are in any way related to Provider's or its owners, directors, officers, managers, employees, agents and subcontractor's willful or negligent acts or omissions in the performance of the services and Providers responsibilities and obligations to be performed under this agreement or its failure to perform or comply with any of its obligations or responsibilities contained in this agreement; excluding, however, such liability, claims, losses, damages or expenses arising from City's sole or active negligence or willful acts. This duty to indemnify, defend, and hold harmless shall survive the termination of this agreement. If Provider maintains additional coverage or higher limits than those required herein, then City shall be entitled to additional coverage or higher limits maintained by Provider.

11. **Independent Contractor Status**. It is understood and agreed that Provider, in the performance of the Services to be performed pursuant to this Agreement, shall act as and be an independent contractor and shall not act as an agent or employee of City. Provider shall obtain no retirement benefits or other benefits which accrue to City's employees and Provider hereby expressly waives any claim it may have to any such rights. Nothing in this Agreement shall create or be construed as creating a partnership, joint venture or any other relationship between City and Provider.

12. **Provider's Books and Records**.

a. Provider shall maintain any and all ledgers, books of account, invoices, vouchers, canceled checks, and other records or documents evidencing or relating to charges for services, or expenditures and disbursements charged to City for a minimum period of three (3) years, or for any longer period required by law, from the date of final payment to Provider under this Agreement.

b. Provider shall maintain all documents and records that demonstrate performance under this Agreement for a minimum period of three (3) years, or for any longer period required by law, from the date of termination or completion of this Agreement.

c. Any records or documents required to be maintained pursuant to this Agreement shall be made available for inspection or audit, at any time during regular business hours, upon written request by the City. Copies of such documents shall be provided to the City for inspection at the City offices.

d. Where City has reason to believe that such records or documents may be lost or discarded due to dissolution, disbandment or termination of Provider's business, City may, by written request, require that custody of the records be given to the City and that the records and documents be maintained in the City offices. Access to such records and documents shall be granted to any party authorized by Provider, Provider's representatives, or Provider's successor-in-interest.

13. **Professional Ability of Provider**. City has relied upon Provider's representations regarding its training and professional ability to perform the Services hereunder as a material inducement to enter into this Agreement. Provider shall therefore provide properly skilled personnel to perform all Services under this Agreement. The primary provider of the Services called for by this Agreement shall be [NAME] who shall not be replaced without the written consent of the City. All work performed by Provider under this Agreement shall be in accordance with the applicable professional standard of care and shall meet the local professional standard of quality ordinarily to be expected of competent persons in Provider's field of expertise working in Tulare County.

14. **Compliance with Laws**. Provider shall use the proper standard of care in performing the Services and shall comply with all applicable federal, state and local laws, codes, ordinances and regulations in effect at the time the Agreement is executed. In addition, if the request for proposal to provide professional services which are the subject of this Agreement cited any federal or state financial assistance involved in the project for which the Services are provided, the Provider shall perform all services in accordance with all applicable federal and state laws, rates and regulations in effect at the time the agreement is executed.

15. **Licenses**. Provider represents and warrants to City that it has all licenses, permits, qualifications, and insurance which are legally required of Provider to lawfully and competently perform the Services. Provider represents and warrants to City that Provider shall, at its sole cost and expense, keep in effect or obtain at all times during the term of this Agreement, any licenses, permits, and insurance which are legally required of Provider to lawfully and competently perform the Services. Provider shall maintain a City of Tulare business license.

16. **Assignment and Subcontracting**. The parties recognize that a substantial inducement to City for entering into this Agreement is the reputation, experience and competence of Provider. Assignments of any or all rights, duties or obligations of the Provider under this Agreement will be permitted only with the express written consent of the City, which will not be unreasonably withheld. Provider shall not subcontract any portion of the Services to be performed under this Agreement, except for AMBIENT Air Quality & Noise Consulting, LLC, and Haro Environmental, Incorporated, without the express written consent of the City, which will not be unreasonably withheld. If City consents to such subcontract, Provider shall be fully responsible to City for all acts

or omissions of the subcontractor. Nothing in this Agreement shall: (1) create any contractual relationship between City and sub Provider; (ii) create any obligation on the part of the City to pay or to see to the payment of any monies due to any such subcontractor; (iii) or relieve Provider of any of its obligations and responsibilities under this Agreement.

17. **Attorneys' Fees**. If an action at law or in equity is necessary to enforce or interpret the terms of this Agreement, the prevailing party shall be entitled to reasonable attorneys' fees, costs and necessary disbursements in addition to any other reasonable relief to which he may be entitled. With respect to any suit, action or proceeding arising out of or related to this Agreement, or the documentation related hereto, the parties hereby submit to the jurisdiction and venue of the Superior Court for the County of Fresno, State of California for any proceeding arising hereunder.

18. **Sole and Only Agreement**. This Agreement supersedes any and all other agreements, either oral or in writing, between the parties hereto with respect to the matters set forth herein and contains all of the covenants and agreements between the parties regarding said matters. Each party to this Agreement acknowledges that no representations, inducements, promises or agreements, orally or in writing, have been made by any party or anyone acting on behalf of any party which are not embodied in this Agreement and no other agreement, statement or promise shall be valid or binding.

19. **Invalidity**. If any provision of this Agreement is held by a court of competent jurisdiction to be invalid, void or unenforceable, the remaining provisions shall nevertheless continue in full force and effect without being impaired or invalidated in any way.

20. **Amendment**. No change, amendment or modification of this Agreement shall be valid unless the same be in writing and signed by the parties hereto.

21. **Governing Law**. This Agreement shall be construed and governed pursuant to the laws of the State of California. Any action to enforce this Agreement is to be brought in Tulare County, California.

22. **Waiver**. Waiver of a breach or default under this Agreement shall not constitute a continuing waiver of a subsequent breach of the same or any other provision under this Agreement.

23. **Mediation**. The parties agree to make a good faith attempt to resolve any disputes arising out of this Agreement through mediation prior to commencing litigation. The parties shall mutually agree upon the mediator and shall divide the costs of mediation equally. If the parties are unable to agree upon a mediator, the dispute shall be submitted to JAMS/ENDISPUTE ("JAMS") or its successor in interest. JAMS shall provide the parties with the names of five qualified mediators. Each party shall have the option to strike two of the five mediators selected by JAMS and thereafter the mediator remaining shall hear the dispute. If the dispute remains unresolved after mediation, either party may commence litigation.

24. **Authority to Enter Agreement**. Provider has all requisite power and authority to conduct its business and to execute, deliver and perform the Agreement. Each party warrants that the individuals who have signed this Agreement have the legal power, right, and authority to make this Agreement and to bind each respective party.

25. **Notice**. Except as otherwise expressly provided herein, any notice, consent, authorization or other communication to be given hereunder shall be in writing and shall be deemed duly given and received when delivered personally, when transmitted by facsimile or e-mail if receipt is acknowledged by the addressee, one business day after being deposited for next-day delivery with a nationally recognized overnight delivery service, or three business days after being mailed by first class mail, charges and postage prepaid, property addressed to the party to receive such notice at the last address furnished for such purpose by the party to whom notice is directed and addressed as follows:

CITY:

City of Coalinga
155 West Durian
Coalinga, California 93210

PROVIDER:

SWCA Environmental Consultants
1422 Monterey Street, C200
San Luis Obispo, CA 93402

IN WITNESS WHEREOF, the parties have executed this Agreement effective on the day and in the year first set forth above.

CITY OF COALINGA, a Municipal Corporation

By:____________________
Marissa Trejo, City Manager

PROVIDER

By:____________________
Bill Henry, Director

APPROVED AS TO CONTENT:

____
Sean Brewer
Assistant City Manager

ATTEST:

____
City Clerk/Deputy City Clerk

Exhibit 1
Scope of Work & Fee Schedule

FIRST AMENDMENT TO THE

PROFESSIONAL SERVICES AGREEMENT

This First Amendment ("Amendment") to the Professional Services Agreement is made and entered into this ______ day of September 2021 by and between the City of Coalinga ("City"), and SWCA, Incorporated, dba SWCA Environmental Consultants ("Provider").

WHEREAS on August 6, 2020 the City and Provider entered into a Professional Services Agreement ("Agreement") to provide environmental services to the City of Coalinga for trail segments 3, 4, and 9 of the City's trails master plan;

WHEREAS, Provider submitted a contract amendment to provide additional environmental services for the City of Coalinga Trails Master Plan Segments 3, 4, and 9 which included additional tasks requested by the California Department of Transportation (Caltrans) in their Preliminary Environmental Study form and letter dated October 23, 2020; and

WHEREAS, the revisions to the original agreement have been made by SWCA to include preparation of a Jurisdictional Delineation and a Biological Assessment, if determined necessary following the fieldwork conducted during preparation of the Natural Environment Study – Minimal Impacts (NES-MI); and

WHEREAS, Provider is requesting an additional $22,683.50 that represents the additional scope of work as well as revisions to various accounting errors identified in the memo dated September 3, 2021; and

THEREFORE, the parties agree to the following modifications of the Agreement:

1. The total contract amount under **Section 4. Compensation**. shall be amended to $84,412.77.

2. All other terms and conditions of the original Agreement shall remain unchanged and continues to be in effect.

City:

Dated: ____________________

____

Marissa Trejo, City Manager of the City of Coalinga

Provider:

Dated: September 8, 2021

____

Bill Henry, Director of SWCA

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Adopt Airport Hangar Inspection Policy for New Coalinga Municipal Airport
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Mercedes Garcia, Senior Administrative Analyst

I. RECOMMENDATION:

The Senior Administrative Analyst and the City Manager recommend the City Council approve the Hangar Inspection Policy for the New Coalinga Municipal Airport.

II. BACKGROUND:

The Federal Aviation Administration (FAA) Airport Compliance Policy requires that the FAA discharge its responsibility for ensuring that airport sponsors comply with their federal obligations through the FAA's Airport Compliance Program. The City of Coalinga accepts these obligations when receiving federal grant funds or when accepting the transfer of federal property for airport purposes.

New Coalinga Municipal Airport does not have a hangar inspection policy in place and should to ensure hangar facilities are being used for aviation-related purposes as defined by the FAA.

III. DISCUSSION:

Over the past several years, there have been issues at airports throughout the country that have resulted in the FAA publishing a policy clarifying what is considered aeronautical use of hangars. The policy went into effect on July 1, 2017.

In May, 2021, the FAA provided recommendations based on a complaint hangars were being used for non-aeronautical purposes. The complaint resulted in the FAA recommending the implementation of a Hangar Inspection Policy. This program will allow the City to ensure hangars are being used for aeronautical purposes and also to ensure compliance with City fire, safety and building codes.

Staff pulled from other general aviation policies for hangar use and the FAA Airport Compliance Manual-Order 5190.6B, the Hangar Inspection Policy presented was produced to ensure hangars are compliant with aeronautical purposes.

Hangar inspections will begin approximately 60 days from the date of approval of the Hangar Use and Inspection Policy and occur annually thereafter, unless there is evidence of suspected misuse, in which case an additional inspection may be required.

IV. ALTERNATIVES:

Do not approve the Airport Hangar Inspection Policy.

V. FISCAL IMPACT:

None

ATTACHMENTS:

File Name	Description
HANGAR_USE_AND_INSPECTION_POLICY_9-21.docx	New Coalinga Municipal Airport Hangar Use and Inspection Policy
HANGAR_INSP_FORM.doc	New Coalinga Municipal Airport Hangar Inspection Checklist

HANGAR USE AND INSPECTION POLICY

Purpose:

To ensure that all hanger facilities are being used for aeronautical purposes or aviation related purposes as defined by the City of Coalinga and the Federal Aviation Administration (FAA); to ensure that all hangar storage facilities are functionally safe and in accordance with applicable fire codes; and to remain in compliance with FAA grant assurances that require hangar facilities to be used for aeronautical or aviation-related purposes.

General: The following provisions are adopted to implement the FAA'S "Policy on the Non-Aeronautical Lessee of Airport Hangars" published in the Federal Register/ Vol. 81, No. 115/ Wednesday, June 15, 2016/ Pages 38906-38911 (Exhibit A), which took effect July 1, 2017, and any subsequent amendments, along with all laws, ordinances, rules, regulations, requirements and orders of national, state, county, or city government:

1. Aircraft storage hangars at the New Coalinga Municipal Airport are to be used and occupied for an aeronautical use.
2. 2- As provided for in the FAA Policy, non-aeronautical items are also permitted in a hangar so long as they do not interfere with the aeronautical use of the hangar

Aeronautical Use: The leased premises shall only be used by the LESSET for aeronautical purposes permitted by the Federal Aviation Administration's (FAA) Hangar Lessee Policy, which may be updated from time to time- These uses include:

- Storing active aircraft; .
- Maintenance, repair, or refurbishment of aircraft, but not indefinite storing of non-operation aircraft:.
- Constructing amateur-built or kit built aircraft provided that activities are conducted safely; .
- Storing aircraft handling equipment, tow bar, glider tow equipment, workbenches, and tools and materials used to service, maintain, repair or outfit aircraft items related to ancillary or incidental uses that do not affect the hangars primary use;
- Storing materials related to an aeronautical activity, balloon and skydiving equipment, office equipment, teaching tools, and materials related to, ancillary, or incidental uses that do not affect the hangars ‘primary use.
- Storing non-aeronautical items that do not interfere with the primary aeronautical purpose of the hangar/ televisions and furniture; or .
- Parking a vehicle at the hangar while the aircraft usually stored in that hangar is flying subject to local airport rules and regulations,

The hangar must be properly insured as outlined in the LESSEE’S agreement.

If the hanger or any part thereof is subleased, proper documentation and approval, including insurance documentation, of such sublease must be on file with the City as outlined in the LESSEE’S agreement.

LESSEE shall comply with all applicable Fire and Safety Codes as well as City of Coalinga Building Codes. Unpermitted alterations subject to the Building Codes are prohibited and must be removed or inspected by a City of Coalinga Building Inspector, and a permit issued, stipulating that all building alterations meet the current standard.

LESSEE shall not construct any improvements or make alterations of any kind (whether permanent or otherwise) on the leased premises without prior written consent of the Airport Manager or designated representative. Additionally, all federal, state, and local building regulations must be complied with for any improvement or alteration to buildings or structures on the premises.

LESSEE shall provide maintenance, repair and upkeep on any structures situated on the leased premises and maintain grounds around the structures in a good, clean, sanitary and safe condition. More specifically, the lessee shall not store items outside of the hangar. The leased premises shall not be used for residential purposes.

LESSEE allow the leased premises or any structure or hangar thereon to be used for living or residential purposes. The determination of whether someone is living or residing on the leased premises or structure shall be made by the City at its sole and absolute discretion.

Consent to Entry

LESSEES of hangars and other facilities at the New Coalinga Municipal Airport have consented to inspections in writing, under the following language (or similar) in their lease agreements: "LESSOR (City) shall have the right to enter upon the leased premises at all reasonable times to inspect the premises and LESSEE's operations thereon."

Inspections

Hangar inspections will be conducted annually, unless there is evidence of suspected misuse, in which case an additional inspection may be required.

Notification of the inspection will be mailed to the Lessee at least thirty (30) days prior to the inspection to allow for any arrangements to be made for entry. A representative of the Lessee may be present in the event the Lessee is unavailable.

Inspectors may consist of the Airport Manager, Code Enforcement Officer, Building Inspector and Fire Department Inspector or their designated representatives.

Compliance letters will be mailed to the LESSEE within fourteen (14) days of the hangar inspection. Any areas of non-compliance shall be corrected within thirty (30) days of the date of the letter.

In the event the LESSEE shall fail, neglect, or refuse to complete the repair or maintenance work required to correct any violations of this policy within thirty (30) days after receipt of a written notice service by the City, or in the event that the LESSEE fails, neglects or refuses to pursue said repair or maintenance work with reasonable diligence to completion, the City shall charge the

LESSEE the fair market value (FMV) rate for non-aeronautical use of the hangar until such repair or maintenance work is completed. The City may, at its sole discretion, perform or cause to be performed such repair or maintenance work and add the cost thereof to the installments of rent due for the Lease as a charge to the LESSEE. If such repair is determined by the LESSEE to be economically unfeasible, either party shall have the option of terminating the agreement, and at LESSEE'S cost, return the leased property to its original condition. Payment for the non-aeronautical rate for the hanger shall in no way reduce, restrict, or otherwise eliminate any federal, state, county, or city recourse to address any violation discovered

Appeal Process

Any hangar tenant may appeal a notice of violation or notice of cost recovery, subject to filing an appeal within ten days of issuance, in writing to the City Manager.

CITY OF COALINGA *The Sunnyside of the Valley*	New Coalinga Municipal Airport Hangar Inspection Checklist 27500 Phelps Avenue Coalinga, CA 93210

Date of Inspection: ___________________________________

Tenant Information:

Name: ____ Hangar# ____________

Address: ____

Primary Phone: ___________________ Emergency Phone: _______________________

Email Address: ____

Registered Aircraft on Lease: _________________ Aircraft in Hangar: ______________

Introduction:	The City of Coalinga Redevelopment Agency must conduct an annual inspection of the Coalinga Waste Management Unit as described above. The following report shall be completed in order to certify that the property is being used in manner consistent with the Land Use Covenant.

Permitted Use:

1.	Storing active aircraft; sheltering aircraft for maintenance, repair or refurbishment, but not indefinitely storing non-operational aircraft. There shall be room for the aircraft in the aircraft hangar for the based aircraft at all times, even when the aircraft is temporarily not located in the hangar. Note: Storage of model, radio-controlled aircraft is not a permitted use.	
2.	Storing aircraft handling equipment, e.g., tow bar, glider tow equipment, prefabricated metal shelving, workbenches, and cabinets and tools and material used to service, maintain, repair or outfit aircraft; items related to ancillary or incidental uses that do not affect the hangar's primary use.	
3.	Storing material related to an aeronautical activity, e.g., balloon and skydiving equipment, office equipment, teaching tools, and materials related to ancillary or incidental uses that do no affect the hangars' primary use.	
4.	A reasonable amount of functional furniture only for use in the hangar such as a table and chairs.	
5.	Spare aircraft tires, batteries, and trickle type battery charges with an automatic shutoff stored and maintained in accordance with fire and City codes.	
6.	Oily rags, oil waste, rags and other waste may only be stored in hangars in metal containers with self-closing, tight fitting lids.	
7.	Passenger vehicles shall only be stored in the hangar temporarily while the based aircraft is being flown.	
8.	Non-aeronautical items permitted to be stored in the hangar if occupying an insignificant amount of space and their function.	

<u>Safety Inspection</u>:

1.	Adequate and readily accessible fire extinguisher(s) with evidence of a current inspection.	
2.	No excessive use of extension cords, appliances, outlets, etc.	
3.	Storing material related to an aeronautical activity, e.g., balloon and skydiving equipment, office equipment, teaching tools, and materials related to ancillary or incidental uses that do no affect the hangars' primary use.	
4.	A reasonable amount of functional furniture only for use in the hangar such as a table and chairs.	
5.	Spare aircraft tires, batteries, and trickle type battery charges with an automatic shutoff stored and maintained in accordance with fire and City codes.	

Comments:

____

____

____

Tenant Signature

____

City of Coalinga Staff Signature

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Public Works, Utilities & Community Development Monthly Report for August 2021
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

Public Works, Utilities and Community Development Monthly Report for August 2021.

II. BACKGROUND:

III. DISCUSSION:

IV. ALTERNATIVES:

V. FISCAL IMPACT:

ATTACHMENTS:

File Name	Description
Monthly_Report_August_2021.pdf	Monthly Report for August 2021

CITY OF COALINGA
The Sunny Side of the Valley

PUBLIC WORKS, UTILITIES AND COMMUNITY DEVELOPMENT MONTHLY REPORT FOR AUGUST 2021

***Note: New items and updates from last month's report are in bold print.**

PUBLIC WORKS

NATURAL GAS DISTRIBUTION:

- Cathodic protection inspections and repairs on gas meters- Continued
- Routes 32,41,42,43
- Replaced 6 gas meters
- Repaired gas leak Van Ness and Lincoln
- **Relocated gas meter 341 Tyler**

WATER DISTRIBUTION:

- Repaired water leak 665 Van Ness
- Repaired water leak in Alley of 147 W. Elm
- Repaired water leak 400 Glenn St.
- Repaired water leak Calaveras/Phelps
- Helped with water leak repair Coalinga Reginal Medical
- Repaired water leak 6" main Sunset
- Repaired water leak 1001 Folsom St.
- Repaired Backflow unit Monterey
- **Repaired Hydrant that was hit on Warthan/ E. Polk.**
- **Installed new water service for 39230 S. Calaveras**
- **Repaired water leak on Alpine Rd.**
- **Installed new 1 ½ meter Caballo Club**
- **Installed 4 new water meters**

WASTEWATER COLLECTION:

- Sewer blockage cleared 500blk Sunset
- Sewer blockage cleared Durian/Elm alley at 3rd St.
- Cleaned Sewer lines (Aera 1)
- Cleaned out Lift Stations
- Repaired La Cuesta Lift Station
- **Cleared sewer line 6th to 3rd Elm/Durian alley**
- **Installed Solar light Jayne Lift Station**
- **Cleared sewer lines E. Pleasant & E. Houston**

SIDEWALKS:

- Nothing to report.

PARKS:

- Aerated both parks
- **Removed Dead tree Frame Park**
- **Repaired broken Sprinklers**

MISCELLANEOUS:

- Removed 2 dead trees on City Plots
- Removed one tree at 455 Madison St. for ATP3
- Trimmed 13 trees
- Red curb painting completed Aera 2 and Aera 4 (Street Sweeping routes)
- Constructed Concrete barricades around west of Warthen Creek gate
- Camera was used to inspect storm drain 4th St.
- Finished Aera 2&3 Fire Hydrant painting
- Put up and took down School banners rotated out weekly
- Repaired irrigation leaks for city plots
- Employee Training room remodel complete
- **Repaired section of road on 4th Street due to collapsed storm drain.**
- **Repaired crosswalk sign Elm & Walnut**
- **Repaired Alley Patch behind 198 W. Forest**
- **Cleaned up Alleys in Prep for Alley Paving project**
- **Removed two trees for ATP3 project**
- **Started trimming trees for School bus routes and Cape Seal Project**

WATER TREATMENR PLANT (WTP)

- City wide flushing will schedule when needed.
- Derrick by-pass valve quotes for 10" PRV and 10" WV. In progress working with Cla-Val & MRC Global. **The 10" PRV valves and the 10" WV have been ordered.**
- Frisch Eng. & Lighthouse working with them on Derrick by-pass and HWY 198 getting signal to SCADA from PRV. **In progress should have quotes by mid-September working on communication signal.**
- Hach equipment quarterly maintenance was done June 30. Next quarterly schedule for October.
- SCADA System – Light House has submitted the submittals for the SCADA hardware & PLC panels to Frisch Eng. **Have received 90% of hardware and panels.**
- Westland Water – Flow meter was installed. Waiting for Westland to install new electrical wiring for meter. Hardware equipment delayed. **New wiring for flow meter was installed by Westland. Waiting on new SCADA system to tie into flow meter.**
- Jennings Consulting Group working on scope of work and cost for ERP. **In progress**
- MKN working on scope of work and cost for updating Emergency Chlorine Disinfection Plan and Watershed Sanitary Survey. We are working with MKN and getting them some information for this project. In Progress. **ECDP is about 90% Complete looking over draft report.**
- Westland Canal Aquatic weed control and WTP shut down was done on May20th. Next schedule treatment is set for June 24th. June & July treatments are complete. Next treatment schedule for August 25th. **Westland did their last Algae treatment for the year.**
- MKN working on scope of work and cost to update Risk and Resilience Plan. We are working with MKN and getting them some information for this project. In progress and did canal site visit

from PVPS – Coalinga WTP. **Risk and Resilience Plan has been completed and filed certification with the EPA.**

- **North moss screen taken out of service. Gear drive taken in for repairs.**
- **Caltrol installed 5 new Limitorq actuators for the filter backwash system.**
- **14" Cla-Val was repaired on P16.**
- **Alum motor #1 was out of service. Installed new motor and Alum pump #1 back in service.**
- **Hypo tank hose was repaired with new hose and fittings.**
- **Hypo pump motor #2 out of service. Ordering new motor.**

WASTEWATER TREATMENT PLANT (WWTP)

- City crew working on getting pond 3 cattails, and small trees. **Ongoing.**
- Control room equipment up grade. **In progress**
- Tri City is working on updating WWTP site areas for discharging effluent water permit. **In progress.**
- Advance Flowline is looking at replacement cost for the Bar Screen Air Actuator. In Progress get quotes.
- SCI working on scum pump. SCI will order one. 12 weeks out for delivery sometime in September.
- **Radio field working on quotes to removed 1' topsoil for drainage. In progress.**
- Ponds 2 & 3 vault getting quotes for new lid cover for safety and security purposes.
- Wastewater vault boxes at old school farm getting quotes for new lid covers for safety and security purposes.
- Control building getting quotes for security screens for windows. **Security screen have been installed.**

ASSISTANT CITY MANAGER

PUBLIC WORKS/UTILITIES

- **Street Light Acquisition**: Tanko has completed the audit process and coordinating effort to acquire the streetlights. We are currently at the point where we have informed PGE and we are interested in purchasing the street lights.
- **TTHM**: Plans and specs and have been finalized and staff is anticipating requesting authorization to bid the project in the Fall 2021 once funding has been finalized.
- **SCADA:** Currently under construction. Expected to be complete in Winter 2021.
- **S. Princeton Drainage Issues**: Staff is still awaiting a response from PG&E on this item.
- **Training:** OQ Evaluations have begun and are nearly complete. 4 staff have been evaluated on basic subjects and intermediary levels.
- **Elm/Pacific Parcel Map** –City Engineer to finalize the parcel map at Pacific and Elm to support future development and the future trail system.
- **2020 Urban Water Management Plan:** City Council approved the contract in July and work has begun with Blackwater Engineering on preliminary work. Blackwater has all of the needed information and a draft document should be ready shortly.
- **Surge Tanks/Northwest and Oil king Infrastructure:** Staff met with Chevron and Aera to discuss proceeding with an engineer report for both facilities and recommended capital improvements. Staff has authorized the preparation of the engineers report for Oil King and still working with the parties on Northwest.
- **Water Treatment Plant Solar Facility:** No response has been received by the property owner. Awaiting counter offer from owner.
- **Metering Logistics and Streamlining:** Staff is working to streamline meter reading through resequencing various read routes. Also, working to correct the number of rereads issued per month by evaluating commonalities month over month and addressing the issues prior to them being issued as rereads. This could potentially save 40+ hours per week.

- **Natural Gas PHMSA (CPUC) Audit 2020:** On December 15-16, 2020, the CPUC conducted an audit of our natural gas system on behalf of PHMSA. This audit will be focused on our Damage Prevention Program. We are presently awaiting an official response from PHMSA. It is unknown when this will occur.
- **Cathodic Protection Survey:** The 2020 Cathodic survey of our natural gas pipeline has been completed, and staff has received the final report. This survey differs from past surveys, as it identified and addresses different criteria to meet compliance. Staff is happy to report that full compliance with 49 CFR 192 has been achieved.
- **Public Works Training Program:** Work has begun to identify the needs of Public Works regarding training. Most of the efforts focuses on natural gas, water distribution, and Sewer distribution. It will also extend to basic skill sets such as basic electrical troubleshooting. The goal is to create regular intervals of standardized training preparing them to qualify and obtain certifications needed to progress in their career. This program will also include a well-organized training room and simulation environment. Materials to complete the training room have been procured.
- **Utilities Conferencing Room:** Work has been completed to setup a conferencing room at our water plant. The environment includes a ceiling mounted projector, a ceiling mounted speaker, a wide-angle webcam, a group-oriented microphone, and supporting hardware. This environment will allow for training in small groups (remote training) and conferencing.
- **AE Contract:** The FHWA requires that agencies solicit for City Engineer's(CE) every 5 years if that CE is involved with federally funded projects. Without the solicitation and other various rules, the City could potentially lose money granted from the federal government. This process is underway.
- **Street Hump Program:** Staff has begun to form a street hump program in which citizens can vote to have street humps installed at their location. The program overview has been completed, and a draft program document is expected on the June 3rd City Council meeting.
- **Phone Systems Upgrade (WTP):** A device that the WTP relied upon for SCADA to warn operators of potential problems during off hours failed. This device was no longer available for replacement. To address the issue now and in the future, a modern phone system was implemented at the WTP. This system is capable of both normal phone calls and is able to interface with SCADA.
- **Hayes Bench Donation:** Staff is working with the donor to get the benches ordered and coordinating sidewalk installation.
- **Contracting Landscape Services:** Staff has been actively inquiring with landscaping companies to get pricing for contract services for landscaping city facilities. Responses have been very limited ad incomplete. Staff will provide something to the City Council in the near future.
- **Risk and Resilience Plan:** The RRA draft has been completed and self-certified. Awaiting a final document.
- **Civic Ready:** Civic Ready recently had an overhaul of their systems. Staff is currently exploring how to best re-launch this program and utilize it to its fullest extent.
- **New Los Gatos Lift Station:** Currently under design. Environmental to proceed once design is complete. Project is expected to be completed in late 2022.
- **La Questa/Phelps Lift Station Improvements:** Installation of new submersible pumps to replace to the existing outdated unreliable pumps. Design is 90% complete and expected to bid in September for construction to commence in late September early October.
- **Tyler EAM:** Awaiting the implementation process to begin.

LOCAL STREET PROEJCTS

- **Phelps Ave Reconstruction Project** –The City Engineer will be inspecting the A/C cross section to ensure it meets industry standards once they inspection equipment arrives. This will most likely be conducted in summer once the device arrives.
- **Sunset Street Reconstruction:** Construction has completed and final punch list items are underway.

- **Precision Concrete Cutting:** Staff has entered in a contract with Precision Concrete Cutting. The goal is to conduct a survey of the entirety of Coalinga's sidewalk infrastructure and to note the optimal method to correct deficiencies. District 2's and District 4 have been completed. Inspections of the remaining districts are underway.
- **Cost Share Program:** Staff has refined the cost share program as requested by Council and presented the program for their approval. Approval was granted with the condition of priority for people who have mobility detriments. The application and program will be posted when a budget has been appropriated at the start of next fiscal year.
- **7th Street Construction:** Design is at 90% and project should go out to bid in August.
- **Fresno Street Construction:** Design is complete and bid award is expected September 16, 2021.

GRANTS

Staff has been continuing to meet with Blais and Associates monthly in accordance with their grant contract to review possible grant opportunities. Below is a status update on all grant activity within the Public Works/Utilities and Community Development Department(s):

- **State Parks Per Capita Program:** Council has authorized the scope of work, staff is working with B&A to complete applications that are due by December 31, 2021.
- **HOME** Staff is awaiting a standard agreement in order to proceed with implementation.
- **AHSC Affordable Housing Grant Application for Pacific and Elm Ave**: Staff is waiting on the submission of the standard agreements so that they may be executed and allow the project to start.
- **STBG (2015):** Forest Phase 4 (Elm -1st) –The project has been placed in suspension until PG&E can energize the lights. Still no expected energize date.
- **CMAQ (2015):** Alley Paving – Project was awarded at the August 5th Council meeting and construction is anticipated to start in 30-45 days.
- **ATP Cycle 3:** Sidewalk Gaps and Safety Enhancements – Construction is underway and expected to last for the next 2 months. Work has begun around the schools.
- **CMAQ:** Trail Segments 10-12 – Design is 90% complete and expected to bid in late summer.
- **ATP Cycle 4** – Trail segments, 9, 4 and 3 (portion) – CEQA work is currently underway and is expected to be completed by fall 2021. The requested extension for CEQA completion due to Caltrans required Biological surveys was approved and the additional work has been completed.
- **STBG (2017) – Polk Street (5th to Elm) –** Project is complete and the contractor is just working non minor punch list items.
- **CMAQ (2019):** The City was notified of two grant awards that the City applied for in early 2020. Under the CMAQ program the City was awarded an alley project in amount of $681,000 and another segment of our master trail system in the amount of $1.1 million. These are programed for late 2021 funding cycle.
- **STBG (2019) – Polk Street (Elm to City Limits) -** Design is currently underway, and construction is expected on FY22.
- **STBG (2021) –** Staff is currently working on two grant applications, (1) Phelps Ave reconstruction and (2) chip and cape sela projects on various roads in the City.
- **CMAQ (2021)** Staff is currently working on applications for the paving of various alleys and Polk Street and surrounding areas safety improvements with trail component.
- **CDBG –** Staff received notice that the City will not be eligible for CDBG funding at this time for Van Ness Storm Drain Project due to the income levels the state has listed for the block in which the project is located. With that, this project will be shovel ready in the coming weeks and staff will be working with Self Help to look into a broader income study or wait for the release of the 2020 census data which is expected to favorable to the City in terms of eligibility.
- **MJLRSP –** Staff has entered into a Multi-Jurisdictional agreement with Fresno COG. Previously we had sought an independent contract with TJKM, but found a MJ-LRSP to be more advantageous in regard to staff time and cost. With the MJ-LRSP, we would still gain the primary benefits of an independent LRSP; HSIP funding and an analysis of traffic data. The MJ-LRSP selection committee has met and cast our scores on proposals. A review of the initial data is scheduled to occur on May 26th.

- **LEAP –** The City has applied for housing funds through the local Early Action Planning Grant for $65,000 in order to support the kickstart to the City's Cottage home program. Staff has executed the standard agreement and is expected to start work in late summer.
- **PLHA -** The City has applied for additional housing funds through the Permanent Local Housing Allocation program to complement the City's Cottage home program by offering down payment assistance and rehabilitation funds to income qualifying residents. Staff is awaiting standard agreements from execution.
- **Clean Water State Revolving Fund Grant Application** – Staff is finalizing the application to be submitted to the state for a planning grant to study needed improvements the waste collection and wastewater treatment plant. Once the Urban Water Management Plan is complete the application will be submitted to the State.
- **Water Meter AMI Pilot Program** – Staff presented the AMI pilot program to the City Council at the October 1, 2020 meeting and currently accepting application for participation. Presently staff is working to implement Beacon read data with Tyler. – **May be repetitive.**
- **ATP Cycle 5 Grant** – Staff was notified by COG that the City will be awarded funds for the preliminary engineering phase of the project and staff expects to apply for construction funding this CMAQ cycle.
- **HSIP (highway Safety Improvement Program) – Cambridge/Elm Signalization** – Signal poles have arrived, installation is expected to occur the second week of September with an anticipated completion sometime in mid-October.

PARKS

- **Frame Park Splash Pad:** This project has been placed on hold due to the drought. Staff will begin working with the City Engineer on re-designing the splash pad with a recirculation system. This project will be revisited in 2022.

COMMUNITY DEVELOPMENT

- Cottage Home Program – *Staff is working with Self Help Enterprises on a fund request to obtain program funds to start the development of the cottage home ADU program. This is being accomplished through the LEAP and PLHA programs.*
- *Council Chambers Technology Modernization* has been completed. The entire audio and video network has been rebuilt completely. The modernization included new microphones, microphone mixers, amplifier, speakers, mute control switches, video camera, projectors, projector screens, computer, video switch, and supporting hardware/wires. Staff will be moving on to completing the modernization of the conference room.
- The City Engineer is currently reviewing the Luxe Estates Final Map application. The final map application should be on the Council consent agenda in the winter once the applicant has given staff the go-a-head to move forward with approval.
- **Heritage Park Assisted Living and Alzheimer's Facility** – The City Council approved this project on June 1st. According to the applicant, construction is anticipated to start in Q4 2021.
- Electronic Plan Checks: Staff is currently working on upgrading the infrastructure in the building department to accept and review electronic plans.
- CUP 21-07 – High Times Signage – Project was approved by the Planning Commission on August 24, 2021.

STAFF REPORT - CITY COUNCIL/SUCCESSOR AGENCY/PUBLIC FINANCE AUTHORITY

Subject:	Council Review and Consideration of the Engineers Report and Direction Related to the Rehabilitation of the Derrick Reservoir
Meeting Date:	September 16, 2021
From:	Marissa Trejo, City Manager
Prepared by:	Sean Brewer, Assistant City Manager

I. RECOMMENDATION:

Staff recommends Council receive and accept the Engineers Report prepared by MKN and discuss and provide direction to staff related to next steps, based on recommendations, for the rehabilitation of the Derrick Reservoir.

II. BACKGROUND:

On May 6, 2021 the Council approved a task order with MKN to prepare a preliminary engineering report including recommendations, evaluation of two roof replacement alternatives, and associated cost estimates in order to guide the next phase of the project which will include choosing the method in which the City will proceed with rehab and subsequently begin preliminary design and preparing the project specifications.

The report was completed in early September and attached to this report for Council's review.

III. DISCUSSION:

Over the course of the last 4 months, MKN has been developing a preliminary engineers report related to the rehabilitation of the 7.5 million gallon water storage tank. Staff in conjunction with MKN will be presenting the findings to the City Council at the meeting in order to receive feedback and direction on the next steps to rehabilitate the Derrick tank. The presentation will consist of addressing the critical components of the rehabilitation from coatings (exterior/interior), structural and appurtenances, alternatives and recommended next steps including implementation and schedule.

IV. ALTERNATIVES:

None at time.

V. FISCAL IMPACT:

Undetermined at this time until a course of action is made.

ATTACHMENTS:

File Name	Description
Report_20210907_City_of_Coalinga_Derrick_Reservoir_Tank_Rehab_Final.pdf	Derrick Reservoir Engineers Report - FINAL

DERRICK RESERVOIR 7.5 MG TANK REHABILITATION PROJECT

PRELIMINARY ENGINEERING REPORT

September 7, 2021

PREPARED FOR:

City of Coalinga

169 W Durian Ave, Coalinga, CA 93210

PREPARED BY:

MKN and Associates, Inc.
Henry Liang, PE – Principal-in-Charge and Project Manager
Tanner Bennett, PE – Technical Lead
Jon Hanlon, PE – Technical Advisor and Quality Control
Ammar Hanna, EIT – Engineering Support

WITH CONTRIBUTIONS BY:

CSI Services, Inc. – Coatings and Shell Thickness Testing
SSG Structural Engineers, LLP – Structural Evaluation

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1 BACKGROUND AND PROJECT UNDERSTANDING

1.1 Purpose and Scope of Evaluation

MKN and Associates, Inc. (MKN) was retained by the City of Coalinga (City) to evaluate the 7.5 MG welded steel Derrick Reservoir located at Jayne Avenue and S. Derrick Avenue in Coalinga, California. The purpose of this report is to assess current conditions, document findings and analysis, and to provide rehabilitation options to bring the existing tank into compliance with the current AWWA D100-11 standard while maintaining an operating level adequate to serve the City of Coalinga. The evaluation investigates tank coatings and other non-structural tank improvements that may improve the performance, operation, and useful life of the tank. The report also includes an alternative of replacing the existing tank with a new tank.

The documents provided to the project team for the evaluation of the Derrick Reservoir include as-built civil and structural drawings (Koebig & Koebig, Inc. dated 6/30/1970), a Maintenance Inspection Report including a dive inspection on 12/6/2019, historical photographs, field measurements (CSI Services dated 1/6/2020), and an "External Fixed Rood" inspection (Mistras Group dated 07/27/2021). MKN's evaluation of the structure was based on a review of provided documents and visual observations made by the MKN team during an on-site condition assessment conducted on 4/21/21. The structural and seismic evaluation was performed by SSG Structural Engineers in accordance with:

- American Water Works Association (AWWA) standard "Welded Carbon Steel Tanks for Water Storage" (AWWA D100-11)
- American Society of Civil Engineers Standard 7-16 "Minimum Design Loads and Associated Criteria for Buildings and Other Structures" (ASCE 7-16).

Based on our discussions with Coalinga staff, maintaining the storage capacity of the tank, to the extent possible, is desired by the City due to the reservoir's location for system optimization as well as for emergency storage. MKN's recommendations consider this objective and include improvements to maximize water storage capacity.

1.2 Tank Description

The following description was based on information collected during a visual observation of the reservoir and a review of drawings and documents provided by the City. Relevant structural parameters for evaluation of the tank are based on the past reports provided by the City. Where pertinent structural information could not be determined in the field, conservative assumptions were made based on the tank's age and our experience with similar structures.

Per the affixed name plate on the wall shell, the tank was built circa 1971, has a nominal diameter of 180'-0", a nominal wall height of 40'-6", and an overall capacity of 7,520,000 gallons. Seismic provisions for the design of steel storage tanks were developed and commonly implemented in 1978. Due the tank's age (Built 1971), it is not guaranteed and is unlikely that the tank was designed for seismic loading (See Figure 1 and Figure 2).

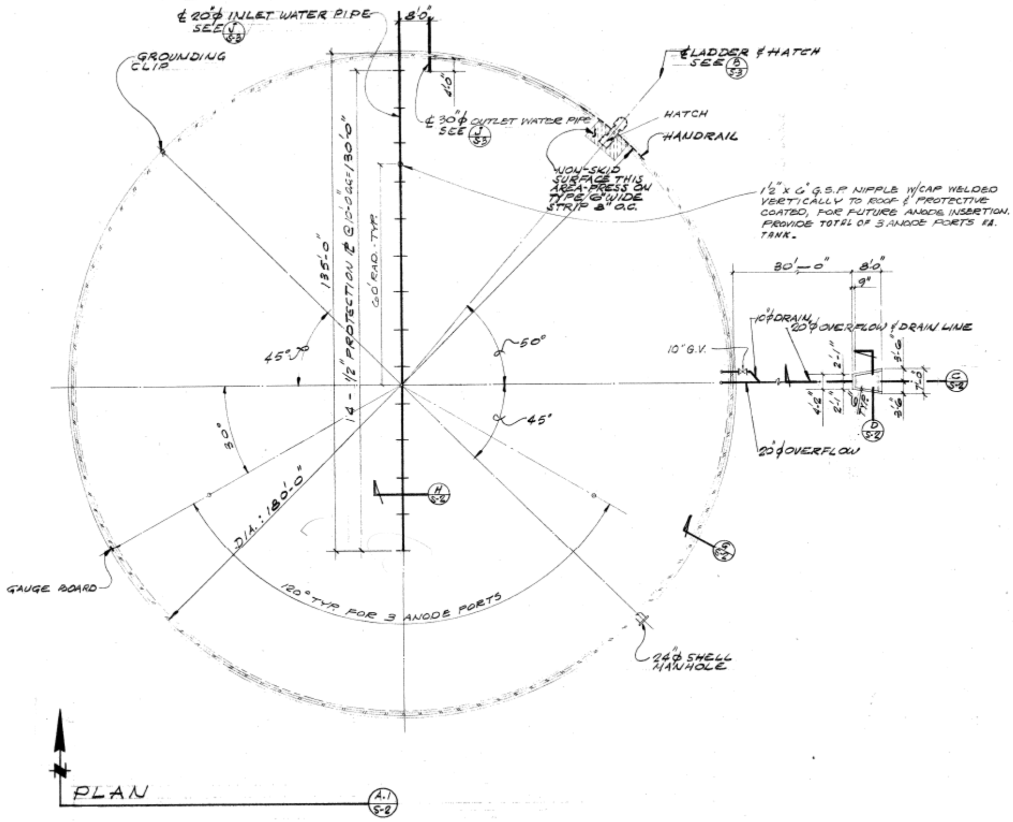

Figure 1: Site Plan (Sheet S-2 From Koebig and Koebig)

Figure 2: Aerial View (By MKN on 04/21/2021)

The tank wall has five shell courses leading to a conical roof with a drip edge. The tank has an internal radial framed roof support structure that is comprised of a dollar plate, rafter beams, girders, and columns. The tank has a caged external ladder that leads to the tank roof, which has handrails in the immediate vicinity of the ladder. The roof on the tank has one center vent, and there are various piping components throughout the tank. The tank is supported by a concrete ring wall that is surrounded by pavement. No anchors are present. The exterior of the tank has painted appurtenances that primarily involved piping. No cathodic protection system was identified.

1.3 Summary of Previous Reports and Information

1.3.1 Coatings Maintenance Report and Dive Inspection Report (2019-2020)

CSI Services, Inc. inspected Derrick Reservoir on December 16, 2019. Deficiencies in the tank are summarized in Table 1.

Table 1: Tank Coating Deficiencies

Item/Part	Deficiency Note
Exterior Walls	Mostly satisfactory condition with some minor isolated and fields of rust spots. The western shell had more rust spots that appeared to be the result of damage from gun fire.
Exterior Roof	The exterior paint on the roof is in poor condition and have heavy amount of chalking. Locations with advanced corrosion were noticed.
Interior Roof	The coating on the inside of the roof seems to have failed many years ago. Large pieces of coating have delaminated from the steel.
Interior Walls (above water line)	Shell was in poor condition with corrosion and fields of blisters.
Interior Walls (below water line)	Lower courses were in relatively better condition with some dark rust and shallow pitting.
Sediment	Not inspected
Drain	One rust tubercle on the bottom of the sump
Columns	In general, the roof support structure was in poor condition.

Overall, the tank's coatings are in poor condition, except for some exterior areas of the shell including some exterior appurtenances such as the ladder, manway, and piping. The most notable areas of rust are the interior roof, roof support structures, and walls of the tank. Seven of the roof beams have become loose and are no longer functional. One of these beams has fallen to the tank bottom. The inspection report also noted concerns regarding the ladder and handrail system. The tank was found to have areas that could benefit from an upgrade to its fall prevention system. The ladder and roof rail system should be upgraded and comply with current safety standards. The tank roof corrosion is extensive and although the City has attempted to repair holes in the past with fiberglass, many of these repairs have failed. Holes within the tank roof are still present.

CSI's dive inspection report noted concern for the interior ladder fall prevention cage on the internal access ladder because it presents an issue for emergency extraction. It is recommended to remove the cage and install a fall protection device suitable for submersion or replace the existing interior ladder with a ladder that does not have a cage at the next maintenance cycle. Personnel shall proceed with caution when accessing the ladder.

1.3.2 Photographic Documentation

Various photographs taken in early 2020 show signs of corrosion and vandalism. The tank shell has circular rust spots that appear to be the result of damage from gunfire (See Figure 3 and Figure 4).

Figure 3: Corrosion at Roof Hatch (By CSI on 01/06/20)

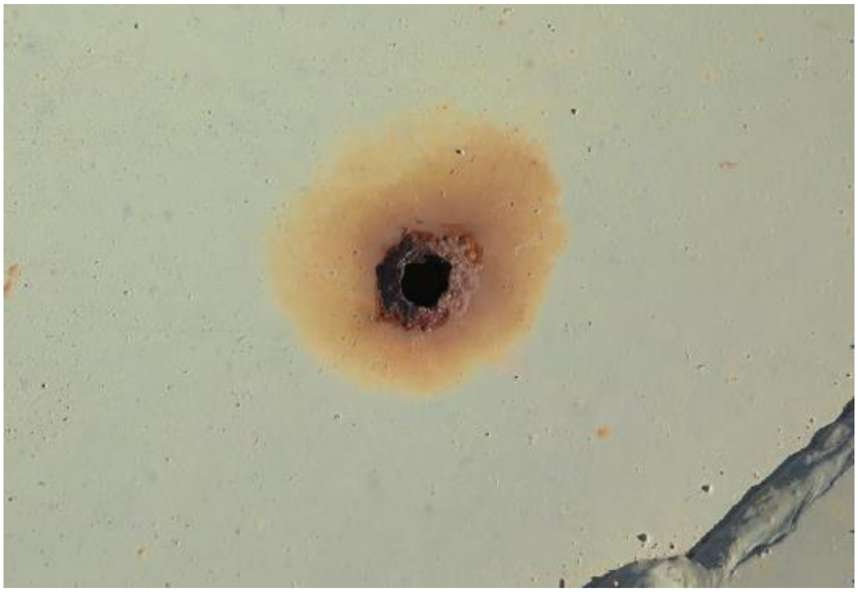

Figure 4: Gunfire Rust Spots (By CSI on 01/06/20)

2 COATING ASSESSMENT

This assessment included overall evaluation of the exterior coating and interior lining systems of the tank which remained in service during MKN's site visit. The evaluation involved visual observation, non-destructive testing, and destructive testing. Photographs were taken to further document the conditions observed.

2.1 General

The exterior paint system has a beige finish, while the interior lining is navy blue. The exterior appears to be painted with an alkyd-based system. The interior lining appeared to be coated with a bitumastic lining system and is likely the original coating applied. The lower part of the tank appears to have a hot-applied coal-tar enamel while the upper part appears to have a bitumastic cut-back (Supertank Solution).

Visual observations of the exterior coatings were limited to the lowest shell course, upper shell areas adjacent to the ladder, and the roof. The exterior paint on the tank is in poor condition on the roof and in overall fair conditions on the shell, with major chalking. Rust was present at various locations on the roof, and although the rust density was low, there were locations with advanced corrosion, mainly on the topside, the perimeter, and appurtenances on the roof. Figure 5 shows some of the corrosion found on top of the tank. The total amount of rust was rated to be 0.03% of the total area per ASTM D610.

Areas of minor, scattered corrosion on the tank shell were present, with the western quadrant of the shell having more rust spots that appeared to be the result of damage from gunfire. The shell's appurtenances including the ladder, piping, and manway were in a condition similar to the shell plate.

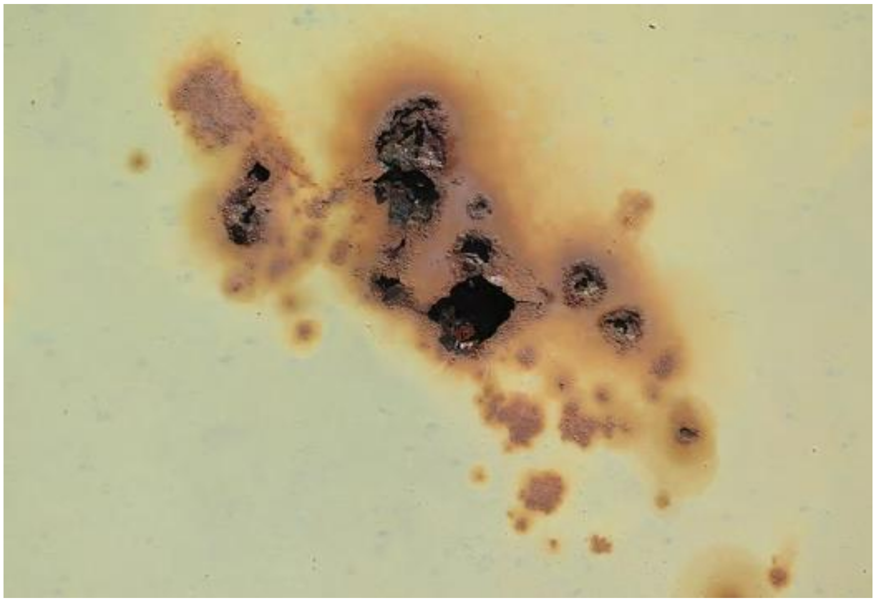

Figure 5: Typical Exterior Shell Corrosion (By CSI on 01/06/20)

The coating on the interior of the roof including all support structures was in poor condition. Most of the roof area had dark corrosion along with metal loss. One rafter beam was observed to have broken free and had fallen to the bottom of the tank. The interior wall liner of the shell was in a poor condition with observable corrosion. Figure 6 shows some of the corrosion found on the inside of the tank. Lower sections of the tank were in a relatively better condition in comparison with the top section. The floor lining was in mostly good condition, with some areas having dark rust and shallow pitting.

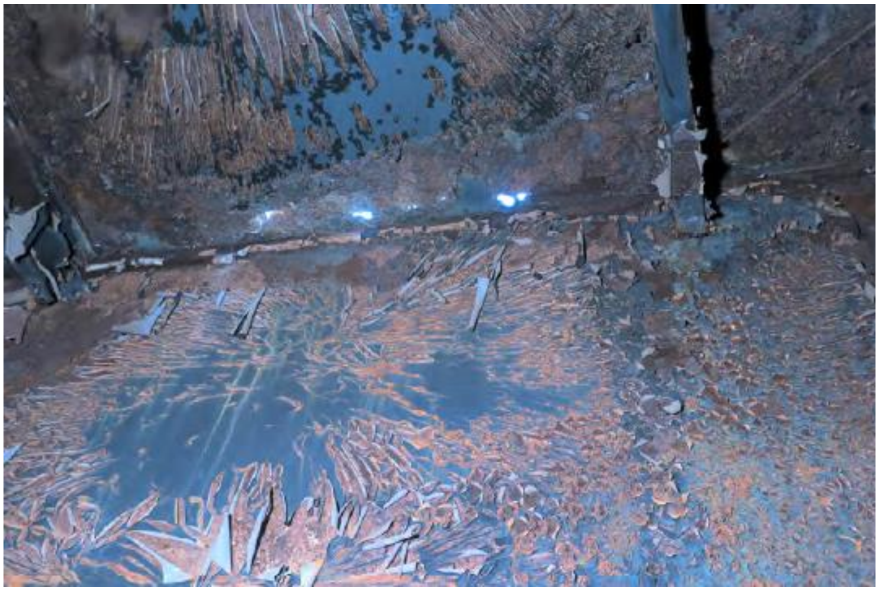

Figure 6: Typical Interior Shell Corrosion (By CSI on 01/06/20)

2.2 Tank Coating Thickness Testing

An inspection of the exterior shell coating was performed by CSI Services using a Positector 6000FN3 Type II dry film thickness gage (Serial No. 41071) in accordance with the requirements of ASTM D7091 and SSPC PA2. The paint dry film thickness on the exterior shell was measured to range between 7 and 16 mils. The fixed roof has coating failures with primer showing in certain areas, the 16-inch vent shows signs of internal corrosion, the autogauge tape guide is corroded, and there is significant sagging on the southwest side of the roof due to rafters failures.

2.3 Tank Exterior Coatings Testing for California Administrative Manual (CAM-17) Heavy Metals

A coating sample was collected from the tank exterior to determine the presence of heavy metals in the tank shell. The sample was sent to Schneider Laboratories in Richmond, VA for analysis of the seventeen CA Title 22 heavy metals (CAM-17) in accordance with EPA Method 2050B and EPA 7471A. Table 2 summarizes the results for all 17 metals which are reported in PPM (mg/kg).

Table 2: CAM-17 Heavy Metals Testing Results	
Parameter	Result (mg/kg)
Antimony	<6.46*
Arsenic	<6.46*
Barium	26,800
Beryllium	<6.46*
Cadmium	<6.46*
Chromium	99.1
Cobalt	141
Copper	18.3
Lead	1,940
Molybdenum	<6.46*
Nickel	12.2
Selenium	<6.46*
Silver	<6.46*
Thallium	<6.46*
Vanadium	<6.46*
Zinc	60.5
*6.46 is the Reporting Limit which is the lowest detectable concentration	

The presence of heavy metals results in additional costs associated with the proper removal and disposal of the coatings. EPA and CAL/OSHA regulations require appropriate worker and environmental protection measures (tenting full containment of the structure, and/or air monitoring may be required as determined by the contractor) to mitigate concerns associated with heavy metals present in coatings. Waste categorization is also required to determine landfill classification requirements for disposal. Disturbance or removal of the exterior tank coatings will require the Contractor to address worker safety and disposal requirements. Cost estimates included within this report include costs associated with mitigation of heavy metals. Specifications and requirements for heavy metal remediation should be included in future contract documents.

2.4 Coating Recommendations

There are multiple approaches available for the rehabilitation of exterior tank coatings ranging from spot repair, to spot repair and overcoat, to complete removal and replacement.

The first consideration is the coating's ability to withstand the added stresses of an additional coat(s). Film thickness and adhesion are primary elements to this determination. If an existing film is too thick or has poor adhesion, the tension from the curing stresses and/or the weight of the additional paint can cause the existing system to detach.

Another consideration is the amount of surface area requiring repair. An industry guideline is that if ten percent or less of the surface area requires repair, rehabilitation can be economically addressed by spot repair. Overcoating is generally feasible with up to ten percent rusting provided adhesion is better than fair, and in some cases top coating can be viable with greater than ten percent rusting if adhesion is satisfactory. However, once the amount of surface area exceeds approximately ten percent, the cost of surface preparation, cleaning, and coating the individual areas generally approaches or exceeds the cost of complete removal and replacement.

As noted above, shell paint was analyzed for heavy metal content (CAM-17 including lead, cadmium, and chromium) and found to contain low levels of Cadmium and relatively high levels of Chromium and Lead. Thus, mitigation of heavy metals will be required, particularly if coating removal and replacement is selected.

2.4.1 Exterior Coating Recommendation

To assess the existing coating's ability to be overcoated, CSI applied a test patch to the tank in conformance with ASTMD5062 and the manufacturer's recommendations. The evaluation of the test patch primarily included testing for film thickness and adhesion in accordance with ASTM D7091 and ASTM D3359A, respectively. The results of the test patch were unsatisfactory, and the existing paint was found to not be a candidate for overcoating (See Figure 7). A satisfactory test would have resulted in minimal lifting of the existing paint under the gray test patch. Figure 7 shows that a majority of the existing paint lifted. It is therefore recommended that the exterior tank coatings be removed by blasting and replaced.

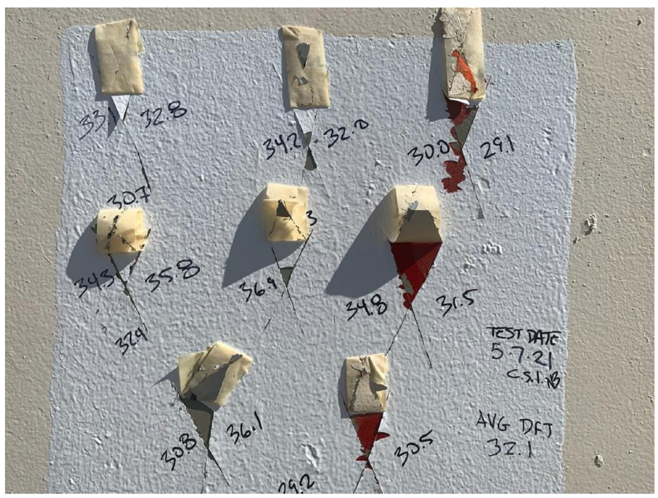

Figure 7: Paint Test Patch on the Shell of the Tank (By CSI on 01/06/20)

MKN recommends the following for replacement of exterior coating:

System 1, Epoxy Zinc, Polysiloxane

1. Description: Two step coating system consisting of a three-component epoxy zinc rich primer and polysiloxane finish coat applied to prepared surfaces. Epoxy zinc rich primer shall meet the performance requirement of SSPC Paint 20 and contain no less than 89% zinc pigment in the dried film. The polysiloxane finish coat shall be greater than 90% volume solids and exhibit excellent long-term color and gloss characteristics as defined by AWWA D102-20 OCS-5.
2. System:
    b. Prime Coat: Epoxy Zinc, 3 - 5 mils dft
        i. SW Zinc Clad 4100, or equal.
    c. Finish Coat: Polysiloxane, 4 - 6 mils dft

i. SW Sherloxane 800, or equal.

2.4.2 Interior Coating Recommendation

For the interior tank coating, it is recommended that the coating system be entirely removed and replaced. This includes that the interior be blasted to near white metal in preparation for recoating.

We recommend the following coatings for the interior surfaces:

A. System 1: Ultra High Solids Epoxy

1. Description: Single coat epoxy lining system consisting of a two-component epoxy finish coat applied directly steel surfaces. The epoxy shall be amine cured, two components, epoxy with greater than 96% volume solids, meet the performance characteristics of MIL PRF 23236 and AWWA C210 Epoxy Lining for Welded Steel Pipe, and be certified for potable water use per ANSI / NSF 61.

2. System:

a. Stripe Coat: Epoxy or Ultra High Solids Epoxy, 3 – 8 mils dft

i. SW Macropoxy 5500 or equal.

b. Finish Coat: Ultra-high solids epoxy, 20 - 30 mils dft

i. SW Duraplate UHS, Sherplate PW, or equal.

B. System 2: High Solids Epoxy

1. Description: Multiple coat epoxy lining system consisting of a two-component epoxy finish coat applied directly steel surfaces. The epoxy shall be amine cured, two components, epoxy with greater than 80% volume solids, meet the performance characteristics of AWWA C210 Epoxy Lining for Welded Steel Pipe, and be certified for potable water use per ANSI / NSF 61.

2. System:

a. Prime Coat: High Solids Epoxy, 4 – 8 mils dft

i. SW Tank Clad HS, or equal.

b. Stripe Coat: High Solids Epoxy, 3 – 8 mils dft

i. SW Tank Clad HS, or equal.

c. Intermediate Coat: High Solids Epoxy, 4 – 8 mils dft

i. SW Tank Clad HS, or equal.

3 STRUCTURAL ASSESSMENT

SSG Structural Engineers (SSG) conducted a limited structural assessment of the Derrick Reservoir to provide options to bring the existing tank into compliance with the current AWWA D100-11 Standard – Welded Carbon Steel Tanks for Water Storage, while maintaining an operating level adequate to serve the City of Coalinga's population. The analysis of the existing tank was performed using AMETank as developed by TechnoSoft. Calculations are provided in the Appendix for reference.

Evaluation of the tank focused on structural deficiencies identified in the 2019 dive inspection report by CSI and select structural elements identified by Mistras. The structural evaluation was based on a review of provided documents and information as well information that was able to be gathered during the on-site inspection. Structural elements not specifically referenced are outside the purview of this report.

3.1 General Assumptions

- Coordinates: 36.1414919, -120.3900433
- Year Built: 1971
- Tank Diameter: 180'-0"
- Tank Wall Height: 40'-6"
- Maximum Operating Water Level (MOL): 35'

3.2 Assumed Materials (Note original shop/fabrication drawings not available)

- Rafters: A36 (Fy= 36 ksi)
- Girders: A36 (Fy= 36 ksi)
- Steel Plates: A36 (Fy=36 ksi)
- Concrete: 2,500 psi

3.3 Seismic Design Values

- Maximum Considered Earthquake (period = 0.2 seconds) $S_S = 1.794$
- Maximum Considered Earthquake (period = 1.0 seconds) $S_1 = 0.593$
- Site-modified Spectral Acceleration Value $S_{MS} = 1.794$
- Site-modified Spectral Acceleration Value $S_{M1} = 0.890$
- Numeric Seismic Design Value at 0.2 sec $S_{DS} = 1.196$
- Numeric Seismic Design Value at 1.0 sec $S_{D1} = 0.596$

When assessing an existing tank for seismic loads, performance objectives should be determined based on the level of risk acceptable for the given tank. A description of performance levels and usage categories is provided below. This analysis assumes the Seismic Use Group of the tank is III, which is defined as a tank that provides direct service to facilities that are deemed essential for post-earthquake recovery and essential to the life, health, and safety of the public, including post-earthquake fire suppression. The Seismic Use Group III falls into the Essential Facilities Usage Category as the water can be used during post-earthquake fire suppression.

Table 3: Performance Objectives				
Usage Categories*	Expect Shell or Roof Damage	Maintain Confinement of Liquid	Maintain Storage Functions	Maintain Storage Seismic Risk
Low Risk Facilities	Yes	No[t]	No	Low
General Facilities	Yes	Yes	No	Medium
Essential Facilities	Minor	Yes	Yes	High

* Low-risk facilities are those that are remotely situated and, should a major spill or fire develop, would not pose serious health or life endangerment. General risk facilities are all others. Essential facilities are those that are used by public works departments during general emergency such as fire water tanks or potable water tanks for public emergencies.

[t] In this context, it is assumed that secondary containment is provided and would provide a localized confinement, or the tank contents should it rupture, preventing an environmental risk.

Information in table 3 above is obtained from Above Ground Storage Tanks by Philip E. Myers, (McGraw Hill, 1997)

3.4 Steel Ultrasonic Thickness Measurements

Spot steel thickness measurements were also collected from the roof plate and each shell course using a Krautkramer Braunston DMS ultrasonic thickness gage. The readings on the shell were taken from randomly selected locations a few inches in size, while the roof spot readings were collected from locations that had topside evidence of severe underside corrosion. These roof readings were continuously scanned perpendicular across a two-foot line that centered over lines of underside corrosion. Table 4 summarizes the results in inches.

Table 4: Steel Thickness Testing Results					
Roof Plate	5th (Upper) Shell Course	4th Shell Course	3rd Shell Course	2nd Shell Course	1st (Lowest) Shell Course
0.092” – 0.210”	0.350” – 0.354”	0.396” – 0.401”	0.594” – 0.601”	0.792”-0.806”	0.990”-0.992”

3.5 Wall Shell

The following is a summary of the tank shell analysis. Calculations can be found in the appendix for reference. All shell courses are based on an allowable tensile hoop stress of 15,000-psi as defined in Table 5 of the AWWA D100. For seismic loads, a 1/3 increase in the allowable stress is used. A Utilization Ratio greater than 1.0 indicates the material is overstressed for the allowable loads as indicated in the AWWA D100.

All analysis was performed assuming that the existing tank is to remain self-anchored without any added mechanical anchors or modification to the existing ringwall foundation. The AWWA D100 outlines values for J as follows:

- J less than 0.785 indicates no uplift
- J less than 1.54, but greater than 0.785 indicates uplift, but a stable tank
- J greater than 1.54 indicates an unstable tank with anchors required.

As-built tank analysis indicated that the tank overturning ratio, J = 1.345, meaning that it is stable, but is subject to uplift. Table 5 is based on the tank shell performance for the as-built tank operating at the maximum capacity.

Table 5: As-built Tank Condition - Shell Analysis Summary

Course (1 Bottom, 5 Top)	Width [in.]	Min. Thickness, Hydrostatic	Min. Thickness, Seismic	Actual Thickness	Utilization Ratio
5	104	0.265	0.379	0.35	1.08
4	96	0.515	0.672	0.4	1.68
3	96	0.765	0.94	0.59	1.59
2	96	1.015	1.177	0.79	1.49
1	96	1.264	1.384	0.99	1.4

All tank shell courses have a thickness that is less than the minimum thickness that is required for seismic and hydrostatic purposes except for the top course which meets the minimum thickness for hydrostatic but not seismic. Therefore, shell courses 1 through 4 were determined to have a utilization ratio that is higher than one, meaning they are overstressed per current AWWA requirements for hydrostatic and seismic conditions.

3.6 Roof System

Magnetic Flux Leakage (MFL) scanning of the fixed roof revealed twenty-three (23) product side corrosion points with a remaining thickness below 0.09” or 35% of 0.250’’ nominal thickness. The inspection found eighteen (18) sketch plates that have holes. API 653, Para. 4.2.1.2 states, “roof plates corroded to an average thickness of less than 0.09 inch in any 100 square inch area or roof plates with any holes through the roof plate shall be repaired or replaced”. 15-foot exclusion zone barriers were installed due to holes on sketch plates and roof significant sagging due to rafters failures. An extension pole and manlift were used to perform Ultrasonic thickness readings within the exclusion zone. Approximately 65% of the roof plates were not scanned with MFL but were measured using UT means. There was no confirmation of the extent of underside corrosion that may be present in the areas that were not scanned using MFL.

Advanced corrosion was common to all roof surfaces including roof plate, rafters, girders, and ties. Multiple areas of daylight were visible through the roof, mostly in the southern half of the tank. Figure 8 shows holes in the fixed roof. All roof support structure fasteners are rusting. The corrosion has advanced to develop localized holes in both the plate and roof support structure. Six rafter beams are hanging and have become detached from one side as shown in figure 9, while a seventh beam had broken free and had fallen to the tank bottom. The original roof hatch has exfoliation and through holes. Based on the current conditions and without alteration, damage to the roof structure and/or partial structural collapse/failure of the tank may occur during an earthquake.

The level of corrosion on the tank interior above the shell has clearly advanced to where the existing steel likely cannot be cost-effectively repaired. However, the surfaces below the roof appear to be in a condition that can be rehabilitated. The tank roof and roof support structure require removal and replacement, while the lower surfaces can be repaired with some minor mechanical repairs and relining work. With respect to the exterior paint, a new roof will have new paint.

Figure 8: Fixed Roof Exterior Corrosion (By CSI on 01/06/20)

Figure 9: Failing Fixed Roof Rafters (By CSI on 01/06/20)

3.7 Seismic Evaluation Findings

3.7.1 Freeboard

AWWA D100 describes the freeboard height as the distance between the top of the overflow and bottom of the rafters. Based on the as-builts provided by the City, the existing over flow elevation is at 40-feet relative to bottom of tank providing 6-inches of freeboard. Per the design criteria discussed previously, SSG calculated the required freeboard for the as-built tank to be 7.38’, which is exceeded by the current maximum operating level.

3.7.2 Overturning

The existing tank at a maximum operating level was analyzed to have an overturning ratio of J=1.345. Per AWWA D100, a J value less than 1.54, but greater than 0.785 indicates that the tank is stable, but that there is a potential for uplift.

3.7.3 Foundation/Anchorage

As previously mentioned, the tank was determined to be stable but subject to uplift per AWWA D100. As such, anchorage of the tank to the foundation is not required for alternatives presented in this report. Based on review of the as-built drawings the existing ringwall is 15-inches wide by 48-inches deep. Based on our understanding of the foundation geometry/construction and assuming an unconstrained slosh wave, the design bearing pressure on the foundation would be approximately 2,500 psf when considering design gravity loading.

3.7.4 Tank Wall Shells

The tank wall shells were analyzed for hydrostatic and seismic conditions considering the current maximum operating level and the measured wall shell thicknesses. Based on this analysis, the shells were determined to be overstressed and non-compliant per AWWA D-100 current code for both hydrostatic and seismic conditions.

3.8 Structural Recommendations

3.8.1 Recommendations for Fixed Rood

The roof structure consists of rafters supported by two girder lines and I-beam columns. Inspection reports noted extensive signs of corrosion at the tank roof structure. The roof structure and roof plate are both exposed to significant corrosion development. The underside corrosion of the steel plates immediately above roof rafter beams has developed to form through holes in the structure. All roof support structure fasteners are rusting. Most of the roof beams have become loose and are no longer functional.

Based on the level of deterioration and deficiencies observed of the fixed roof structure including rafters, girders, columns, and metal sheet plates, it is recommended that the roof be demolished and replaced with a new roof structure. Due to signs of major corrosion and damage, all rehabilitation options will include the requirement for replacement of the existing fixed roof structure.

MKN has explored the following three options as valid alternatives for roof demolition and replacement:

1. Demolition of the existing roof and installation of a new free-span aluminum dome roof:
   This alternative has the lowest cost compared to other roof replacement alternatives and might be the most suitable given the City’s limited budget for this project. It is designed to meet the latest design codes including Eurocode, Aluminum Association’s 2010 Aluminum Design Manual, IBC 2012, AWWA D108, and API 650G. This aluminum roof system is custom designed to meet the specific requirements of the project and is engineered for any snow, wind, or suspended load capacity as well as span-to-rise-ratio. The properties of this alternative include corrosion resistance, low maintenance cost, fast and low-cost construction, design flexibility, and Aluminum being

a recyclable material. The cost associated with this alternative, including prevailing wages, is expected to be approximately $830,000.

2. Demolition of the existing fixed roof and installation of a new Conventional Roof System:
   This alternative provides a roof plate thickness of 3/16” which is the AWWA D100 minimum requirement. Conventional roof systems are supported by a system of rafters that are placed underneath the roof plates’ overlapping areas, creating inaccessible areas that are hard to coat. Conventional roof systems have a lower capital cost than other roof systems, but they have a higher ongoing maintenance cost because of the higher chance of rafters failures. The cost associated with this alternative is expected to be approximately $1,650,000.

3. Demolition of the existing roof and installation of a new Bent Plate Roof System:
   This alternative provides an increased roof plate thickness from the AWWA D100 3/16” minimum requirement to ¼”, which gives the roof improved forming characteristics. This roof design reduces the inaccessible areas that are associated with a conventional roof system with rafters, eliminating a large percentage of the areas that are hard to coat. Rafters are impeded into each plate’s design making it easier and more efficient to install and reducing the number of structural parts that might need to be fixed or replaced throughout the life cycle of the tank. The cost associated with this alternative is expected to be approximately $2,150,000.

3.8.2 Recommendations for Shell Overstressing

At the current overflow elevation and maximum operating level, the tank shell courses are overstressed. MKN has explored the following three options for addressing the overstressed bottom shell courses:

1. Reduce the Maximum Operating Level
   For this alternative, the maximum operating water level would be reduced to 29-feet to prevent overstressing the bottom courses of the tank. This will result in the loss of about 2.0 MG of water capacity resulting in a total storage volume of 5.5 MG. By reducing the operating water level, the overturning ratio decreases to J=0.6558 resulting in a stable tank. This alternative does not require any improvements to the shell.

   Table 6 summarizes the tank shell performance after reducing the maximum operating level.

Table 6: Reduce Operating Level - Shell Analysis Summary

Course (1 Bottom, 5 Top)	Width [in.]	Min Thickness, Hydrostatic	Min. Thickness Seismic	Actual Thickness	Utilization Ratio
5	104	0.25	0.25	0.35	0.714
4	96	0.25	0.25	0.40	0.625
3	96	0.406	0.533	0.59	0.903
2	96	0.655	0.785	0.79	0.994
1	96	0.905	0.996	0.99	1.006

2. Retrofitting the Lower Two Shell Course(s)

   This option would require that steel compression bands ("belly bands") be installed on the outside of the existing lower two shells to provide additional support to the shell's hydrostatic and hydrodynamic hoop stresses. Structural analysis has shown that retrofitting only the first bottom course would not allow the City to increase the operating level over 29-feet as the second bottom course would become overstressed. Therefore, the two bottom shell courses will have to be reinforced in order to increase the operating water level to 31-feet.

   The cost associated with this alternative is expected to be approximately $ 775,000.

3. Add a New 8-foot Course to Bottom of the Existing Tank
   For this alternative, a new bottom shell course would be installed, and the rest of the shell would be lifted and placed above the new course. The tank operating level could be maintained at 35-feet above the tank finish floor, which will keep the tank closer to its current capacity (About 0.8 MG less than existing) and the overturning ratio is lowered to J=0.7783 resulting in a stable tank. Adding an extra shell course to the top of the tank wall will not alleviate the overstressed conditions on the lower shell courses.

   Table 7 summarizes the tank shell performance after adding an 8-foot lower shell course.

Table 7: Increase Tank Height - Shell Analysis Summary

Course (1 Bottom, 5 Top)	Width [in.]	Min. Thickness, Hydrostatic	Min. Thickness, Seismic	Actual Thickness	Utilization Ratio
5	104	0.25	0.25	0.35	0.71
4	96	0.25	0.25	0.40	0.625
3	96	0.343	0.472	0.59	0.80
2	96	0.593	0.748	0.79	0.95
1	96	0.843	0.99	0.99	1.0
New Bottom Course	96	1.093	1.199	1.2	1.0

The cost associated with this alternative is expected to be approximately $ 1,715,000.

4 TANK APPURTENANCES

4.1 External Ladder and Roof Fall Protection

The external access ladder features a fall protection cage with a security gate as shown in Figure 10. The cage itself is attached securely and in good condition. A new fall protection system conforming to OSHA requirements is recommended. It is recommended to install a partial roof edge rail and a roof fall protection device anchored to the center of the top of roof.

Figure 10: External Access Ladder (By MKN on 04/21/21)

4.2 Internal Ladder

The interior ladder contains a safety cage and presents an access and safety challenge for maintenance dive inspections. The interior ladder fall prevention cage should be removed or a new cageless ladder with a fall prevention device meeting AWWA and OSHA standards should be installed in place of the existing one. A stainless steel or fiberglass reinforced polymer (FRP) interior ladder would eliminate the need for coating the ladder and is recommended during Tank Rehabilitation.

4.3 Manways

The Derrick Reservoir has one existing, 24-inch diameter shell manway. AWWA D100 recommends a minimum of two shell manways, with one being a minimum of 30 inches in diameter. MKN recommends adding a second 30-inch diameter manway in conformance with AWWA and industry standards.

4.4 Level Gauge

The tank is equipped with a standard level gauge with an interior float. The auto-gauge tape guide is corroded and the water level indicator is no longer operational. It is recommended that a new, manual level gauge system be installed.

4.5 Roof Hatches

The existing tank has two roof hatches. Both hatches are square openings. One is 24-inch by 24-inch, and the other is 48-inch by 48-inch. Dark corrosion with metal loss was also present. It is recommended that two new roof hatches be installed as part of the new roof.

4.6 Cathodic Protection

No cathodic protection system was present. It is recommended that impressed current cathodic protection system be added to the tank.

4.7 Tank Piping and Connections

The existing tank piping is consistent with tanks of this vintage. At the time, seismic flexibility was typically not part of the design. The inlet, outlet, overflow, and drain piping are all rigidly connected to the tank, either at the tank floor or the tank wall shell. Not having flexible connections can result in failures during a seismic event. To provide better protection against failures (leaks or loss of contents), MKN recommends installing flexible connections in accordance with AWWA D100.

4.7.1 Tank Inlet

From the as-builts, MKN observed that the tank inlet is a 20-inch welded steel pipe on the northern side of the tank. The inlet is below grade as it approaches the tank from the north, rises from below grade, turns horizontal via a fabricated 90-degree elbow, penetrates the tanks shell wall approximately 1.5' above the concrete ringwall. The inlet pipe then runs along the bottom of the tank for 135' heading south along the center line of the tank. The 90-degree elbow is coupled to the tank with mechanical joints and flanged connections. An approximate ¼-inch steel plate for reinforcement is present on the outer shell around the penetration and no flexible connection is present. Figure 11 shows the current inlet pipe configuration.

Figure 11: Inlet Piping (By CSI on 01/06/20)

Per AWWA D100, piping must be flexible enough to accommodate shell rotation and deflection due to elastic growth caused by hydrostatic pressure, seismic movements, and settlement in the tank or piping system. The minimum design displacement for piping connections is defined in Table 30 of AWWA D100. Considering that the City proceeds with an alternative presented in this report, the tank would be considered self-anchored and have an overturning ratio of J=0.7783 which is smaller than J=0.785, resulting in a minimum upward vertical displacement design of 1 inch and a minimum horizontal displacement design of 2 inch, relative to the foundation of the tank.

MKN evaluated two styles of flexible connections that can provide the required deflection: the double ball articulating joint (such as "Flex-Tend" by EBAA Iron shown in Figure 12); and the single-arch rubber expansion joint (such as Style 233 by Proco shown in Figure 13). The main benefit of the double ball joint is the large degree of flexibility that it provides. 20-inch Flex-tend flexible expansion joints deflect up to 15 degrees per ball, in any direction, and has a 12 inches of expansion or contraction. The disadvantages include size, and cost. The Flex-tend coupling is approximately 6-feet in length and has a list price of $16,500, not including tax or freight. Additionally, to accommodate this fitting, significant revisions to the buried 20-inch piping would be required.

Figure 12: Flex-Tend Flexible Expansion Joint

Comparatively, the Proco Style-233L 20-inch rubber expansion joints provide 4 inches of lateral deflection and 11.1 degrees of angular deflection, which is less than the Flex-tend, but is sufficient to meet the AWWA recommendations. The product is smaller in size than the double ball joint which makes it easier to install. The list price for the 20-inch NSF 61 Certified Proco style 233 is $5,040, which makes it relatively cheaper than the double ball joint option.

Figure 13: Proco Flexible Joint

MKN recommends installing a 20-inch rubber expansion joint on the tank inlet as part of the tank rehabilitation project. This flexible joint would be added above ground between the 90-degree elbow and the shell penetration. The existing inlet piping will have to be modified to accommodate the joint's 22-inch lay length.

4.7.2 Tank Overflow Piping

The tank's overflow consists of a 20-inch welded steel internal pipe at the eastern side of the tank. As seen in Figures 14 and Figure 15 the overflow pipe penetrates the sidewall of the tank with the centerline of the pipe about 1.5' above the bottom of the tank floor. On the interior of the tank, the pipe runs vertically approximately 2-feet from the tank shell to the overflow level of 40.0-feet. The overflow pipe is supported with side brackets and has a widened funnel overflow weir.

AWWA D-100 requires overflows to have a capacity of at least the specified inlet rate and gives it the option of being internal or external unless specified. The tank's overflow pipe is the same size of its inlet pipe, and with the funnel design it appears to comply with AWWA D100.

MKN recommends modifying the overflow elevation to align with the selected maximum operating level. The City may select to keep the overflow at a level higher than the recommended maximum operating level (29.0-feet) to allow for emergency storage, however, the City would be operating at a higher level than recommended at its own risk. In addition to this modification, MKN recommends moving the sidewall penetration higher above the tank floor which will allow for the design and installation of a 20-inch rubber expansion joint or an air gap on the vertical overflow piping. MKN recommends eliminating the below grade connection and installing an air gap with a duckbill type check valve to eliminate any connection to below grade piping. The City may elect to install a funnel piece on the overflow pipe that drops below grade to reduce spillage onto the surrounding asphalt in the event of an overflow. Cost estimates presented in this report reflect this recommendation. These modifications comply with Division of Drinking Water requirements and prevent backflow into the tank.

Figure 14: Overflow Pipe (By CSI on 01/06/20)

4.7.3 Tank Outlet and Drain

The tank outlet (Figure 16) consists of a 30-inch floor penetration located 8 feet to the east of the inlet pipe and about 4 feet from the shell wall. The tank also has a 10-inch drain that penetrates the tank floor approximately three feet to the north of the overflow pipe and two feet away from the shell wall (Figure 15). The drain line has a gate valve outside of the tank and connects to the tank's 20-inch overflow line below grade. Both the outlet and the drain pipes are welded steel.

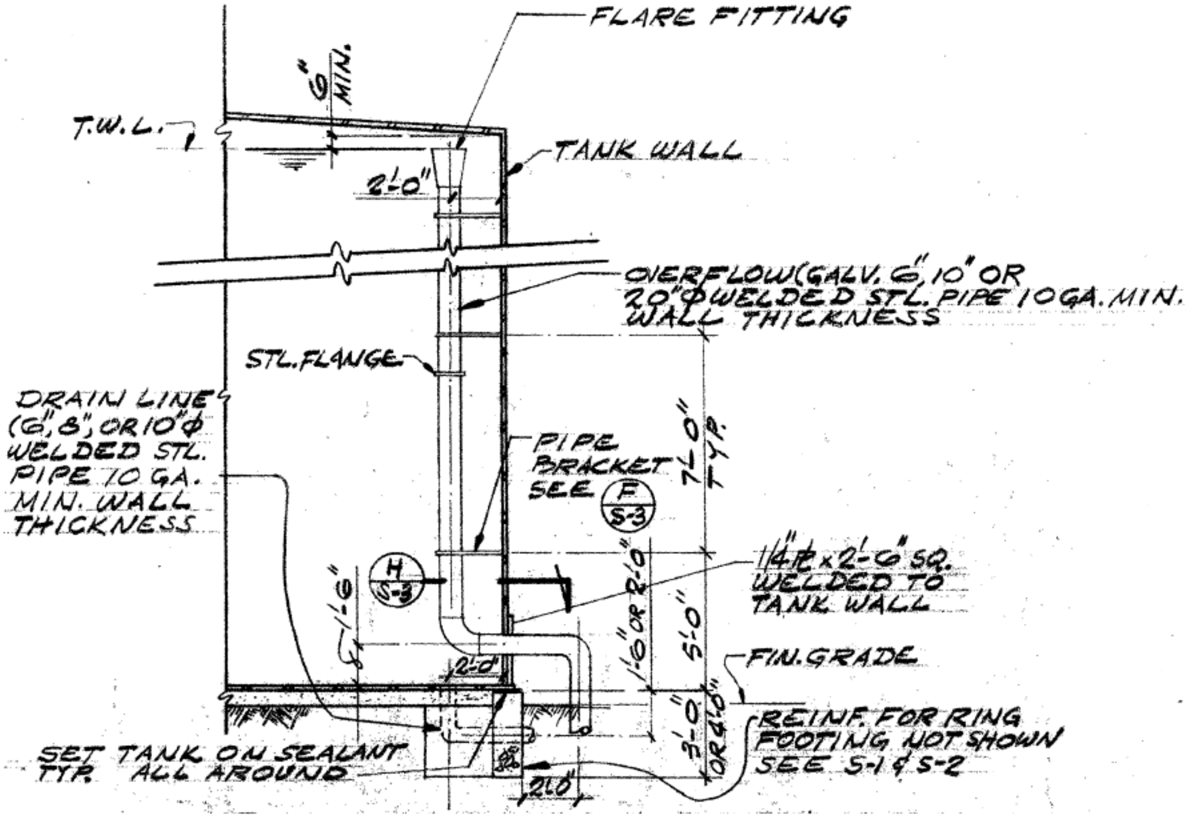

Figure 15: Tank Overflow and Drain Record Drawing

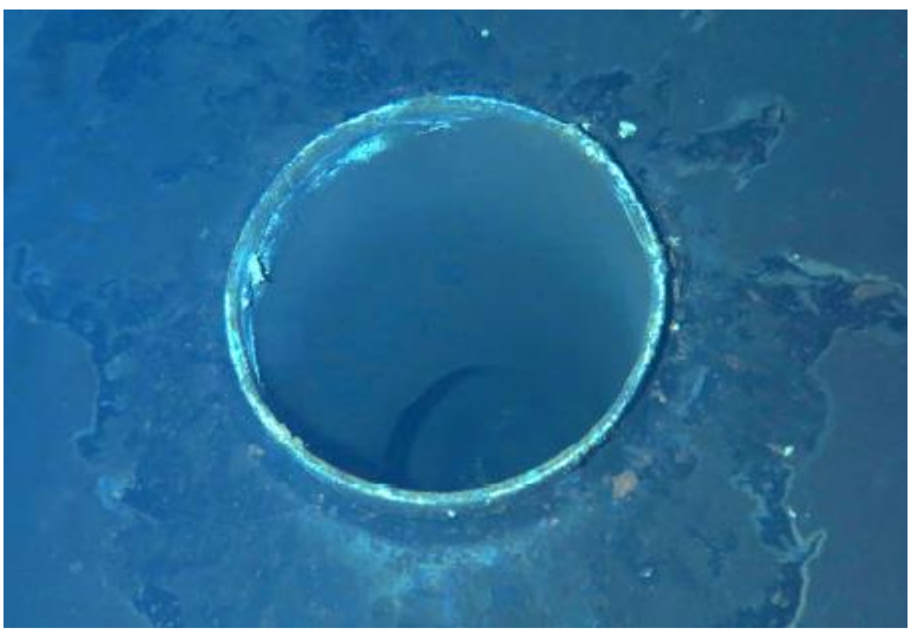

Figure 16: Tank Outlet (By CSI on 01/06/20)

AWWA guidelines determine the required minimum distance of floor connections from the shell wall. Assuming a ¼-inch thick floor plate, the edge of the drain and outlet should be at least 2.62 feet (1.62 feet + 1 foot) from the shell, based on equation 13-38 from AWWA D100. As stated previously, the tank outlet is four feet away from the shell wall and is compliant with AWWA standards while the drain does not meet the standard. The floor drain is only two feet away from the shell wall and is not compliant with AWWA standards. It is recommended that the City consider the relocation of the floor drain to comply with current AWWA standards.

There appears to be no existing flexible connections on the tank outlet or drain. MKN recommends that the City install double ball articulating joints beyond the tank footprint for both lines to provide adequate flexibility, provide some resistance to shear forces that can develop during a seismic event, and are suitable for buried applications.

5 SUMMARY OF RECOMMENDATIONS

5.1 Rehabilitation Alternatives

MKN has developed three main tank rehabilitation alternatives for the City's consideration. The alternatives developed include the "least cost" alternative (Alternative 1), which results in the loss of significant storage volume, and two solutions that require either raising of the roof and tank shell to maintain a storage capacity closer to the existing volume or strengthening the lower shell courses to optimize the maximum operating height.

5.1.1 Alternative 1 – Reduce Operating Level

The baseline, lowest cost alternative to bring the existing tank into compliance with the current AWWA D100 Standard is to reduce the operating level of the tank. This option minimizes the modifications required to the existing tank shell by reducing the forces on the shell by lowering the maximum operating level. To bring the tank utilization ratio to within 1.0, the tank maximum operating level must be reduced to 29-feet. The maximum operating capacity of the tank reduces to 5.519 MG with this option. Reducing the maximum operating level to 29-feet also addresses any freeboard concerns. The City may elect to modify the overflow elevation as is appropriate to accommodate infrequent emergency storage volume at its own risk, although the tank will not meet current AWWA requirements if operated above 29-feet.

5.1.2 Alternative 2 – Retrofitting Lower Two Shell Courses

This alternative allows the tank to have a maximum operating level of approximately 31-feet by strengthening the overstressed lower two shell courses fitting and welding on ½" thick steel sheets around the bottom two courses. Note that retrofitting only the lower course does not allow increasing the operating level.

5.1.3 Alternative 3 – Increase Tank Height, Add Course to Bottom of Existing Tank

This alternative keeps the tank near 7.5 MG of capacity by adding a thickened 8-foot steel shell course to the bottom of the existing tank. This option would require the existing tank to be detached from the existing tank floor, shored in place, and lifted 8-feet for the new steel to be installed. By adding an 8-foot course the tank can be operated at a maximum operating level of 35-feet and brings the total tank height to 48.5-feet. The maximum operating capacity of the tank is 6.662 MG with this option. Having the operating level at 35-feet and raising the overall tank height also meets freeboard requirements.

5.2 Recommendations Common to Alternatives 1 Through 3

The following improvements are recommended for all rehab alternatives and the associated costs of these improvements are included in the cost estimates presented in Table 9 of Section 5.4 below.

Table 8: Recommendation Summary		
Item	**Recommendation**	**Notes**
Demolition and Replacement of Existing Roof	Demolition and replacement of the existing roof with a new free-span aluminum dome roof system.	
Interior and Exterior Blasting and Coating	Remove interior and exterior coatings by abrasive blasting and coat.	• Include requirements in contract documents for contractor to prepare a plan to protect its workers and the environment from heavy metals. Proper Disposal will also be required.
Ladders, Appurtenances, and Safety Upgrades	Replace and add all recommended parts per the "Tank Appurtenances" section in the report.	• Add a fall prevention system to the exterior ladder. • Install a new interior cageless ladder with a fall prevention system. • Install a new level gauge system. • Install new roof hatches. • Add a second 30-inch diameter manway.
Flexible Connections	Add flexible connections to all tank connections to comply with AWWA Standards	• Single-arch rubber expansion joint shall be utilized on aboveground applications such as inlet and overflow and double-ball flexible couplings shall be utilized for below grade applications such as outlet and drain. • If airgap is provided on tank overflow, no flexible coupling is required.
Piping Modifications	Repair coatings and linings in the immediate vicinity of any piping modifications to accommodate adding the recommended flexible connections.	

5.3 Replacement Alternatives

MKN evaluated replacing the existing reservoir with an AWWA D110 Prestressed Concrete Tank and an AWWA D100 Welded Steel Tank.

MKN has developed two main tank replacement alternatives for the City of Coalinga's consideration, with Alternative 4 having a lower life cycle cost but a higher capital cost than Alternative 5:

5.3.1 Alternative 4 – Replace Existing Tank with a Prestressed Concrete Tank (AWWA D110 Type 1)

The existing steel tank would be replaced with a new, 7.0 MG, AWWA D110 Type 1 Circular prestressed concrete tank. Prestressed concrete tanks have a relatively lower total life-cycle cost of ownership when compared to other types of water tanks for multiple reasons. Unlike steel water tanks, they do not require coatings which is a significant recurring maintenance cost. Also, they allow for soil to be backfilled against the exterior walls of the tank and can be placed below grade, featuring a lower profile above finished grade. This alternative would be designed in accordance with ANSI/AWWA D110-13 standard which dictates the design for wire-wound and strand-wound circular, pre-stressed concrete water tanks.

If a "Column Supported Flat Slab Concrete" roof type is chosen, the capacity for this tank would be from the finished floor elevation to the top of the overflow at wall, along with a 180' inside diameter, a 38' side water depth, and a 5.5' assumed freeboard. This takes into consideration a 2% floor slope and the existence of interior columns to support the roof. If a "Concrete Dome Roof" type is chosen, the capacity for this tank would be from the finished floor elevation to the top of the overflow at wall, along with a 178' inside diameter, a 38' side water depth, and a 5.5' assumed freeboard. This takes into consideration a 0% floor slope and the absence of interior columns for the "Free Span Concrete Dome" roof type. This recommendation is provided based on the assumption that the tank is to be backfilled to an at-grade level, and that no excessive live load is present on the roof of the tank.

One disadvantage for having a prestressed concrete tank is the high capital cost. It is important to note that the replacement cost presented in this report account for favorable geotechnical conditions which would result in the use of an optimized 6-inch membrane floor slab. Further investigation would be required.

5.3.2 Alternative 5 – Replace Existing Tank with a Welded Steel Tank (AWWA D100)

The existing steel tank would be replaced with a new, 7.0 MG, AWWA D100 steel tank. Steel tanks are long-lasting, durable structures when properly maintained. With the right selection and application of coatings and cathodic protection, the structures are highly resistant to effects of corrosion. One of the key benefits to constructing a welded steel tank is the constructability. They do not require extensive equipment or laydown areas, as compared to prestressed concrete tanks. Also, welded steel tanks have a relatively lower capital cost than prestressed concrete tanks. This alternative would be designed in accordance with ANSI/AWWA D100 standard which dictates the design for welded carbon steel tanks.

The new steel tank would have a cone-shaped roof with 3/16" plate thickness and floor plates with a ¼" thickness. This alternative assumes the construction of a concrete ringwall foundation and the addition of an impressed current cathodic protection system to help mitigate corrosion of the tank metals. The new tank would be coated with a 12-mil epoxy coating system on the interior and a 6-mil epoxy urethane coating on the exterior. Shop and field painter is expected to have at least ten (10) years of field erected water tank abrasive blasting and coating experience. This alternative would also include installation of all necessary tank appurtenances.

A disadvantage of a welded steel tank is the higher life-cycle cost in comparison with a prestressed concrete tank. Steel corrodes and rusts if not well maintained. Also, steel tanks must be taken out of service for longer periods of time during interior recoating projects, while pre-stressed concrete tanks do not require interior coatings.

5.4 Alternatives Cost Comparison

Table 9 summarizes and compares the different cost opinions for the rehabilitation and replacement alternatives.

Table 9: Relative Cost Comparisons for Rehabilitation and Replacement Alternatives

Item	Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
1	Mobilization (10%)	$239,000	$317,000	$420,000	$410,000	$576,000
2	Interior Blasting and Coating	$813,000	$813,000	$858,000		
3	Exterior Blasting and Coating	$533,000	$533,000	$583,000		
4	Ladders, Appurtenances, Safety Upgrades	$60,000	$60,000	$60,000		
5	Demo and Replacement of Fixed Roof	$830,000	$830,000	$830,000		
6	Tank overflow	$12,500	$12,500	$12,500		
7	Tank Flex Joints	$70,000	$70,000	$70,000	$70,000	$70,000
8	Flex Joints Installation	$10,000	$10,000	$10,000	$10,000	$10,000
9	Piping Modifications	$40,000	$40,000	$40,000		
10	Cathodic Protection	$20,000	$20,000	$20,000		
11	Containment and Abrasive Disposal	$310,000	$310,000	$310,000		
12	Retrofitting First Bottom Course (8')					
13	Retrofitting Two Bottom Courses (16')		$775,000			
14	Adding 8' Lower Shell Course			$1,715,000		
15	New Welded Steel 7.0 MG Tank				$3,625,000	
16	New Prestressed Concrete 7.0 MG Tank					$5,100,000
17	Demolition of Existing Tank				$75,000	$75,000
18	Tank Appurtenances				$25,000	$100,000
19	Site Work and Mechanical				$286,000	$402,000
	Construction Subtotal	$2,937,500	$3,790,500	$4,928,500	$4,501,000	$6,333,000
	Contingency	$293,750[1]	$1,137,150[2]	$1,478,550[2]	$1,350,300[2]	$1,899,900[2]
	Total	$3,232,000	$4,928,000	$6,408,000	$5,852,000	$8,233,000

[1] Contingency is taken as 10% of the Construction Total
[2] Contingency is taken as 30% of the Construction Total

5.5 Welded Steel Vs. Prestressed Concrete Tank Life Cycle Cost Analysis

Typically, pre-stressed concrete tanks have a higher construction capital cost than welded steel tanks. However, pre-stressed concrete tanks have a lower maintenance cost than welded steel tanks. Welded steel tanks require periodic inspection and exterior and interior re-coating application that contain associated engineering, inspection, and construction management costs. Pre-stressed concrete tanks require power washing and inspection as part of their routine maintenance, but the cost is significantly less than welded steel tanks.

The life cycle cost analysis is based on the following assumptions:

- Initial cost based on vendor quotes for at-grade 7 MG tank on an ideal site.
- Coating period for steel tank is 20 years, totaling $1,804,354.50 per period based on $10/square foot for exterior recoating and $11/square foot for interior coating.
- Maintenance period for pre-stressed concrete option is 20 years, totaling $100,000.00 per period consisting of power washing, routine maintenance, and inspection.

The results of the life cycle cost analysis are provided as Figure 17. As illustrated in the figure, while the steel tank option has a higher 100-year life cycle cost by approximately 66%, the breakeven point is at approximately 30 years.

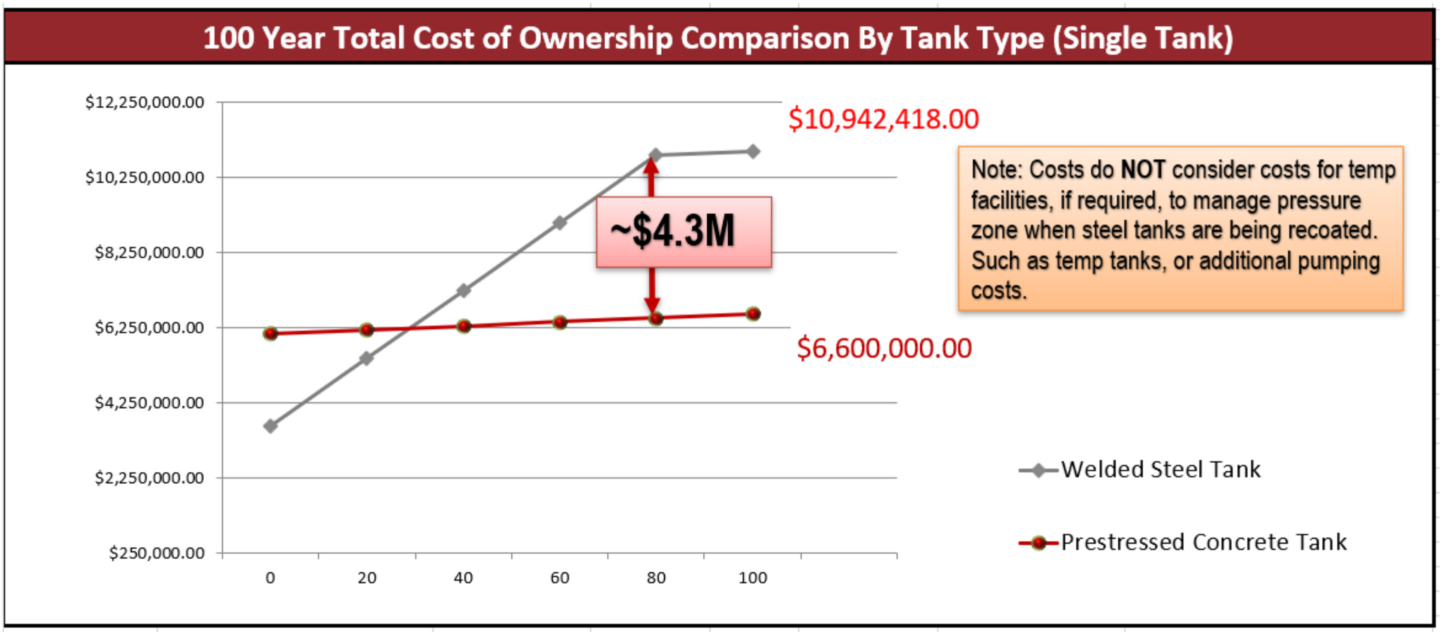

Figure 17: 100 Year Total Cost of Ownership Comparison by Tank Type (By DN Tanks)

ATTACHMENTS

Attachment 1: Preliminary Opinion of Construction Cost

Attachment 2: Structural Calculations By SSG Structural Engineers, LLP

ATTACHMENT 1

Preliminary Opinion of Construction Cost

City of Coalinga
7.5 MILLION GALLON WATER TANK REHABILITATION
DRAFT OPINION OF PROBABLE CONSTRUCTION COST
ALTERNATIVE 1
July 2021

Item	Description	Quantity	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$238,850	$239,000
2	Interior Blasting and Coating	81232	SF	$10	$813,000
3	Exterior Blasting and Coating	48400	SF	$11	$533,000
4	Ladders, Appurtenances, Safety Upgrades	1	EA	$60,000	$60,000
5	Demo and Replacement of Fixed Roof	1	EA	$830,000	$830,000
6	Tank overflow	1	EA	$12,500	$12,500
7	Tank Flex Joints	1	EA	$69,982	$70,000
8	Flex Joints Installation	1	LS	$10,000	$10,000
9	Piping Modifications	1	LS	$40,000	$40,000
10	Cathodic Protection	1	EA	$20,000	$20,000
11	Containment and Abrasive Disposal	1	EA	$310,000	$310,000

Subtotal (not including optional items)	$2,937,500
Contingency 10%	$293,750
Total	$3,232,000

Prepared By: Ammar Hanna, EIT
Prepared on: 8/2/2021

The opinion of probable construction cost presented here is only an opinion of possible construction costs for budgeting purposes. This opinion is limited to the conditions existing at issuance and is not a guaranty of actual price or cost. Uncertain market conditions such as, but not limited to, local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events and developing bidding conditions, etc. may affect the accuracy of this estimate. MKN & Associates, Inc., is not responsible for any variance from this budgetary opinion of construction cost or actual prices and conditions obtained. The opinion of probable construction cost is based on the draft design plans prepared for the City; addition or subtraction of design elements will impact the final project cost.

City of Coalinga
7.5 MILLION GALLON WATER TANK REHABILITATION
DRAFT OPINION OF PROBABLE CONSTRUCTION COST
ALTERNATIVE 2
July 2021

Item	Description	Quantity	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$316,350	$317,000
2	Interior Blasting and Coating	81232	SF	$10	$813,000
3	Exterior Blasting and Coating	48400	SF	$11	$533,000
4	Retrofitting Two Bottom Courses (16')	1	EA	$775,000	$775,000
5	Ladders, Appurtenances, Safety Upgrades	1	EA	$60,000	$60,000
6	Demo and Replacement of Fixed Roof	1	EA	$830,000	$830,000
7	Tank overflow	1	EA	$12,500	$12,500
8	Tank Flex Joints	1	EA	$69,982	$70,000
9	Flex Joints Installation	1	LS	$10,000	$10,000
10	Piping Modifications	1	LS	$40,000	$40,000
11	Cathodic Protection	1	EA	$20,000	$20,000
12	Containment and Abrasive Disposal	1	EA	$310,000	$310,000

Subtotal (not including optional items)	$3,790,500
Contingency 30%	$1,137,150
Total	$4,928,000

Prepared By: Ammar Hanna, EIT
Prepared on: 8/2/2021

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City of Coalinga

7.5 MILLION GALLON WATER TANK REHABILITATION

DRAFT OPINION OF PROBABLE CONSTRUCTION COST

ALTERNATIVE 3

July 2021

Item	Description	Quantity	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$419,850	$420,000
2	Interior Blasting and Coating	85756	SF	$10	$858,000
3	Exterior Blasting and Coating	52924	SF	$11	$583,000
4	Adding 8' Lower Shell Course	1	EA	$1,714,286	$1,715,000
5	Ladders, Appurtenances, Safety Upgrades	1	EA	$60,000	$60,000
6	Demo and Replacement of Fixed Roof	1	EA	$830,000	$830,000
7	Tank overflow	1	EA	$12,500	$12,500
8	Tank Flex Joints	1	EA	$69,982	$70,000
9	Flex Joints Installation	1	LS	$10,000	$10,000
10	Piping Modifications	1	LS	$40,000	$40,000
11	Cathodic Protection	1	EA	$20,000	$20,000
12	Containment and Abrasive Disposal	1	EA	$310,000	$310,000

Subtotal (not including optional items)	$4,928,500
Contingency 30%	$1,478,550
Total	$6,408,000

Prepared By: Ammar Hanna, EIT

Prepared on: 8/2/2021

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City of Coalinga
7.5 MILLION GALLON WATER TANK REHABILITATION
DRAFT OPINION OF PROBABLE CONSTRUCTION COST
ALTERNATIVE 4
July 2021

Item	Description	Quantity	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$409,100	$410,000
4	New Welded Steel 7.0 MG Tank	1	EA	$3,625,000	$3,625,000
5	Demolition of Existing Tank	1	EA	$75,000	$75,000
7	Tank Flex Joints	1	EA	$69,982	$70,000
8	Flex Joints Installation	1	LS	$10,000	$10,000
9	Tank Appurtenances	1	EA	$25,000	$25,000
10	Site Work and Mechanical	1	LS	$286,000	$286,000

Subtotal (not including optional items)	$4,501,000
Contingency 30%	$1,350,300
Total	$5,852,000

Prepared By: Ammar Hanna, EIT
Prepared on: 8/2/2021

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City of Coalinga
7.5 MILLION GALLON WATER TANK REHABILITATION
DRAFT OPINION OF PROBABLE CONSTRUCTION COST
ALTERNATIVE 5
July 2021

Item	Description	Quantity	Unit	Unit Price	Amount
1	Mobilization (10%)	1	LS	$575,700	$576,000
4	New Prestressed Concrete 7.0 MG Tank	1	EA	$5,100,000	$5,100,000
5	Demolition of Existing Tank	1	EA	$75,000	$75,000
7	Tank Flex Joints	1	EA	$69,982	$70,000
8	Flex Joints Installation	1	LS	$10,000	$10,000
9	Tank Appurtenances	1	EA	$100,000	$100,000
10	Site Work and Mechanical	1	LS	$402,000	$402,000

Subtotal (not including optional items)	$6,333,000
Contingency 30%	$1,899,900
Total	$8,233,000

Prepared By: Ammar Hanna, EIT
Prepared on: 8/2/2021

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ATTACHMENT 2

Structural Calculations By SSG Structural Engineers, LLP

Existing Tank Condition
Seismic and Shell Analysis

Seismic Design Calculations

Site Ground Motion Design

Ac = Compute Impulsive Design Response Spectrum Acceleration Coefficient per AWWA D100-11 13.2.9.2
Af = Compute Acceleration Coefficient for Sloshing Wave Height per AWWA D100-11 13.5.4.4
Ai = Compute Impulsive Design Response Spectrum Acceleration Coefficient per AWWA D100-11 13.2.9.2
Anchorage_System = Anchorage System
Av = Vertical Ground Acceleration Coefficient per AWWA D100-11 13.5.4.1 and 13.5.4.3
D = Nominal Tank Diameter (ft)
Fa = Site Acceleration Coefficient
Fv = Site Velocity Coefficient
I = Importance Factor
K = Spectral Acceleration Adjustment Coefficient
Lmax = Maximum Design Product Level (ft)
Rwc = Convective Force Reduction Factor
Rwi = Impulsive Force Reduction Factor
S1 = Spectral Response Acceleration at a Period of One Second
SD1 = Compute Design Spectral Response Acceleration at a Period of One Second per AWWA D100-11 13.2.7.3
SDS = Compute Design Spectral Response Acceleration at Short Period per AWWA D100-11 13.2.7.3
SM1 = Compute Maximum Considered Earthquake Spectral Response Acceleration at a Period of One Second per AWWA D100-11 13.2.7.2
SMS = Compute Maximum Considered Earthquake Spectral Response Acceleration at Short Period per AWWA D100-11 13.2.7.2
SUG = Seismic Use Group
Sac = Compute Convective Design Response Spectrum Acceleration Coefficient For Convective Components per AWWA D100-11 13.2.7.3.2
Sai =
Seismic_Site_Class = Seismic Site Class
Ss = Spectral Response Acceleration Short Period
TL = Regional Dependent Transistion Period for Longer Period Ground Motion (sec)
Tc = Compute Convective Natural Period per AWWA D100-11 13.5.1 (sec)
Ti = Structure Natural Period (sec)
U = Scaling Factor
d_ratio = Dampening Ratio
g = Acceleration Due To Gravity (ft/sec^2)
structure_type = Structure Type

Anchorage_System = SELF-ANCHORED
D = 180.0825 ft
Fa = 1.0
Fv = 1.3
I = 1.5
K = 1.5
Lmax = 40.5 ft
Rwc = 1.5
Rwi = 2.5
S1 = 0.593
SUG = SEISMIC-USE-GROUP-III
Seismic_Site_Class = SEISMIC-SITE-CLASS-C
Ss = 1.794
TL = 12 sec

Ti = 0 sec
U = 0.6667
d_ratio = 0.05
g = 32.17 ft/sec^2
structure_type = GROUND-SUPPORTED-FLAT-BOTTOM-TANK

Tc = 2 * pi * SQRT((D / (3.68 * g * TANH(((3.68 * Lmax) / D)))))
Tc = 2 * pi * SQRT((180.0825 / (3.68 * 32.17 * TANH(((3.68 * 40.5) / 180.0825)))))
Tc = 9.403 sec

SMS = Fa * Ss
SMS = 1.0 * 1.794
SMS = 1.794

SM1 = Fv * S1
SM1 = 1.3 * 0.593
SM1 = 0.7709

SDS = U * SMS
SDS = 0.6667 * 1.794
SDS = 1.196

SD1 = U * SM1
SD1 = 0.6667 * 0.7709
SD1 = 0.5139

Sai = SDS
Sai = 1.196
Sai = 1.196

Sac = MIN(((K * SD1) / Tc) , SDS)
Sac = MIN(((1.5 * 0.5139) / 9.403) , 1.196)
Sac = 0.082

Ai = MAX(((Sai * I) / (1.4 * Rwi)) , ((0.36 * S1 * I) / Rwi))
Ai = MAX(((1.196 * 1.5) / (1.4 * 2.5)) , ((0.36 * 0.593 * 1.5) / 2.5))
Ai = 0.5126

Ac = (Sac * I) / (1.4 * Rwc)
Ac = (0.082 * 1.5) / (1.4 * 1.5)
Ac = 0.0586

Av = 0.14 * SDS
Av = 0.14 * 1.196
Av = 0.1674

Af = (K * SD1) / Tc
Af = (1.5 * 0.5139) / 9.403
Af = 0.082

Seismic Design

A = Roof Surface Area (ft^2)
Ac = Convective Design Response Spectrum Acceleration Coefficient
Af = Acceleration Coefficient for Sloshing Wave Height
Ah-rs = Roof Horizontal Projected Area Supported by The Shell (ft^2)

Ai = Impulsive Design Response Spectrum Acceleration Coefficient
Anchorage_System = Anchorage System
Arss = Roof Area Supported by The Shell (ft^2)
Av = Vertical Ground Acceleration Coefficient
CA = Bottom Corrosion Allowance (in)
D = Nominal Tank Diameter (ft)
DELTA_Cc = Compute Pressure Stabilizing Buckling Coefficient per AWWA D100-11 13.5.4.2.4
DELTA_SIGMAcr = Compute Self Anchored Tank Critical Buckling Stress Increase Caused By Pressure Equation per AWWA D100-11 13.5.4.2.4 (lb/in^2)
Fa = Site Acceleration Coefficient
Freeboard = Actual Freeboard (ft)
Fv = Site Velocity Coefficient
Hs = Shell Total Height (ft)
Hs = Shell height (ft)
I = Importance Factor
J = Compute Anchorage Ratio per AWWA D100-11 13.5.4.1
K = Spectral Acceleration Adjustment Coefficient
L_max = Compute Annular Ring Required Minimum Width Max Limit per AWWA D100-11 13.5.4.1.2 (ft)
Lmax = Maximum Design Product Level (ft)
Ls = Actual Annular Ring Width (ft)
Ma = Material Name
Mmf = Compute Overturning Moment per AWWA D100-11 13.5.2.1 (ft.lb)
Ms = Compute Overturning Moment per AWWA D100-11 13.5.2.1 (ft.lb)
P = Design Pressure (lbf/in^2)
R = (ft)
S1 = Spectral Response Acceleration at a Period of One Second
SD1 = Design Spectral Response Acceleration at a Period of 1 Second
SDS = Design Spectral Response Acceleration at Short Period
SG = Specific Gravity
SIGMAc_self_anchored = Compute Self Anchored Maximum Longitudinal Shell Compression Stress per AWWA D100-11 13.5.4.2.1 (lbf/in^2)
SIGMAe_self_anchored = Compute Seismic Allowable Longitudinal Compressive Stress per AWWA D100-11 13.5.4.2.4 (lb/in^2)
SUG = Seismic Use Group
Seismic_Site_Class = Seismic Site Class
Ss = Spectral Response Acceleration Short Period
TL = Regional Dependent Transistion Period for Longer Period Ground Motion (sec)
Tc = Convective Natural Period (sec)
U = Scaling Factor
V_allow = Compute Self Anchored Sliding Resistance Base Shear per AWWA D100-11 13.5.4.6 (lbf)
Vf = Compute Total Design Base Shear per AWWA D100-11 13.5.3.1 (lbf)
Wc = Compute Convective Effective Weight per AWWA D100-11 13.5.2.2.1 (lbf)
Wf = Tank Bottom Total Weight (lbf)
Wi = Compute Impulsive Effective Weight per AWWA D100-11 13.5.2.2.1 (lbf)
Wp = Tank Contents Total Weight (lbf)
Wr = Total Weight of Fixed Tank Roof including Framing, Knuckles, any Permanent Attachments and 10 % of the Roof Balanced Design Snow Load (lbf)
Wrs = Roof Load Acting on The Tank Shell Including 10 % of the Roof Balanced Design Snow Load (lbf)
Ws = Total Weight of Tank Shell and Appurtenances (lbf)
Wss = Roof Structure Weight Supported by The Tank Shell (lb)
Xc = Height from tank shell bottom to the center of action of convective lateral force for computing ringwall overturning moment per AWWA D100-11 13.5.2.2.2 (ft)
Xcmf = Height from tank shell bottom to the center of action of convective lateral force for computing slab overturning moment per AWWA D100-11 13.5.3.2.2 (ft)
Xi = Height from tank shell bottom to the center of action of impulsive lateral force for computing ringwall overturning moment per AWWA D100-11 13.5.2.2.2 (ft)

Ximf = Height from tank shell bottom to the center of action of impulsive lateral force for computing slab overturning moment per AWWA D100-11 13.5.3.2.2 (ft)
Xs = Height from tank shell bottom to shell's center of gravity (ft)
ca1 = Bottom Shell Course Corrosion Allowance (in)
ca_annulus = Bottom Annular Ring Design Corrosion Allowance (in)
d = Sloshing Wave Height Above Product Design Height per AWWA D100-11 Section 13.5.4.4 (ft)
g = Acceleration Due To Gravity (ft/sec^2)
lw = Lap of the Bottom Plates Over the Annular Plate (in)
outside_projection = Bottom Outside Projection (in)
site_ground_motion_input_mode = Site Ground Motion Input Mode
t_bottom = Bottom Plate Thickness (in)
tb = Bottom Annular Ring Design Thickness (in)
tb_less_ca = Bottom Annular Ring Design Thickness Without Corrosion Allowance (in)
tb_limited_less_ca = (in)
ts1 = Bottom Shell Course Thickness (in)
ts_less_ca = Bottom Shell Course Thickness Without Corrosion Allowance (in)
using_annular_ring = Using Annular Ring
wL = Compute Self Anchored Force Resisting Uplift per AWWA D100-11 13.5.4.1.1 (lbf/ft)
wrs = Specified Tank Roof Load Acting on Tank Shell (lbf/ft)
wt = Compute Tank and Roof Weight Acting at base of Shell per AWWA D100-11 13.5.4.2.1 (lbf/ft)

A = 25,554.4252 ft^2
Ac = 0.0586
Af = 0.082
Ah-rs = 8,638.5493 ft^2
Ai = 0.5126
Anchorage_System = SELF-ANCHORED
Arss = 8,655.405 ft^2
Av = 0.1674
CA = 0 in
D = 180.0825 ft
Fa = 1.0
Fv = 1.3
Hs = 40.5 ft
Hs = 40.5 ft
I = 1.5
K = 1.5
Lmax = 40.5 ft
Ls = 2.1258 ft
Ma = A36
P = 0.0 lbf/in^2
S1 = 0.593
SD1 = 0.5139
SDS = 1.196
SG = 1
SUG = SEISMIC-USE-GROUP-III
Seismic_Site_Class = SEISMIC-SITE-CLASS-C
Ss = 1.794
TL = 12 sec
Tc = 9.403 sec
U = 0.6667
Wp = 64,338,160.6538 lbf
Wss = 24,091.3622 lb
Xs = 15.8876 ft
ca1 = 0 in
ca_annulus = 0 in

g = 32.17 ft/sec^2
lw = 1.5 in
outside_projection = 2 in
site_ground_motion_input_mode = ASCE7-MAPPED-SS-AND-S1
t_bottom = 0.25 in
tb = 0.25 in
ts1 = 0.99 in
using_annular_ring = t

Wf = Wb-pl
Wf = 259,765.8038
Wf = 259,765.8038 lbf

Wr = (Wr-pl + Wr-attachments + W-struct + Wr-DL-add) + (0.1 * Sb * Ah)
Wr = (195,468.3541 + 0.0 + 152,898.1204 + 0.0) + (0.1 * 0.0 * 25,504.66)
Wr = 348,366.4745 lbf

Wrs = ((Wr-pl + Wr-attachments + Wr-DL-add) * (Arss / A)) + Wss + (0.1 * Sb * Ah-rs)
Wrs = ((195,468.3541 + 0.0 + 0.0) * (8,655.405 / 25,554.4252)) + 24,091.3622 + (0.1 * 0.0 * 8,638.5493)
Wrs = 90,297.4209 lbf

Ws = Ws-pl + Ws-framing + Ws-attachments
Ws = 580,034.4853 + 4,057.6387 + 4.0
Ws = 584,096.124 lbf

R = D / 2
R = 180.0825 / 2
R = 90.0412 ft

tb_less_ca = tb - ca_annulus
tb_less_ca = 0.25 - 0
tb_less_ca = 0.25 in

ts_less_ca = ts1 - ca1
ts_less_ca = 0.99 - 0
ts_less_ca = 0.99 in

tb_limited_less_ca = MIN(tb_less_ca , ts_less_ca)
tb_limited_less_ca = MIN(0.25 , 0.99)
tb_limited_less_ca = 0.25 in

Effective weight of product

Wi = (TANH((0.866 * (D / Lmax))) / (0.866 * (D / Lmax))) * Wp
Wi = (TANH((0.866 * (180.0825 / 40.5))) / (0.866 * (180.0825 / 40.5))) * 64,338,160.6538
Wi = 16,693,271.3711 lbf

Wc = 0.23 * (D / Lmax) * TANH(((3.67 * Lmax) / D)) * Wp
Wc = 0.23 * (180.0825 / 40.5) * TANH(((3.67 * 40.5) / 180.0825)) * 64,338,160.6538
Wc = 44,609,953.2195 lbf

Center of action for effective lateral forces

Xi = 0.375 * Lmax
Xi = 0.375 * 40.5
Xi = 15.1875 ft

Xc = (1.0 - ((COSH(((3.67 * Lmax) / D)) - 1) / (((3.67 * Lmax) / D) * SINH(((3.67 * Lmax) / D))))) * Lmax
Xc = (1.0 - ((COSH(((3.67 * 40.5) / 180.0825)) - 1) / (((3.67 * 40.5) / 180.0825) * SINH(((3.67 * 40.5) / 180.0825))))) * 40.5
Xc = 21.3263 ft

Ximf = 0.375 * (1.0 + ((4 / 3) * (((0.866 * (D / Lmax)) / TANH((0.866 * (D / Lmax)))) - 1.0))) * Lmax
Ximf = 0.375 * (1.0 + ((4 / 3) * (((0.866 * (180.0825 / 40.5)) / TANH((0.866 * (180.0825 / 40.5)))) - 1.0))) * 40.5
Ximf = 72.9838 ft

Xcmf = (1.0 - ((COSH(((3.67 * Lmax) / D)) - 1.937) / (((3.67 * Lmax) / D) * SINH(((3.67 * Lmax) / D))))) * Lmax
Xcmf = (1.0 - ((COSH(((3.67 * 40.5) / 180.0825)) - 1.937) / (((3.67 * 40.5) / 180.0825) * SINH(((3.67 * 40.5) / 180.0825))))) * 40.5
Xcmf = 71.1757 ft

Overturning moment

Ms = SQRT((((Ai * ((Ws * Xs) + (Wr * Hs) + (Wi * Xi)))^2) + ((Ac * (Wc * Xc))^2)))
Ms = SQRT((((0.5126 * ((584,096.124 * 15.8876) + (348,366.4745 * 40.5) + (16,693,271.3711 * 15.1875)))^2) + ((0.0586 * (44,609,953.2195 * 21.3263))^2)))
Ms = 152,482,250.1501 ft.lb

Mmf = SQRT((((Ai * ((Ws * Xs) + (Wr * Hs) + (Wi * Ximf)))^2) + ((Ac * (Wc * Xcmf))^2)))
Mmf = SQRT((((0.5126 * ((584,096.124 * 15.8876) + (348,366.4745 * 40.5) + (16,693,271.3711 * 72.9838)))^2) + ((0.0586 * (44,609,953.2195 * 71.1757))^2)))
Mmf = 663,077,019.526 ft.lb

Resistance to design loads

wL = MIN((7.9 * tb_limited_less_ca * SQRT((Fy * Lmax * SG))) , (1.28 * Lmax * D * SG))
wL = MIN((7.9 * 0.25 * SQRT((36,000 * 40.5 * 1))) , (1.28 * 40.5 * 180.0825 * 1))
wL = 2,384.7665 lbf/ft

wrs = Wrs / (pi * D)
wrs = 90,297.4209 / (pi * 180.0825)
wrs = 159.6077 lbf/ft

wt = (Ws / (pi * D)) + wrs
wt = (584,096.124 / (pi * 180.0825)) + 159.6077
wt = 1,192.0433 lbf/ft

Tank Stability

J = Ms / ((D^2) * ((wt * (1 - (0.4 * Av))) + wL))
J = 152,482,250.1501 / ((180.0825^2) * ((1,192.0433 * (1 - (0.4 * 0.1674))) + 2,384.7665))
J = 1.3446

Bottom Annular Plates requirements

As per AWWA 3.10.8
Ls >= 18 ==> PASS

L_max = 0.035 * D
L_max = 0.035 * 180.0825
L_max = 6.3029 ft

As per AWWA 13.5.4.1
Ls <= L_max ==> PASS

Shell Stresses
SIGMAc_self_anchored = ((((wt * (1 + (0.4 * Av))) + wL) / (0.607 - (0.18667 * (J^2.3)))) - wL) * (1 / (12 * ts_less_ca))
SIGMAc_self_anchored = ((((1,192.0433 * (1 + (0.4 * 0.1674))) + 2,384.7665) / (0.607 - (0.18667 * (1.3446^2.3)))) - 2,384.7665) * (1 / (12 * 0.99))
SIGMAc_self_anchored = 1,091.5415 lbf/in^2

DELTA_Cc = 0.72 * (((P / E) * ((R / ts_less_ca)^2))^0.84)
DELTA_Cc = 0.72 * (((0.0 / 28,800,000) * ((1,080.495 / 0.99)^2))^0.84)
DELTA_Cc = 0.0

DELTA_SIGMAcr = (DELTA_Cc * E * ts_less_ca) / R
DELTA_SIGMAcr = (0.0 * 28,800,000 * 0.99) / 1,080.495
DELTA_SIGMAcr = 0.0 lb/in^2

FL = Compute Allowable Local Buckling Compressive Stress per AWWA D100-11 Section 3.4.3.1.2 (lb/in^2)
Material_Class = Compute Material Class From Minimum Yield Strength per AWWA D100-11 Section 3.2 and Table 4
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = Thickness Radius Ratio Boundary Elastic Inelastic Buckling per AWWA D100-11 Sections 3.4.3.1.1 and 3.4.3.1.2

Material_Class = :material-class-2
Material_Class = :material-class-2
Material_Class = :material-class-2

Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035372
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035372
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035

FL = 17.5 * (10^5) * (ts_less_ca / R) * (1 + (50000 * ((ts_less_ca / R)^2)))
FL = 17.5 * (10^5) * (0.99 / 1,080.495) * (1 + (50000 * ((0.99 / 1,080.495)^2)))
FL = 1,670.7365 lb/in^2

Allowable Local Buckling Compressive Stress (FL) = 1,670.7365 lb/in^2

SIGMAe_self_anchored = 1.333 * (FL + (DELTA_SIGMAcr / 2))
SIGMAe_self_anchored = 1.333 * (1,670.7365 + (0.0 / 2))
SIGMAe_self_anchored = 2,227.0917 lb/in^2

Freeboard
d = 0.5 * D * Af
d = 0.5 * 180.0825 * 0.082
d = 7.3834 ft [88.6006 in]

Freeboard = Hs - Lmax-operating
Freeboard = 40.5 - 40.5
Freeboard = 0.0 ft [0.0 in]

(SDS >= One_Third_g) AND (SUG = :seismic-use-group-iii)

[Required]
Sloshing Wave Height Above Product Design Height (d) = 7.3834 ft

Freeboard < d ==> FAIL

***** WARNING *** :** Freeboard, 0.0 ft [0.0 in], is less than the required value of 7.3834 ft [88.6006 in]

Sliding Resistance

Vf = SQRT((((Ai * (Ws + Wr + Wf + Wi))^2) + ((Ac * Wc)^2)))
Vf = SQRT((((0.5126 * (584,096.124 + 348,366.4745 + 259,765.8038 + 16,693,271.3711))^2) + ((0.0586 * 44,609,953.2195)^2)))
Vf = 9,532,536.4861 lbf

V_allow = TAN(30) * (Ws + Wr + Wi + Wc) * (1 - (0.4 * Av))
V_allow = TAN(30) * (584,096.124 + 348,366.4745 + 16,693,271.3711 + 44,609,953.2195) * (1 - (0.4 * 0.1674))
V_allow = 33,525,798.0431 lbf

Vf <= V_allow

Shell Design Calculations

Ac = Convective Design Response Spectrum Acceleration Coefficient
Ai = Impulsive Design Response Spectrum Acceleration Coefficient
Av = Vertical ground acceleration coefficient description
CG-shell = Shell center of gravity (ft)
D = Tank Nominal Diameter (ft)
Hs = Shell height (ft)
Lmax = Max Liquid Level (ft)
P = Design Internal Pressure (psi)
Pv = Design External Pressure (psf)
SG = Product Design Specific Gravity
SGt = Hydrotest Specific Gravity
V = Wind velocity (mile/hr)
W-ins = Shell Insulation Weight (lbf)
W-shell = Shell Nominal Weight (lb)
W-shell-corr = Shell Corroded Weight (lb)
ds-ins = Insulation Density (lbf/ft^3)
h-min = Minimum Shell Course Height per API-650 5.6.1.2 (in)
ts-ins = Insulation Thickness (in)

Ac = 0.0586
Ai = 0.5126
Av = 0.1674
D = 180.0825 ft
Hs = 40.5 ft
Lmax = 40.5 ft
P = 0.0 psi
Pv = 0.0 psf
SG = 1
SGt = 1
V = 100.0 mile/hr
ds-ins = 8 lbf/ft^3
h-min = 96 in
ts-ins = 0 in

Course # 1 (bottom course) Design

CA = Corrosion allowance (in)
D1 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-1 = Shell Course Nominal Weight (lb)
W-1-corr = Shell Course Nominal Weight (lb)
h1 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 40.5 ft

JE = 1
Ma = A36
h1 = 8.0 ft
loc = 0 ft
t = 0.99 in

Shell Course Center of Gravity (CG-1) = 4.0 ft

D1 = ID + t
D1 = 2,160.0 + 0.99
D1 = 2,160.99 in

W-1 = pi * D1 * t * h1 * d
W-1 = pi * 2,160.99 * 0.99 * 96.0 * 0.2833
W-1 = 182,791.3465 lb

W-1-corr = pi * D1 * (t - CA) * h1 * d
W-1-corr = pi * 2,160.99 * (0.99 - 0) * 96.0 * 0.2833
W-1-corr = 182,791.3465 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi
Maximum Thickness (t-max) = 0.75 in

t > t-max ==> FAIL

***** WARNING *** :** Course-1, installed thickness , 0.99 in, is greater than the maximum allowable thickness of 0.75 in for A36 material

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 40.5
hp = 40.5 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0825 * 40.5 * 1) / (1 * 15,000)) + 0
td = 1.2642 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 40.5 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0825 * 40.5 * ((40.5 / 40.5) - (0.5 * ((40.5 / 40.5)^2))) * TANH((0.866 * (180.0825 / 40.5)))

Ni = 8,403.7019 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0586 * 1 * (180.0825^2) * COSH(((3.68 * (40.5 - 40.5)) / 180.0825))) / COSH(((3.68 * 40.5) / 180.0825))
Nc = 1,365.9694 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (40.5 - 0) * 180.0825 * 1
Nh = 18,962.6872 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (18,962.6872 + SQRT(((8,403.7019^2) + (1,365.9694^2) + (((0.1674 * 18,962.6872) / 2.5)^2)))) / MAX((0.99 - 0) , 0.0001)
S_T+ = 27,849.335 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (18,962.6872 - SQRT(((8,403.7019^2) + (1,365.9694^2) + (((0.1674 * 18,962.6872) / 2.5)^2)))) / MAX((0.99 - 0) , 0.0001)
S_T- = 10,459.1241 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((27,849.335 * (0.99 - 0)) / 19,950.0) + 0
ts = 1.382 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 1.2642 , 1.382)
t-min = 1.382 in

t < t-min ==> FAIL

***** WARNING *** :** Course 1 thickness, 0.99 in, is less than the required value of 1.382 in

Course # 2 Design

CA = Corrosion allowance (in)
D2 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-2 = Shell Course Nominal Weight (lb)
W-2-corr = Shell Course Nominal Weight (lb)
h2 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 32.5 ft
JE = 1
Ma = A36
h2 = 8.0 ft
loc = 8.0 ft
t = 0.79 in

Shell Course Center of Gravity (CG-2) = 12.0 ft

D2 = ID + t
D2 = 2,160.0 + 0.79
D2 = 2,160.79 in

W-2 = pi * D2 * t * h2 * d
W-2 = pi * 2,160.79 * 0.79 * 96.0 * 0.2833
W-2 = 145,850.302 lb

W-2-corr = pi * D2 * (t - CA) * h2 * d
W-2-corr = pi * 2,160.79 * (0.79 - 0) * 96.0 * 0.2833
W-2-corr = 145,850.302 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi
Maximum Thickness (t-max) = 0.75 in

t > t-max ==> FAIL

***** WARNING *** :** Course-2, installed thickness , 0.79 in, is greater than the maximum allowable thickness of 0.75 in for A36 material

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 32.5
hp = 32.5 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0825 * 32.5 * 1) / (1 * 15,000)) + 0
td = 1.0145 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 32.5 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))

Ni = 4.5 * 0.5126 * 1 * 180.0825 * 40.5 * ((32.5 / 40.5) - (0.5 * ((32.5 / 40.5)^2))) * TANH((0.866 * (180.0825 / 40.5)))
Ni = 8,075.8026 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0586 * 1 * (180.0825^2) * COSH(((3.68 * (40.5 - 32.5)) / 180.0825))) / COSH(((3.68 * 40.5) / 180.0825))
Nc = 1,384.2635 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (32.5 - 0) * 180.0825 * 1
Nh = 15,216.9712 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (15,216.9712 + SQRT(((8,075.8026^2) + (1,384.2635^2) + (((0.1674 * 15,216.9712) / 2.5)^2)))) / MAX((0.79 - 0) , 0.0001)
S_T+ = 29,713.4997 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (15,216.9712 - SQRT(((8,075.8026^2) + (1,384.2635^2) + (((0.1674 * 15,216.9712) / 2.5)^2)))) / MAX((0.79 - 0) , 0.0001)
S_T- = 8,810.4782 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((29,713.4997 * (0.79 - 0)) / 19,950.0) + 0
ts = 1.1766 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 1.0145 , 1.1766)
t-min = 1.1766 in

t < t-min ==> FAIL

***** WARNING *** :** Course 2 thickness, 0.79 in, is less than the required value of 1.1766 in

Course # 3 Design
CA = Corrosion allowance (in)
D3 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-3 = Shell Course Nominal Weight (lb)
W-3-corr = Shell Course Nominal Weight (lb)
h3 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)

td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 24.5 ft
JE = 1
Ma = A36
h3 = 8.0 ft
loc = 16.0 ft
t = 0.59 in

Shell Course Center of Gravity (CG-3) = 20.0 ft

D3 = ID + t
D3 = 2,160.0 + 0.59
D3 = 2,160.59 in

W-3 = pi * D3 * t * h3 * d
W-3 = pi * 2,160.59 * 0.59 * 96.0 * 0.2833
W-3 = 108,916.0929 lb

W-3-corr = pi * D3 * (t - CA) * h3 * d
W-3-corr = pi * 2,160.59 * (0.59 - 0) * 96.0 * 0.2833
W-3-corr = 108,916.0929 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 24.5
hp = 24.5 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0825 * 24.5 * 1) / (1 * 15,000)) + 0
td = 0.7648 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 24.5 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0825 * 40.5 * ((24.5 / 40.5) - (0.5 * ((24.5 / 40.5)^2))) * TANH((0.866 * (180.0825 / 40.5)))
Ni = 7,092.1045 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0586 * 1 * (180.0825^2) * COSH(((3.68 * (40.5 - 24.5)) / 180.0825))) / COSH(((3.68 * 40.5) / 180.0825))
Nc = 1,439.6358 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (24.5 - 0) * 180.0825 * 1
Nh = 11,471.2553 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (11,471.2553 + SQRT(((7,092.1045^2) + (1,439.6358^2) + (((0.1674 * 11,471.2553) / 2.5)^2)))) / MAX((0.59 - 0) , 0.0001)
S_T+ = 31,777.3757 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (11,471.2553 - SQRT(((7,092.1045^2) + (1,439.6358^2) + (((0.1674 * 11,471.2553) / 2.5)^2)))) / MAX((0.59 - 0) , 0.0001)
S_T- = 7,108.2354 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((31,777.3757 * (0.59 - 0)) / 19,950.0) + 0
ts = 0.9398 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.7648 , 0.9398)
t-min = 0.9398 in

t < t-min ==> FAIL

***** WARNING *** :** Course 3 thickness, 0.59 in, is less than the required value of 0.9398 in

Course # 4 Design
CA = Corrosion allowance (in)
D4 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-4 = Shell Course Nominal Weight (lb)
W-4-corr = Shell Course Nominal Weight (lb)
h4 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 16.5 ft

JE = 1
Ma = A36
h4 = 8.0 ft
loc = 24.0 ft
t = 0.4 in

Shell Course Center of Gravity (CG-4) = 28.0 ft

D4 = ID + t
D4 = 2,160.0 + 0.4
D4 = 2,160.4 in

W-4 = pi * D4 * t * h4 * d
W-4 = pi * 2,160.4 * 0.4 * 96.0 * 0.2833
W-4 = 73,834.9254 lb

W-4-corr = pi * D4 * (t - CA) * h4 * d
W-4-corr = pi * 2,160.4 * (0.4 - 0) * 96.0 * 0.2833
W-4-corr = 73,834.9254 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 16.5
hp = 16.5 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0825 * 16.5 * 1) / (1 * 15,000)) + 0
td = 0.515 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 16.5 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0825 * 40.5 * ((16.5 / 40.5) - (0.5 * ((16.5 / 40.5)^2))) * TANH((0.866 * (180.0825 / 40.5)))
Ni = 5,452.6077 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0586 * 1 * (180.0825^2) * COSH(((3.68 * (40.5 - 16.5)) / 180.0825))) / COSH(((3.68 * 40.5) / 180.0825))
Nc = 1,533.5694 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (16.5 - 0) * 180.0825 * 1
Nh = 7,725.5393 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (7,725.5393 + SQRT(((5,452.6077^2) + (1,533.5694^2) + (((0.1674 * 7,725.5393) / 2.5)^2)))) / MAX((0.4 - 0) , 0.0001)
S_T+ = 33,533.1939 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (7,725.5393 - SQRT(((5,452.6077^2) + (1,533.5694^2) + (((0.1674 * 7,725.5393) / 2.5)^2)))) / MAX((0.4 - 0) , 0.0001)
S_T- = 5,094.5023 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((33,533.1939 * (0.4 - 0)) / 19,950.0) + 0
ts = 0.6723 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.515 , 0.6723)
t-min = 0.6723 in

t < t-min ==> FAIL

***** WARNING *** :** Course 4 thickness, 0.4 in, is less than the required value of 0.6723 in

Course # 5 Design
CA = Corrosion allowance (in)
D5 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-5 = Shell Course Nominal Weight (lb)
W-5-corr = Shell Course Nominal Weight (lb)
h5 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 8.5 ft
JE = 1
Ma = A36
h5 = 8.5 ft
loc = 32.0 ft

t = 0.35 in

Shell Course Center of Gravity (CG-5) = 36.25 ft

D5 = ID + t
D5 = 2,160.0 + 0.35
D5 = 2,160.35 in

W-5 = pi * D5 * t * h5 * d
W-5 = pi * 2,160.35 * 0.35 * 102.0 * 0.2833
W-5 = 68,641.8185 lb

W-5-corr = pi * D5 * (t - CA) * h5 * d
W-5-corr = pi * 2,160.35 * (0.35 - 0) * 102.0 * 0.2833
W-5-corr = 68,641.8185 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 8.5
hp = 8.5 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0825 * 8.5 * 1) / (1 * 15,000)) + 0
td = 0.2653 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 8.5 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0825 * 40.5 * ((8.5 / 40.5) - (0.5 * ((8.5 / 40.5)^2))) * TANH((0.866 * (180.0825 / 40.5)))
Ni = 3,157.3122 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0586 * 1 * (180.0825^2) * COSH(((3.68 * (40.5 - 8.5)) / 180.0825))) / COSH(((3.68 * 40.5) / 180.0825))
Nc = 1,668.5804 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (8.5 - 0) * 180.0825 * 1
Nh = 3,979.8233 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (3,979.8233 + SQRT(((3,157.3122^2) + (1,668.5804^2) + (((0.1674 * 3,979.8233) / 2.5)^2)))) / MAX((0.35 - 0) , 0.0001)
S_T+ = 21,602.4464 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (3,979.8233 - SQRT(((3,157.3122^2) + (1,668.5804^2) + (((0.1674 * 3,979.8233) / 2.5)^2)))) / MAX((0.35 - 0) , 0.0001)
S_T- = 1,139.4008 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((21,602.4464 * (0.35 - 0)) / 19,950.0) + 0
ts = 0.379 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.2653 , 0.379)
t-min = 0.379 in

t < t-min ==> FAIL

***** WARNING *** :** Course 5 thickness, 0.35 in, is less than the required value of 0.379 in

W-ins = ts-ins * ds-ins * pi * (OD + ts-ins) * Hs
W-ins = 0.0 * 8 * pi * (180.165 + 0.0) * 40.5
W-ins = 0.0 lbf

W-shell-corr = W-1-corr + W-2-corr + W-3-corr + W-4-corr + W-5-corr
W-shell-corr = 182,791.3465 + 145,850.302 + 108,916.0929 + 73,834.9254 + 68,641.8185
W-shell-corr = 580,034.4853 lb

W-shell = W-1 + W-2 + W-3 + W-4 + W-5
W-shell = 182,791.3465 + 145,850.302 + 108,916.0929 + 73,834.9254 + 68,641.8185
W-shell = 580,034.4853 lb

CG-shell = ((CG-1 * W-1) + (CG-2 * W-2) + (CG-3 * W-3) + (CG-4 * W-4) + (CG-5 * W-5)) / W-shell
CG-shell = ((4.0 * 182,791.3465) + (12.0 * 145,850.302) + (20.0 * 108,916.0929) + (28.0 * 73,834.9254) + (36.25 * 68,641.8185)) / 580,034.4853
CG-shell = 15.8876 ft

Shell Design Summary

Course	Height (ft)	Material	CA (in)	JE	Sy (psi)	Sut (psi)	Sd (psi)	St (psi)	t-erec (in)
5	8.5	A36	0	1	36,000	58,000	15,000	15,000	0.3125
4	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
3	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
2	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125

1	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125

Shell Design Summary (continued)

Course	t-design (in)	t-test (in)	t-seismic (in)	t-ext (in)	t-min (in)	t-installed (in)	Status	H-max-@-Pi (ft)	Pi-max-@-H (psi)
5	0.2653	N/A	0.379	N/A	0.379	0.35	FAIL	44.2128	1.6096
4	0.515	N/A	0.6723	N/A	0.6723	0.4	FAIL	37.8146	0.0
3	0.7648	N/A	0.9398	N/A	0.9398	0.59	FAIL	35.9016	0.0
2	1.0145	N/A	1.1766	N/A	1.1766	0.79	FAIL	34.3089	0.0
1	1.2642	N/A	1.382	N/A	1.382	0.99	FAIL	32.7162	0.0

Intermediate Stiffeners Design

Stiffeners Design For Wind Loading

D = Nominal Tank Diameter (ft)
N = Actual Wind Girders Quantity
Ns = Required Number of Girders per API 650 5.9.6.3 and 5.9.6.4
V = Wind velocity (mile/hr)
h = Maximum Unstiffened Transformed Shell Height per AWWA-D100-11 3.5.2 (ft)
ts_min = Thickness of the Thinnest Shell Course

D = 180.0825 ft
N = 0
V = 100.0 mile/hr

Shell Courses Heights (W) = [8.0 8.0 8.0 8.0 8.5] ft

ts_min = MIN(ts_corr_1 , ts_corr_2 , ts_corr_3 , ts_corr_4 , ts_corr_5)
ts_min = MIN(0.99 , 0.79 , 0.59 , 0.4 , 0.35)
ts_min = 0.35

Stiffeners Required Quantity

HTS = Height of Transformed Shell per API 650 5.9.6.2 (ft)

Transformed shell courses heights

Variable	Equation	Value	Unit
Wtr_1	W_1 * SQRT(((ts_min / ts_corr_1)^5))	0.5945	ft
Wtr_2	W_2 * SQRT(((ts_min / ts_corr_2)^5))	1.0452	ft
Wtr_3	W_3 * SQRT(((ts_min / ts_corr_3)^5))	2.1684	ft
Wtr_4	W_4 * SQRT(((ts_min / ts_corr_4)^5))	5.7294	ft
Wtr_5	W_5 * SQRT(((ts_min / ts_corr_5)^5))	8.5000	ft

HTS = Wtr_1 + Wtr_2 + Wtr_3 + Wtr_4 + Wtr_5
HTS = 0.5945 + 1.0452 + 2.1684 + 5.7294 + 8.5
HTS = 18.0375 ft

h = (10.625 * (10^6) * ts_min) / (PWS * ((D / ts_min)^1.5))

h = (10.625 * (10^6) * 0.35) / (18.0 * ((180.0825 / 0.35)^1.5))
h = 17.7019 ft

Ns = CEILING(((HTS / h) - 1))
Ns = CEILING(((18.0375 / 17.7019) - 1))
Ns = 1

N < Ns ==> FAIL

***** WARNING *** :** Number of intermediate stiffeners, 0, is less than the required number of 1

Option 1
Seismic and Shell Analysis

Seismic Design Calculations

Site Ground Motion Design

Ac = Compute Impulsive Design Response Spectrum Acceleration Coefficient per AWWA D100-11 13.2.9.2
Af = Compute Acceleration Coefficient for Sloshing Wave Height per AWWA D100-11 13.5.4.4
Ai = Compute Impulsive Design Response Spectrum Acceleration Coefficient per AWWA D100-11 13.2.9.2
Anchorage_System = Anchorage System
Av = Vertical Ground Acceleration Coefficient per AWWA D100-11 13.5.4.1 and 13.5.4.3
D = Nominal Tank Diameter (ft)
Fa = Site Acceleration Coefficient
Fv = Site Velocity Coefficient
I = Importance Factor
K = Spectral Acceleration Adjustment Coefficient
Lmax = Maximum Design Product Level (ft)
Rwc = Convective Force Reduction Factor
Rwi = Impulsive Force Reduction Factor
S1 = Spectral Response Acceleration at a Period of One Second
SD1 = Compute Design Spectral Response Acceleration at a Period of One Second per AWWA D100-11 13.2.7.3
SDS = Compute Design Spectral Response Acceleration at Short Period per AWWA D100-11 13.2.7.3
SM1 = Compute Maximum Considered Earthquake Spectral Response Acceleration at a Period of One Second per AWWA D100-11 13.2.7.2
SMS = Compute Maximum Considered Earthquake Spectral Response Acceleration at Short Period per AWWA D100-11 13.2.7.2
SUG = Seismic Use Group
Sac = Compute Convective Design Response Spectrum Acceleration Coefficient For Convective Components per AWWA D100-11 13.2.7.3.2
Sai =
Seismic_Site_Class = Seismic Site Class
Ss = Spectral Response Acceleration Short Period
TL = Regional Dependent Transistion Period for Longer Period Ground Motion (sec)
Tc = Compute Convective Natural Period per AWWA D100-11 13.5.1 (sec)
Ti = Structure Natural Period (sec)
U = Scaling Factor
d_ratio = Dampening Ratio
g = Acceleration Due To Gravity (ft/sec^2)
structure_type = Structure Type

Anchorage_System = SELF-ANCHORED
D = 180.0828 ft
Fa = 1.0
Fv = 1.5
I = 1.5
K = 1.5
Lmax = 29 ft
Rwc = 1.5
Rwi = 2.5
S1 = 0.593
SUG = SEISMIC-USE-GROUP-III
Seismic_Site_Class = SEISMIC-SITE-CLASS-D
Ss = 1.794
TL = 12 sec

Ti = 0 sec
U = 0.6667
d_ratio = 0.05
g = 32.17 ft/sec^2
structure_type = GROUND-SUPPORTED-FLAT-BOTTOM-TANK

Tc = 2 * pi * SQRT((D / (3.68 * g * TANH(((3.68 * Lmax) / D)))))
Tc = 2 * pi * SQRT((180.0828 / (3.68 * 32.17 * TANH(((3.68 * 29) / 180.0828)))))
Tc = 10.6268 sec

SMS = Fa * Ss
SMS = 1.0 * 1.794
SMS = 1.794

SM1 = Fv * S1
SM1 = 1.5 * 0.593
SM1 = 0.8895

SDS = U * SMS
SDS = 0.6667 * 1.794
SDS = 1.196

SD1 = U * SM1
SD1 = 0.6667 * 0.8895
SD1 = 0.593

Sai = SDS
Sai = 1.196
Sai = 1.196

Sac = MIN(((K * SD1) / Tc) , SDS)
Sac = MIN(((1.5 * 0.593) / 10.6268) , 1.196)
Sac = 0.0837

Ai = MAX(((Sai * I) / (1.4 * Rwi)) , ((0.36 * S1 * I) / Rwi))
Ai = MAX(((1.196 * 1.5) / (1.4 * 2.5)) , ((0.36 * 0.593 * 1.5) / 2.5))
Ai = 0.5126

Ac = (Sac * I) / (1.4 * Rwc)
Ac = (0.0837 * 1.5) / (1.4 * 1.5)
Ac = 0.0598

Av = 0.14 * SDS
Av = 0.14 * 1.196
Av = 0.1674

Af = (K * SD1) / Tc
Af = (1.5 * 0.593) / 10.6268
Af = 0.0837

Seismic Design
A = Roof Surface Area (ft^2)
Ac = Convective Design Response Spectrum Acceleration Coefficient
Af = Acceleration Coefficient for Sloshing Wave Height
Ah-rs = Roof Horizontal Projected Area Supported by The Shell (ft^2)

Ai = Impulsive Design Response Spectrum Acceleration Coefficient
Anchorage_System = Anchorage System
Arss = Roof Area Supported by The Shell (ft^2)
Av = Vertical Ground Acceleration Coefficient
CA = Bottom Corrosion Allowance (in)
D = Nominal Tank Diameter (ft)
DELTA_Cc = Compute Pressure Stabilizing Buckling Coefficient per AWWA D100-11 13.5.4.2.4
DELTA_SIGMAcr = Compute Self Anchored Tank Critical Buckling Stress Increase Caused By Pressure Equation per AWWA D100-11 13.5.4.2.4 (lb/in^2)
Fa = Site Acceleration Coefficient
Freeboard = Actual Freeboard (ft)
Fv = Site Velocity Coefficient
Hs = Shell height (ft)
Hs = Shell Total Height (ft)
I = Importance Factor
J = Compute Anchorage Ratio per AWWA D100-11 13.5.4.1
K = Spectral Acceleration Adjustment Coefficient
Lmax = Maximum Design Product Level (ft)
Ls = Actual Annular Ring Width (ft)
Ma = Material Name
Mmf = Compute Overturning Moment per AWWA D100-11 13.5.2.1 (ft.lb)
Ms = Compute Overturning Moment per AWWA D100-11 13.5.2.1 (ft.lb)
P = Design Pressure (lbf/in^2)
R = (ft)
S1 = Spectral Response Acceleration at a Period of One Second
SD1 = Design Spectral Response Acceleration at a Period of 1 Second
SDS = Design Spectral Response Acceleration at Short Period
SG = Specific Gravity
SIGMAc_self_anchored = Compute Self Anchored Maximum Longitudinal Shell Compression Stress per AWWA D100-11 13.5.4.2.1 (lbf/in^2)
SIGMAe_self_anchored = Compute Seismic Allowable Longitudinal Compressive Stress per AWWA D100-11 13.5.4.2.4 (lb/in^2)
SUG = Seismic Use Group
Seismic_Site_Class = Seismic Site Class
Ss = Spectral Response Acceleration Short Period
TL = Regional Dependent Transistion Period for Longer Period Ground Motion (sec)
Tc = Convective Natural Period (sec)
U = Scaling Factor
V_allow = Compute Self Anchored Sliding Resistance Base Shear per AWWA D100-11 13.5.4.6 (lbf)
Vf = Compute Total Design Base Shear per AWWA D100-11 13.5.3.1 (lbf)
Wc = Compute Convective Effective Weight per AWWA D100-11 13.5.2.2.1 (lbf)
Wf = Tank Bottom Total Weight (lbf)
Wi = Compute Impulsive Effective Weight per AWWA D100-11 13.5.2.2.1 (lbf)
Wp = Tank Contents Total Weight (lbf)
Wr = Total Weight of Fixed Tank Roof including Framing, Knuckles, any Permanent Attachments and 10 % of the Roof Balanced Design Snow Load (lbf)
Wrs = Roof Load Acting on The Tank Shell Including 10 % of the Roof Balanced Design Snow Load (lbf)
Ws = Total Weight of Tank Shell and Appurtenances (lbf)
Wss = Roof Structure Weight Supported by The Tank Shell (lb)
Xc = Height from tank shell bottom to the center of action of convective lateral force for computing ringwall overturning moment per AWWA D100-11 13.5.2.2.2 (ft)
Xcmf = Height from tank shell bottom to the center of action of convective lateral force for computing slab overturning moment per AWWA D100-11 13.5.3.2.2 (ft)
Xi = Height from tank shell bottom to the center of action of impulsive lateral force for computing ringwall overturning moment per AWWA D100-11 13.5.2.2.2 (ft)
Ximf = Height from tank shell bottom to the center of action of impulsive lateral force for computing slab

overturning moment per AWWA D100-11 13.5.3.2.2 (ft)
Xs = Height from tank shell bottom to shell's center of gravity (ft)
ca1 = Bottom Shell Course Corrosion Allowance (in)
ca_annulus = Bottom Annular Ring Design Corrosion Allowance (in)
d = Sloshing Wave Height Above Product Design Height per AWWA D100-11 Section 13.5.4.4 (ft)
g = Acceleration Due To Gravity (ft/sec^2)
lw = Lap of the Bottom Plates Over the Annular Plate (in)
outside_projection = Bottom Outside Projection (in)
site_ground_motion_input_mode = Site Ground Motion Input Mode
t_bottom = Bottom Plate Thickness (in)
tb = Bottom Annular Ring Design Thickness (in)
tb_less_ca = Bottom Annular Ring Design Thickness Without Corrosion Allowance (in)
tb_limited_less_ca = (in)
ts1 = Bottom Shell Course Thickness (in)
ts_less_ca = Bottom Shell Course Thickness Without Corrosion Allowance (in)
using_annular_ring = Using Annular Ring
wL = Compute Self Anchored Force Resisting Uplift per AWWA D100-11 13.5.4.1.1 (lbf/ft)
wrs = Specified Tank Roof Load Acting on Tank Shell (lbf/ft)
wt = Compute Tank and Roof Weight Acting at base of Shell per AWWA D100-11 13.5.4.2.1 (lbf/ft)

A = 25,591.0721 ft^2
Ac = 0.0598
Af = 0.0837
Ah-rs = 8,675.0865 ft^2
Ai = 0.5126
Anchorage_System = SELF-ANCHORED
Arss = 8,692.0135 ft^2
Av = 0.1674
CA = 0 in
D = 180.0828 ft
Fa = 1.0
Fv = 1.5
Hs = 40.5 ft
Hs = 40.5 ft
I = 1.5
K = 1.5
Lmax = 29 ft
Ls = 2.1255 ft
Ma = A36
P = 0.0 lbf/in^2
S1 = 0.593
SD1 = 0.593
SDS = 1.196
SG = 1
SUG = SEISMIC-USE-GROUP-III
Seismic_Site_Class = SEISMIC-SITE-CLASS-D
Ss = 1.794
TL = 12 sec
Tc = 10.6268 sec
U = 0.6667
Wp = 46,069,300.2213 lbf
Wss = 23,642.8267 lb
Xs = 15.8724 ft
ca1 = 0 in
ca_annulus = 0 in
g = 32.17 ft/sec^2

lw = 1.5 in
outside_projection = 2 in
site_ground_motion_input_mode = ASCE7-MAPPED-SS-AND-S1
t_bottom = 0.25 in
tb = 0.25 in
ts1 = 0.994 in
using_annular_ring = t

Wf = Wb-pl
Wf = 259,766.7655
Wf = 259,766.7655 lbf

Wr = (Wr-pl + Wr-attachments + W-struct + Wr-DL-add) + (0.1 * Sb * Ah)
Wr = (260,998.2266 + 0.0 + 152,429.9155 + 0.0) + (0.1 * 0.0 * 25,541.2355)
Wr = 413,428.1421 lbf

Wrs = ((Wr-pl + Wr-attachments + Wr-DL-add) * (Arss / A)) + Wss + (0.1 * Sb * Ah-rs)
Wrs = ((260,998.2266 + 0.0 + 0.0) * (8,692.0135 / 25,591.0721)) + 23,642.8267 + (0.1 * 0.0 * 8,675.0865)
Wrs = 112,290.9341 lbf

Ws = Ws-pl + Ws-framing + Ws-attachments
Ws = 580,773.3759 + 9,920.082 + 4.0
Ws = 590,697.4579 lbf

R = D / 2
R = 180.0828 / 2
R = 90.0414 ft

tb_less_ca = tb - ca_annulus
tb_less_ca = 0.25 - 0
tb_less_ca = 0.25 in

ts_less_ca = ts1 - ca1
ts_less_ca = 0.994 - 0
ts_less_ca = 0.994 in

tb_limited_less_ca = MIN(tb_less_ca , ts_less_ca)
tb_limited_less_ca = MIN(0.25 , 0.994)
tb_limited_less_ca = 0.25 in

Effective weight of product

Wi = (TANH((0.866 * (D / Lmax))) / (0.866 * (D / Lmax))) * Wp
Wi = (TANH((0.866 * (180.0828 / 29))) / (0.866 * (180.0828 / 29))) * 46,069,300.2213
Wi = 8,566,449.8632 lbf

Wc = 0.23 * (D / Lmax) * TANH(((3.67 * Lmax) / D)) * Wp
Wc = 0.23 * (180.0828 / 29) * TANH(((3.67 * 29) / 180.0828)) * 46,069,300.2213
Wc = 34,913,729.6493 lbf

Center of action for effective lateral forces

Xi = 0.375 * Lmax
Xi = 0.375 * 29
Xi = 10.875 ft

Xc = (1.0 - ((COSH(((3.67 * Lmax) / D)) - 1) / (((3.67 * Lmax) / D) * SINH(((3.67 * Lmax) / D))))) * Lmax

Xc = (1.0 - ((COSH(((3.67 * 29) / 180.0828)) - 1) / (((3.67 * 29) / 180.0828) * SINH(((3.67 * 29) / 180.0828))))) * 29
Xc = 14.9078 ft

Ximf = 0.375 * (1.0 + ((4 / 3) * (((0.866 * (D / Lmax)) / TANH((0.866 * (D / Lmax)))) - 1.0))) * Lmax
Ximf = 0.375 * (1.0 + ((4 / 3) * (((0.866 * (180.0828 / 29)) / TANH((0.866 * (180.0828 / 29)))) - 1.0))) * 29
Ximf = 74.3542 ft

Xcmf = (1.0 - ((COSH(((3.67 * Lmax) / D)) - 1.937) / (((3.67 * Lmax) / D) * SINH(((3.67 * Lmax) / D))))) * Lmax
Xcmf = (1.0 - ((COSH(((3.67 * 29) / 180.0828)) - 1.937) / (((3.67 * 29) / 180.0828) * SINH(((3.67 * 29) / 180.0828))))) * 29
Xcmf = 88.3524 ft

Overturning moment

Ms = SQRT((((Ai * ((Ws * Xs) + (Wr * Hs) + (Wi * Xi)))^2) + ((Ac * (Wc * Xc))^2)))
Ms = SQRT((((0.5126 * ((590,697.4579 * 15.8724) + (413,428.1421 * 40.5) + (8,566,449.8632 * 10.875)))^2) + ((0.0598 * (34,913,729.6493 * 14.9078))^2)))
Ms = 68,603,346.1485 ft.lb

Mmf = SQRT((((Ai * ((Ws * Xs) + (Wr * Hs) + (Wi * Ximf)))^2) + ((Ac * (Wc * Xcmf))^2)))
Mmf = SQRT((((0.5126 * ((590,697.4579 * 15.8724) + (413,428.1421 * 40.5) + (8,566,449.8632 * 74.3542)))^2) + ((0.0598 * (34,913,729.6493 * 88.3524))^2)))
Mmf = 386,686,755.762 ft.lb

Resistance to design loads

wL = MIN((7.9 * tb_limited_less_ca * SQRT((Fy * Lmax * SG))) , (1.28 * Lmax * D * SG))
wL = MIN((7.9 * 0.25 * SQRT((36,000 * 29 * 1))) , (1.28 * 29 * 180.0828 * 1))
wL = 2,017.9823 lbf/ft

wrs = Wrs / (pi * D)
wrs = 112,290.9341 / (pi * 180.0828)
wrs = 198.4826 lbf/ft

wt = (Ws / (pi * D)) + wrs
wt = (590,697.4579 / (pi * 180.0828)) + 198.4826
wt = 1,242.5846 lbf/ft

Tank Stability

J = Ms / ((D^2) * ((wt * (1 - (0.4 * Av))) + wL))
J = 68,603,346.1485 / ((180.0828^2) * ((1,242.5846 * (1 - (0.4 * 0.1674))) + 2,017.9823))
J = 0.6658

Bottom Annular Plates requirements

As per AWWA 3.10.8
Ls >= 18 ==> PASS

Shell Stresses

SIGMAc_self_anchored = ((wt * (1 + (0.4 * Av))) + ((1.273 * Ms) / (D^2))) * (1 / (12 * ts_less_ca))
SIGMAc_self_anchored = ((1,242.5846 * (1 + (0.4 * 0.1674))) + ((1.273 * 68,603,346.1485) / (180.0828^2))) * (1 / (12 * 0.994))
SIGMAc_self_anchored = 336.9167 lbf/in^2

DELTA_Cc = 0.72 * (((P / E) * ((R / ts_less_ca)^2))^0.84)
DELTA_Cc = 0.72 * (((0.0 / 28,800,000) * ((1,080.497 / 0.994)^2))^0.84)

DELTA_Cc = 0.0

DELTA_SIGMAcr = (DELTA_Cc * E * ts_less_ca) / R
DELTA_SIGMAcr = (0.0 * 28,800,000 * 0.994) / 1,080.497
DELTA_SIGMAcr = 0.0 lb/in^2

FL = Compute Allowable Local Buckling Compressive Stress per AWWA D100-11 Section 3.4.3.1.2 (lb/in^2)
Material_Class = Compute Material Class From Minimum Yield Strength per AWWA D100-11 Section 3.2 and Table 4
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = Thickness Radius Ratio Boundary Elastic Inelastic Buckling per AWWA D100-11 Sections 3.4.3.1.1 and 3.4.3.1.2

Material_Class = :material-class-2
Material_Class = :material-class-2
Material_Class = :material-class-2

Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035372
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035372
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035

FL = 17.5 * (10^5) * (ts_less_ca / R) * (1 + (50000 * ((ts_less_ca / R)^2)))
FL = 17.5 * (10^5) * (0.994 / 1,080.497) * (1 + (50000 * ((0.994 / 1,080.497)^2)))
FL = 1,678.0307 lb/in^2

Allowable Local Buckling Compressive Stress (FL) = 1,678.0307 lb/in^2

SIGMAe_self_anchored = 1.333 * (FL + (DELTA_SIGMAcr / 2))
SIGMAe_self_anchored = 1.333 * (1,678.0307 + (0.0 / 2))
SIGMAe_self_anchored = 2,236.815 lb/in^2

Freeboard

d = 0.5 * D * Af
d = 0.5 * 180.0828 * 0.0837
d = 7.5365 ft [90.4376 in]

Freeboard = Hs - Lmax-operating
Freeboard = 40.5 - 29
Freeboard = 11.5 ft [138.0 in]

(SDS >= One_Third_g) AND (SUG = :seismic-use-group-iii)

[Required]
Sloshing Wave Height Above Product Design Height (d) = 7.5365 ft

Freeboard >= d ==> PASS

Sliding Resistance

Vf = SQRT((((Ai * (Ws + Wr + Wf + Wi))^2) + ((Ac * Wc)^2)))
Vf = SQRT((((0.5126 * (590,697.4579 + 413,428.1421 + 259,766.7655 + 8,566,449.8632))^2) + ((0.0598 * 34,913,729.6493)^2)))
Vf = 5,454,024.2158 lbf

V_allow = TAN(30) * (Ws + Wr + Wi + Wc) * (1 - (0.4 * Av))

V_allow = TAN(30) * (590,697.4579 + 413,428.1421 + 8,566,449.8632 + 34,913,729.6493) * (1 - (0.4 * 0.1674))
V_allow = 23,963,290.1418 lbf

Vf <= V_allow

Shell Design Calculations

Ac = Convective Design Response Spectrum Acceleration Coefficient
Ai = Impulsive Design Response Spectrum Acceleration Coefficient
Av = Vertical ground acceleration coefficient description
CG-shell = Shell center of gravity (ft)
D = Tank Nominal Diameter (ft)
Hs = Shell height (ft)
Lmax = Max Liquid Level (ft)
P = Design Internal Pressure (psi)
Pv = Design External Pressure (psf)
SG = Product Design Specific Gravity
SGt = Hydrotest Specific Gravity
V = Wind velocity (mile/hr)
W-ins = Shell Insulation Weight (lbf)
W-shell = Shell Nominal Weight (lb)
W-shell-corr = Shell Corroded Weight (lb)
ds-ins = Insulation Density (lbf/ft^3)
h-min = Minimum Shell Course Height per API-650 5.6.1.2 (in)
ts-ins = Insulation Thickness (in)

Ac = 0.0598
Ai = 0.5126
Av = 0.1674
D = 180.0828 ft
Hs = 40.5 ft
Lmax = 29 ft
P = 0.0 psi
Pv = 0.0 psf
SG = 1
SGt = 1
V = 5.0 mile/hr
ds-ins = 8 lbf/ft^3
h-min = 96 in
ts-ins = 0 in

Course # 1 (bottom course) Design

CA = Corrosion allowance (in)
D1 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-1 = Shell Course Nominal Weight (lb)
W-1-corr = Shell Course Nominal Weight (lb)
h1 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 29 ft

JE = 1
Ma = A36
h1 = 8.0 ft
loc = 0 ft
t = 0.994 in

Shell Course Center of Gravity (CG-1) = 4.0 ft

D1 = ID + t
D1 = 2,160.0 + 0.994
D1 = 2,160.994 in

W-1 = pi * D1 * t * h1 * d
W-1 = pi * 2,160.994 * 0.994 * 96.0 * 0.2833
W-1 = 183,530.2371 lb

W-1-corr = pi * D1 * (t - CA) * h1 * d
W-1-corr = pi * 2,160.994 * (0.994 - 0) * 96.0 * 0.2833
W-1-corr = 183,530.2371 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi
Maximum Thickness (t-max) = 0.75 in

t > t-max ==> FAIL

***** WARNING *** :** Course-1, installed thickness , 0.994 in, is greater than the maximum allowable thickness of 0.75 in for A36 material

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 29
hp = 29 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0828 * 29 * 1) / (1 * 15,000)) + 0
td = 0.9052 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 29 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0828 * 29 * ((29 / 29) - (0.5 * ((29 / 29)^2))) * TANH((0.866 * (180.0828 / 29)))
Ni = 6,022.6649 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0598 * 1 * (180.0828^2) * COSH(((3.68 * (29 - 29)) / 180.0828))) / COSH(((3.68 * 29) / 180.0828))
Nc = 1,609.2027 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (29 - 0) * 180.0828 * 1
Nh = 13,578.2456 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (13,578.2456 + SQRT(((6,022.6649^2) + (1,609.2027^2) + (((0.1674 * 13,578.2456) / 2.5)^2)))) / MAX((0.994 - 0) , 0.0001)
S_T+ = 19,998.1287 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (13,578.2456 - SQRT(((6,022.6649^2) + (1,609.2027^2) + (((0.1674 * 13,578.2456) / 2.5)^2)))) / MAX((0.994 - 0) , 0.0001)
S_T- = 7,322.285 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((19,998.1287 * (0.994 - 0)) / 19,950.0) + 0
ts = 0.9964 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.9052 , 0.9964)
t-min = 0.9964 in

t < t-min ==> FAIL

***** WARNING *** :** Course 1 thickness, 0.994 in, is less than the required value of 0.9964 in

Course # 2 Design
CA = Corrosion allowance (in)
D2 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-2 = Shell Course Nominal Weight (lb)
W-2-corr = Shell Course Nominal Weight (lb)
h2 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in

H = 21.0 ft
JE = 1
Ma = A36
h2 = 8.0 ft
loc = 8.0 ft
t = 0.79 in

Shell Course Center of Gravity (CG-2) = 12.0 ft

D2 = ID + t
D2 = 2,160.0 + 0.79
D2 = 2,160.79 in

W-2 = pi * D2 * t * h2 * d
W-2 = pi * 2,160.79 * 0.79 * 96.0 * 0.2833
W-2 = 145,850.302 lb

W-2-corr = pi * D2 * (t - CA) * h2 * d
W-2-corr = pi * 2,160.79 * (0.79 - 0) * 96.0 * 0.2833
W-2-corr = 145,850.302 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi
Maximum Thickness (t-max) = 0.75 in

t > t-max ==> FAIL

***** WARNING *** :** Course-2, installed thickness , 0.79 in, is greater than the maximum allowable thickness of 0.75 in for A36 material

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 21.0
hp = 21.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0828 * 21.0 * 1) / (1 * 15,000)) + 0
td = 0.6555 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 21.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0828 * 29 * ((21.0 / 29) - (0.5 * ((21.0 / 29)^2))) * TANH((0.866 * (180.0828 /

29)))
Ni = 5,564.3408 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0598 * 1 * (180.0828^2) * COSH(((3.68 * (29 - 21.0)) / 180.0828))) / COSH(((3.68 * 29) / 180.0828))
Nc = 1,630.7542 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (21.0 - 0) * 180.0828 * 1
Nh = 9,832.5227 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (9,832.5227 + SQRT(((5,564.3408^2) + (1,630.7542^2) + (((0.1674 * 9,832.5227) / 2.5)^2)))) / MAX((0.79 - 0) , 0.0001)
S_T+ = 19,833.1201 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (9,832.5227 - SQRT(((5,564.3408^2) + (1,630.7542^2) + (((0.1674 * 9,832.5227) / 2.5)^2)))) / MAX((0.79 - 0) , 0.0001)
S_T- = 5,059.3425 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((19,833.1201 * (0.79 - 0)) / 19,950.0) + 0
ts = 0.7854 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.6555 , 0.7854)
t-min = 0.7854 in

Course # 3 Design
CA = Corrosion allowance (in)
D3 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-3 = Shell Course Nominal Weight (lb)
W-3-corr = Shell Course Nominal Weight (lb)
h3 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 13.0 ft
JE = 1

Ma = A36
h3 = 8.0 ft
loc = 16.0 ft
t = 0.59 in

Shell Course Center of Gravity (CG-3) = 20.0 ft

D3 = ID + t
D3 = 2,160.0 + 0.59
D3 = 2,160.59 in

W-3 = pi * D3 * t * h3 * d
W-3 = pi * 2,160.59 * 0.59 * 96.0 * 0.2833
W-3 = 108,916.0929 lb

W-3-corr = pi * D3 * (t - CA) * h3 * d
W-3-corr = pi * 2,160.59 * (0.59 - 0) * 96.0 * 0.2833
W-3-corr = 108,916.0929 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 13.0
hp = 13.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0828 * 13.0 * 1) / (1 * 15,000)) + 0
td = 0.4058 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 13.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0828 * 29 * ((13.0 / 29) - (0.5 * ((13.0 / 29)^2))) * TANH((0.866 * (180.0828 / 29)))
Ni = 4,189.3685 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0598 * 1 * (180.0828^2) * COSH(((3.68 * (29 - 13.0)) / 180.0828))) / COSH(((3.68 * 29) / 180.0828))
Nc = 1,695.9862 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (13.0 - 0) * 180.0828 * 1
Nh = 6,086.7998 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (6,086.7998 + SQRT(((4,189.3685^2) + (1,695.9862^2) + (((0.1674 * 6,086.7998) / 2.5)^2)))) / MAX((0.59 - 0) , 0.0001)
S_T+ = 18,008.107 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (6,086.7998 - SQRT(((4,189.3685^2) + (1,695.9862^2) + (((0.1674 * 6,086.7998) / 2.5)^2)))) / MAX((0.59 - 0) , 0.0001)
S_T- = 2,625.1126 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((18,008.107 * (0.59 - 0)) / 19,950.0) + 0
ts = 0.5326 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.4058 , 0.5326)
t-min = 0.5326 in

Course # 4 Design

CA = Corrosion allowance (in)
D4 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-4 = Shell Course Nominal Weight (lb)
W-4-corr = Shell Course Nominal Weight (lb)
h4 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 5.0 ft
JE = 1
Ma = A36
h4 = 8.0 ft
loc = 24.0 ft
t = 0.4 in

Shell Course Center of Gravity (CG-4) = 28.0 ft

D4 = ID + t

D4 = 2,160.0 + 0.4
D4 = 2,160.4 in

W-4 = pi * D4 * t * h4 * d
W-4 = pi * 2,160.4 * 0.4 * 96.0 * 0.2833
W-4 = 73,834.9254 lb

W-4-corr = pi * D4 * (t - CA) * h4 * d
W-4-corr = pi * 2,160.4 * (0.4 - 0) * 96.0 * 0.2833
W-4-corr = 73,834.9254 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 5.0
hp = 5.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0828 * 5.0 * 1) / (1 * 15,000)) + 0
td = 0.1561 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 5.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0828 * 29 * ((5.0 / 29) - (0.5 * ((5.0 / 29)^2))) * TANH((0.866 * (180.0828 / 29)))
Ni = 1,897.7481 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0598 * 1 * (180.0828^2) * COSH(((3.68 * (29 - 5.0)) / 180.0828))) / COSH(((3.68 * 29) / 180.0828))
Nc = 1,806.6458 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (5.0 - 0) * 180.0828 * 1
Nh = 2,341.0768 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (2,341.0768 + SQRT(((1,897.7481^2) + (1,806.6458^2) + (((0.1674 * 2,341.0768) / 2.5)^2)))) /

MAX((0.4 - 0) , 0.0001)
S_T+ = 12,414.8898 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (2,341.0768 - SQRT(((1,897.7481^2) + (1,806.6458^2) + (((0.1674 * 2,341.0768) / 2.5)^2)))) /
MAX((0.4 - 0) , 0.0001)
S_T- = -709.5057 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((12,414.8898 * (0.4 - 0)) / 19,950.0) + 0
ts = 0.2489 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.1561 , 0.2489)
t-min = 0.3125 in

Course # 5 Design
CA = Corrosion allowance (in)
D5 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-5 = Shell Course Nominal Weight (lb)
W-5-corr = Shell Course Nominal Weight (lb)
h5 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = -3.0 ft
JE = 1
Ma = A36
h5 = 8.5 ft
loc = 32.0 ft
t = 0.35 in

Shell Course Center of Gravity (CG-5) = 36.25 ft

D5 = ID + t
D5 = 2,160.0 + 0.35
D5 = 2,160.35 in

W-5 = pi * D5 * t * h5 * d
W-5 = pi * 2,160.35 * 0.35 * 102.0 * 0.2833
W-5 = 68,641.8185 lb

W-5-corr = pi * D5 * (t - CA) * h5 * d
W-5-corr = pi * 2,160.35 * (0.35 - 0) * 102.0 * 0.2833

W-5-corr = 68,641.8185 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = -3.0
hp = -3.0 ft

Design liquid level is below the design point under consideration

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.0828 * -3.0 * 1) / (1 * 15,000)) + 0
td = -0.0936 (Set to 0 in since it cannot be less than 0)

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = -3.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.0828 * 29 * ((-3.0 / 29) - (0.5 * ((-3.0 / 29)^2))) * TANH((0.866 * (180.0828 / 29)))
Ni = -1,310.5204 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0598 * 1 * (180.0828^2) * COSH(((3.68 * (29 - -3.0)) / 180.0828))) / COSH(((3.68 * 29) / 180.0828))
Nc = 1,965.6971 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (-3.0 - 0) * 180.0828 * 1
Nh = -1,404.6461 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (-1,404.6461 + SQRT(((-1,310.5204^2) + (1,965.6971^2) + (((0.1674 * -1,404.6461) / 2.5)^2)))) / MAX((0.35 - 0) , 0.0001)
S_T+ = 2,742.0863 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (-1,404.6461 - SQRT(((-1,310.5204^2) + (1,965.6971^2) + (((0.1674 * -1,404.6461) / 2.5)^2)))) / MAX((0.35 - 0) , 0.0001)

S_T- = -10,768.6354 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((2,742.0863 * (0.35 - 0)) / 19,950.0) + 0
ts = 0.0481 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0 , 0.0481)
t-min = 0.3125 in

W-ins = ts-ins * ds-ins * pi * (OD + ts-ins) * Hs
W-ins = 0.0 * 8 * pi * (180.1657 + 0.0) * 40.5
W-ins = 0.0 lbf

W-shell-corr = W-1-corr + W-2-corr + W-3-corr + W-4-corr + W-5-corr
W-shell-corr = 183,530.2371 + 145,850.302 + 108,916.0929 + 73,834.9254 + 68,641.8185
W-shell-corr = 580,773.3759 lb

W-shell = W-1 + W-2 + W-3 + W-4 + W-5
W-shell = 183,530.2371 + 145,850.302 + 108,916.0929 + 73,834.9254 + 68,641.8185
W-shell = 580,773.3759 lb

CG-shell = ((CG-1 * W-1) + (CG-2 * W-2) + (CG-3 * W-3) + (CG-4 * W-4) + (CG-5 * W-5)) / W-shell
CG-shell = ((4.0 * 183,530.2371) + (12.0 * 145,850.302) + (20.0 * 108,916.0929) + (28.0 * 73,834.9254) + (36.25 * 68,641.8185)) / 580,773.3759
CG-shell = 15.8724 ft

Shell Design Summary

Course	Height (ft)	Material	CA (in)	JE	Sy (psi)	Sut (psi)	Sd (psi)	St (psi)	t-erec (in)
5	8.5	A36	0	1	36,000	58,000	15,000	15,000	0.3125
4	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
3	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
2	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
1	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125

Shell Design Summary (continued)

Course	t-design (in)	t-test (in)	t-seismic (in)	t-ext (in)	t-min (in)	t-installed (in)	Status	H-max-@-Pi (ft)	Pi-max-@-H (psi)
5	0	N/A	0.0481	N/A	0.3125	0.35	PASS	44.2128	6.595
4	0.1561	N/A	0.2489	N/A	0.3125	0.4	PASS	37.8146	3.8213
3	0.4058	N/A	0.5326	N/A	0.5326	0.59	PASS	35.9016	2.9919
2	0.6555	N/A	0.7854	N/A	0.7854	0.79	PASS	34.3089	2.3015
1	0.9052	N/A	0.9964	N/A	0.9964	0.994	FAIL	32.8443	1.6666

Intermediate Stiffeners Design

Stiffeners Design For Wind Loading

D = Nominal Tank Diameter (ft)
N = Actual Wind Girders Quantity
Ns = Required Number of Girders per API 650 5.9.6.3 and 5.9.6.4
V = Wind velocity (mile/hr)
h = Maximum Unstiffened Transformed Shell Height per AWWA-D100-11 3.5.2 (ft)
ts_min = Thickness of the Thinnest Shell Course

D = 180.0828 ft
N = 0
V = 5.0 mile/hr

Shell Courses Heights (W) = [8.0 8.0 8.0 8.0 8.5] ft

ts_min = MIN(ts_1 , ts_2 , ts_3 , ts_4 , ts_5)
ts_min = MIN(0.994 , 0.79 , 0.59 , 0.4 , 0.35)
ts_min = 0.35

Stiffeners Required Quantity

HTS = Height of Transformed Shell per API 650 5.9.6.2 (ft)

Transformed shell courses heights

Variable	Equation	Value	Unit
Wtr_1	W_1 * SQRT(((ts_min / ts_1)^5))	0.5886	ft
Wtr_2	W_2 * SQRT(((ts_min / ts_2)^5))	1.0452	ft
Wtr_3	W_3 * SQRT(((ts_min / ts_3)^5))	2.1684	ft
Wtr_4	W_4 * SQRT(((ts_min / ts_4)^5))	5.7294	ft
Wtr_5	W_5 * SQRT(((ts_min / ts_5)^5))	8.5000	ft

HTS = Wtr_1 + Wtr_2 + Wtr_3 + Wtr_4 + Wtr_5
HTS = 0.5886 + 1.0452 + 2.1684 + 5.7294 + 8.5
HTS = 18.0315 ft

h = (10.625 * (10^6) * ts_min) / (PWS * ((D / ts_min)^1.5))
h = (10.625 * (10^6) * 0.35) / (18.0 * ((180.0828 / 0.35)^1.5))
h = 17.7018 ft

Ns = CEILING(((HTS / h) - 1))
Ns = CEILING(((18.0315 / 17.7018) - 1))
Ns = 1

N < Ns ==> FAIL

***** WARNING *** :** Number of intermediate stiffeners, 0, is less than the required number of 1

Option 2
Seismic and Shell Analysis

Seismic Design Calculations

Site Ground Motion Design

Ac = Compute Impulsive Design Response Spectrum Acceleration Coefficient per AWWA D100-11 13.2.9.2
Af = Compute Acceleration Coefficient for Sloshing Wave Height per AWWA D100-11 13.5.4.4
Ai = Compute Impulsive Design Response Spectrum Acceleration Coefficient per AWWA D100-11 13.2.9.2
Anchorage_System = Anchorage System
Av = Vertical Ground Acceleration Coefficient per AWWA D100-11 13.5.4.1 and 13.5.4.3
D = Nominal Tank Diameter (ft)
Fa = Site Acceleration Coefficient
Fv = Site Velocity Coefficient
I = Importance Factor
K = Spectral Acceleration Adjustment Coefficient
Lmax = Maximum Design Product Level (ft)
Rwc = Convective Force Reduction Factor
Rwi = Impulsive Force Reduction Factor
S1 = Spectral Response Acceleration at a Period of One Second
SD1 = Compute Design Spectral Response Acceleration at a Period of One Second per AWWA D100-11 13.2.7.3
SDS = Compute Design Spectral Response Acceleration at Short Period per AWWA D100-11 13.2.7.3
SM1 = Compute Maximum Considered Earthquake Spectral Response Acceleration at a Period of One Second per AWWA D100-11 13.2.7.2
SMS = Compute Maximum Considered Earthquake Spectral Response Acceleration at Short Period per AWWA D100-11 13.2.7.2
SUG = Seismic Use Group
Sac = Compute Convective Design Response Spectrum Acceleration Coefficient For Convective Components per AWWA D100-11 13.2.7.3.2
Sai =
Seismic_Site_Class = Seismic Site Class
Ss = Spectral Response Acceleration Short Period
TL = Regional Dependent Transistion Period for Longer Period Ground Motion (sec)
Tc = Compute Convective Natural Period per AWWA D100-11 13.5.1 (sec)
Ti = Structure Natural Period (sec)
U = Scaling Factor
d_ratio = Dampening Ratio
g = Acceleration Due To Gravity (ft/sec^2)
structure_type = Structure Type

Anchorage_System = SELF-ANCHORED
D = 180.1142 ft
Fa = 1.0
Fv = 1.5
I = 1.5
K = 1.5
Lmax = 35 ft
Rwc = 1.5
Rwi = 2.5
S1 = 0.593
SUG = SEISMIC-USE-GROUP-III
Seismic_Site_Class = SEISMIC-SITE-CLASS-D
Ss = 1.794
TL = 12 sec

Ti = 0 sec
U = 0.6667
d_ratio = 0.05
g = 32.17 ft/sec^2
structure_type = GROUND-SUPPORTED-FLAT-BOTTOM-TANK

Tc = 2 * pi * SQRT((D / (3.68 * g * TANH(((3.68 * Lmax) / D)))))
Tc = 2 * pi * SQRT((180.1142 / (3.68 * 32.17 * TANH(((3.68 * 35) / 180.1142)))))
Tc = 9.8916 sec

SMS = Fa * Ss
SMS = 1.0 * 1.794
SMS = 1.794

SM1 = Fv * S1
SM1 = 1.5 * 0.593
SM1 = 0.8895

SDS = U * SMS
SDS = 0.6667 * 1.794
SDS = 1.196

SD1 = U * SM1
SD1 = 0.6667 * 0.8895
SD1 = 0.593

Sai = SDS
Sai = 1.196
Sai = 1.196

Sac = MIN(((K * SD1) / Tc) , SDS)
Sac = MIN(((1.5 * 0.593) / 9.8916) , 1.196)
Sac = 0.0899

Ai = MAX(((Sai * I) / (1.4 * Rwi)) , ((0.36 * S1 * I) / Rwi))
Ai = MAX(((1.196 * 1.5) / (1.4 * 2.5)) , ((0.36 * 0.593 * 1.5) / 2.5))
Ai = 0.5126

Ac = (Sac * I) / (1.4 * Rwc)
Ac = (0.0899 * 1.5) / (1.4 * 1.5)
Ac = 0.0642

Av = 0.14 * SDS
Av = 0.14 * 1.196
Av = 0.1674

Af = (K * SD1) / Tc
Af = (1.5 * 0.593) / 9.8916
Af = 0.0899

Seismic Design

A = Roof Surface Area (ft^2)
Ac = Convective Design Response Spectrum Acceleration Coefficient
Af = Acceleration Coefficient for Sloshing Wave Height
Ah-rs = Roof Horizontal Projected Area Supported by The Shell (ft^2)

Ai = Impulsive Design Response Spectrum Acceleration Coefficient
Anchorage_System = Anchorage System
Arss = Roof Area Supported by The Shell (ft^2)
Av = Vertical Ground Acceleration Coefficient
CA = Bottom Corrosion Allowance (in)
D = Nominal Tank Diameter (ft)
DELTA_Cc = Compute Pressure Stabilizing Buckling Coefficient per AWWA D100-11 13.5.4.2.4
DELTA_SIGMAcr = Compute Self Anchored Tank Critical Buckling Stress Increase Caused By Pressure Equation per AWWA D100-11 13.5.4.2.4 (lb/in^2)
Fa = Site Acceleration Coefficient
Freeboard = Actual Freeboard (ft)
Fv = Site Velocity Coefficient
Hs = Shell height (ft)
Hs = Shell Total Height (ft)
I = Importance Factor
J = Compute Anchorage Ratio per AWWA D100-11 13.5.4.1
K = Spectral Acceleration Adjustment Coefficient
Lmax = Maximum Design Product Level (ft)
Ls = Actual Annular Ring Width (ft)
Ma = Material Name
Mmf = Compute Overturning Moment per AWWA D100-11 13.5.2.1 (ft.lb)
Ms = Compute Overturning Moment per AWWA D100-11 13.5.2.1 (ft.lb)
P = Design Pressure (lbf/in^2)
R = (ft)
S1 = Spectral Response Acceleration at a Period of One Second
SD1 = Design Spectral Response Acceleration at a Period of 1 Second
SDS = Design Spectral Response Acceleration at Short Period
SG = Specific Gravity
SIGMAc_self_anchored = Compute Self Anchored Maximum Longitudinal Shell Compression Stress per AWWA D100-11 13.5.4.2.1 (lbf/in^2)
SIGMAe_self_anchored = Compute Seismic Allowable Longitudinal Compressive Stress per AWWA D100-11 13.5.4.2.4 (lb/in^2)
SUG = Seismic Use Group
Seismic_Site_Class = Seismic Site Class
Ss = Spectral Response Acceleration Short Period
TL = Regional Dependent Transistion Period for Longer Period Ground Motion (sec)
Tc = Convective Natural Period (sec)
U = Scaling Factor
V_allow = Compute Self Anchored Sliding Resistance Base Shear per AWWA D100-11 13.5.4.6 (lbf)
Vf = Compute Total Design Base Shear per AWWA D100-11 13.5.3.1 (lbf)
Wc = Compute Convective Effective Weight per AWWA D100-11 13.5.2.2.1 (lbf)
Wf = Tank Bottom Total Weight (lbf)
Wi = Compute Impulsive Effective Weight per AWWA D100-11 13.5.2.2.1 (lbf)
Wp = Tank Contents Total Weight (lbf)
Wr = Total Weight of Fixed Tank Roof including Framing, Knuckles, any Permanent Attachments and 10 % of the Roof Balanced Design Snow Load (lbf)
Wrs = Roof Load Acting on The Tank Shell Including 10 % of the Roof Balanced Design Snow Load (lbf)
Ws = Total Weight of Tank Shell and Appurtenances (lbf)
Wss = Roof Structure Weight Supported by The Tank Shell (lb)
Xc = Height from tank shell bottom to the center of action of convective lateral force for computing ringwall overturning moment per AWWA D100-11 13.5.2.2.2 (ft)
Xcmf = Height from tank shell bottom to the center of action of convective lateral force for computing slab overturning moment per AWWA D100-11 13.5.3.2.2 (ft)
Xi = Height from tank shell bottom to the center of action of impulsive lateral force for computing ringwall overturning moment per AWWA D100-11 13.5.2.2.2 (ft)
Ximf = Height from tank shell bottom to the center of action of impulsive lateral force for computing slab

overturning moment per AWWA D100-11 13.5.3.2.2 (ft)
Xs = Height from tank shell bottom to shell's center of gravity (ft)
ca1 = Bottom Shell Course Corrosion Allowance (in)
ca_annulus = Bottom Annular Ring Design Corrosion Allowance (in)
d = Sloshing Wave Height Above Product Design Height per AWWA D100-11 Section 13.5.4.4 (ft)
g = Acceleration Due To Gravity (ft/sec^2)
lw = Lap of the Bottom Plates Over the Annular Plate (in)
outside_projection = Bottom Outside Projection (in)
site_ground_motion_input_mode = Site Ground Motion Input Mode
t_bottom = Bottom Plate Thickness (in)
tb = Bottom Annular Ring Design Thickness (in)
tb_less_ca = Bottom Annular Ring Design Thickness Without Corrosion Allowance (in)
tb_limited_less_ca = (in)
ts1 = Bottom Shell Course Thickness (in)
ts_less_ca = Bottom Shell Course Thickness Without Corrosion Allowance (in)
using_annular_ring = Using Annular Ring
wL = Compute Self Anchored Force Resisting Uplift per AWWA D100-11 13.5.4.1.1 (lbf/ft)
wrs = Specified Tank Roof Load Acting on Tank Shell (lbf/ft)
wt = Compute Tank and Roof Weight Acting at base of Shell per AWWA D100-11 13.5.4.2.1 (lbf/ft)

A = 25,554.4252 ft^2
Ac = 0.0642
Af = 0.0899
Ah-rs = 8,634.9045 ft^2
Ai = 0.5126
Anchorage_System = SELF-ANCHORED
Arss = 8,651.7531 ft^2
Av = 0.1674
CA = 0 in
D = 180.1142 ft
Fa = 1.0
Fv = 1.5
Hs = 48 ft
Hs = 48 ft
I = 1.5
K = 1.5
Lmax = 35 ft
Ls = 2.0942 ft
Ma = A537-2
P = 0.0 lbf/in^2
S1 = 0.593
SD1 = 0.593
SDS = 1.196
SG = 1
SUG = SEISMIC-USE-GROUP-III
Seismic_Site_Class = SEISMIC-SITE-CLASS-D
Ss = 1.794
TL = 12 sec
Tc = 9.8916 sec
U = 0.6667
Wp = 55,600,879.5774 lbf
Wss = 24,091.3622 lb
Xs = 17.6995 ft
ca1 = 0 in
ca_annulus = 0 in
g = 32.17 ft/sec^2

lw = 1.5 in
outside_projection = 2 in
site_ground_motion_input_mode = ASCE7-MAPPED-SS-AND-S1
t_bottom = 0.25 in
tb = 0.25 in
ts1 = 1.37 in
using_annular_ring = t

Wf = Wb-pl
Wf = 259,857.169
Wf = 259,857.169 lbf

Wr = (Wr-pl + Wr-attachments + W-struct + Wr-DL-add) + (0.1 * Sb * Ah)
Wr = (195,468.3541 + 0.0 + 157,760.6059 + 0.0) + (0.1 * 0.0 * 25,504.66)
Wr = 353,228.9599 lbf

Wrs = ((Wr-pl + Wr-attachments + Wr-DL-add) * (Arss / A)) + Wss + (0.1 * Sb * Ah-rs)
Wrs = ((195,468.3541 + 0.0 + 0.0) * (8,651.7531 / 25,554.4252)) + 24,091.3622 + (0.1 * 0.0 * 8,634.9045)
Wrs = 90,269.4867 lbf

Ws = Ws-pl + Ws-framing + Ws-attachments
Ws = 828,994.8935 + 4,057.6387 + 4.0
Ws = 833,056.5322 lbf

R = D / 2
R = 180.1142 / 2
R = 90.0571 ft

tb_less_ca = tb - ca_annulus
tb_less_ca = 0.25 - 0
tb_less_ca = 0.25 in

ts_less_ca = ts1 - ca1
ts_less_ca = 1.37 - 0
ts_less_ca = 1.37 in

tb_limited_less_ca = MIN(tb_less_ca , ts_less_ca)
tb_limited_less_ca = MIN(0.25 , 1.37)
tb_limited_less_ca = 0.25 in

Effective weight of product

Wi = (TANH((0.866 * (D / Lmax))) / (0.866 * (D / Lmax))) * Wp
Wi = (TANH((0.866 * (180.1142 / 35))) / (0.866 * (180.1142 / 35))) * 55,600,879.5774
Wi = 12,472,887.7672 lbf

Wc = 0.23 * (D / Lmax) * TANH(((3.67 * Lmax) / D)) * Wp
Wc = 0.23 * (180.1142 / 35) * TANH(((3.67 * 35) / 180.1142)) * 55,600,879.5774
Wc = 40,318,508.7383 lbf

Center of action for effective lateral forces

Xi = 0.375 * Lmax
Xi = 0.375 * 35
Xi = 13.125 ft

Xc = (1.0 - ((COSH(((3.67 * Lmax) / D)) - 1) / (((3.67 * Lmax) / D) * SINH(((3.67 * Lmax) / D))))) * Lmax

Xc = (1.0 - ((COSH(((3.67 * 35) / 180.1142)) - 1) / (((3.67 * 35) / 180.1142) * SINH(((3.67 * 35) / 180.1142))))) * 35
Xc = 18.2058 ft

Ximf = 0.375 * (1.0 + ((4 / 3) * (((0.866 * (D / Lmax)) / TANH((0.866 * (D / Lmax)))) - 1.0))) * Lmax
Ximf = 0.375 * (1.0 + ((4 / 3) * (((0.866 * (180.1142 / 35)) / TANH((0.866 * (180.1142 / 35)))) - 1.0))) * 35
Ximf = 73.6354 ft

Xcmf = (1.0 - ((COSH(((3.67 * Lmax) / D)) - 1.937) / (((3.67 * Lmax) / D) * SINH(((3.67 * Lmax) / D))))) * Lmax
Xcmf = (1.0 - ((COSH(((3.67 * 35) / 180.1142)) - 1.937) / (((3.67 * 35) / 180.1142) * SINH(((3.67 * 35) / 180.1142))))) * 35
Xcmf = 77.5293 ft

Overturning moment

Ms = SQRT((((Ai * ((Ws * Xs) + (Wr * Hs) + (Wi * Xi)))^2) + ((Ac * (Wc * Xc))^2)))
Ms = SQRT((((0.5126 * ((833,056.5322 * 17.6995) + (353,228.9599 * 48) + (12,472,887.7672 * 13.125)))^2) + ((0.0642 * (40,318,508.7383 * 18.2058))^2)))
Ms = 110,701,933.6481 ft.lb

Mmf = SQRT((((Ai * ((Ws * Xs) + (Wr * Hs) + (Wi * Ximf)))^2) + ((Ac * (Wc * Xcmf))^2)))
Mmf = SQRT((((0.5126 * ((833,056.5322 * 17.6995) + (353,228.9599 * 48) + (12,472,887.7672 * 73.6354)))^2) + ((0.0642 * (40,318,508.7383 * 77.5293))^2)))
Mmf = 526,781,705.484 ft.lb

Resistance to design loads

wL = MIN((7.9 * tb_limited_less_ca * SQRT((Fy * Lmax * SG))) , (1.28 * Lmax * D * SG))
wL = MIN((7.9 * 0.25 * SQRT((60,000.0 * 35 * 1))) , (1.28 * 35 * 180.1142 * 1))
wL = 2,862.0469 lbf/ft

wrs = Wrs / (pi * D)
wrs = 90,269.4867 / (pi * 180.1142)
wrs = 159.5303 lbf/ft

wt = (Ws / (pi * D)) + wrs
wt = (833,056.5322 / (pi * 180.1142)) + 159.5303
wt = 1,631.7639 lbf/ft

Tank Stability

J = Ms / ((D^2) * ((wt * (1 - (0.4 * Av))) + wL))
J = 110,701,933.6481 / ((180.1142^2) * ((1,631.7639 * (1 - (0.4 * 0.1674))) + 2,862.0469))
J = 0.7783

Bottom Annular Plates requirements

As per AWWA 3.10.8
Ls >= 18 ==> PASS

Shell Stresses

SIGMAc_self_anchored = ((wt * (1 + (0.4 * Av))) + ((1.273 * Ms) / (D^2))) * (1 / (12 * ts_less_ca))
SIGMAc_self_anchored = ((1,631.7639 * (1 + (0.4 * 0.1674))) + ((1.273 * 110,701,933.6481) / (180.1142^2))) * (1 / (12 * 1.37))
SIGMAc_self_anchored = 370.1343 lbf/in^2

DELTA_Cc = 0.72 * (((P / E) * ((R / ts_less_ca)^2))^0.84)
DELTA_Cc = 0.72 * (((0.0 / 28,800,000) * ((1,080.685 / 1.37)^2))^0.84)

DELTA_Cc = 0.0

DELTA_SIGMAcr = (DELTA_Cc * E * ts_less_ca) / R
DELTA_SIGMAcr = (0.0 * 28,800,000 * 1.37) / 1,080.685
DELTA_SIGMAcr = 0.0 lb/in^2

FL = Compute Allowable Local Buckling Compressive Stress per AWWA D100-11 Section 3.4.3.1.2 (lb/in^2)
Material_Class = Compute Material Class From Minimum Yield Strength per AWWA D100-11 Section 3.2 and Table 4
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = Thickness Radius Ratio Boundary Elastic Inelastic Buckling per AWWA D100-11 Sections 3.4.3.1.1 and 3.4.3.1.2

Material_Class = :material-class-2
Material_Class = :material-class-2
Material_Class = :material-class-2

Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035372
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035372
Thickness_Radius_Ratio_Boundary_Elastic_Inelastic_Buckling = 0.0035

FL = 17.5 * (10^5) * (ts_less_ca / R) * (1 + (50000 * ((ts_less_ca / R)^2)))
FL = 17.5 * (10^5) * (1.37 / 1,080.685) * (1 + (50000 * ((1.37 / 1,080.685)^2)))
FL = 2,396.7679 lb/in^2

Allowable Local Buckling Compressive Stress (FL) = 2,396.7679 lb/in^2

SIGMAe_self_anchored = 1.333 * (FL + (DELTA_SIGMAcr / 2))
SIGMAe_self_anchored = 1.333 * (2,396.7679 + (0.0 / 2))
SIGMAe_self_anchored = 3,194.8916 lb/in^2

Freeboard

d = 0.5 * D * Af
d = 0.5 * 180.1142 * 0.0899
d = 8.0961 ft [97.1536 in]

Freeboard = Hs - Lmax-operating
Freeboard = 48 - 35
Freeboard = 13 ft [156.0 in]

(SDS >= One_Third_g) AND (SUG = :seismic-use-group-iii)

[Required]
Sloshing Wave Height Above Product Design Height (d) = 8.0961 ft

Freeboard >= d ==> PASS

Sliding Resistance

Vf = SQRT((((Ai * (Ws + Wr + Wf + Wi))^2) + ((Ac * Wc)^2)))
Vf = SQRT((((0.5126 * (833,056.5322 + 353,228.9599 + 259,857.169 + 12,472,887.7672))^2) + ((0.0642 * 40,318,508.7383)^2)))
Vf = 7,589,977.9447 lbf

V_allow = TAN(30) * (Ws + Wr + Wi + Wc) * (1 - (0.4 * Av))

V_allow = TAN(30) * (833,056.5322 + 353,228.9599 + 12,472,887.7672 + 40,318,508.7383) * (1 - (0.4 * 0.1674))
V_allow = 29,077,285.8343 lbf

Vf <= V_allow

Shell Design Calculations

Ac = Convective Design Response Spectrum Acceleration Coefficient
Ai = Impulsive Design Response Spectrum Acceleration Coefficient
Av = Vertical ground acceleration coefficient description
CG-shell = Shell center of gravity (ft)
D = Tank Nominal Diameter (ft)
Hs = Shell height (ft)
Lmax = Max Liquid Level (ft)
P = Design Internal Pressure (psi)
Pv = Design External Pressure (psf)
SG = Product Design Specific Gravity
SGt = Hydrotest Specific Gravity
V = Wind velocity (mile/hr)
W-ins = Shell Insulation Weight (lbf)
W-shell = Shell Nominal Weight (lb)
W-shell-corr = Shell Corroded Weight (lb)
ds-ins = Insulation Density (lbf/ft^3)
h-min = Minimum Shell Course Height per API-650 5.6.1.2 (in)
ts-ins = Insulation Thickness (in)

Ac = 0.0642
Ai = 0.5126
Av = 0.1674
D = 180.1142 ft
Hs = 48 ft
Lmax = 35 ft
P = 0.0 psi
Pv = 0.0 psf
SG = 1
SGt = 1
V = 100.0 mile/hr
ds-ins = 8 lbf/ft^3
h-min = 96 in
ts-ins = 0 in

Course # 1 (bottom course) Design

CA = Corrosion allowance (in)
D1 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-1 = Shell Course Nominal Weight (lb)
W-1-corr = Shell Course Nominal Weight (lb)
h1 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 35 ft

JE = 1
Ma = A537-2
h1 = 8.0 ft
loc = 0 ft
t = 1.37 in

Shell Course Center of Gravity (CG-1) = 4.0 ft

D1 = ID + t
D1 = 2,160.0 + 1.37
D1 = 2,161.37 in

W-1 = pi * D1 * t * h1 * d
W-1 = pi * 2,161.37 * 1.37 * 96.0 * 0.2833
W-1 = 252,998.1623 lb

W-1-corr = pi * D1 * (t - CA) * h1 * d
W-1-corr = pi * 2,161.37 * (1.37 - 0) * 96.0 * 0.2833
W-1-corr = 252,998.1623 lb

Material Properties
Material = A537-2
Minimum Tensile Strength (Sut) = 80,000 psi
Minimum Yield Strength (Sy) = 60,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 35
hp = 35 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.1142 * 35 * 1) / (1 * 15,000)) + 0
td = 1.0927 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 35 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.1142 * 35 * ((35 / 35) - (0.5 * ((35 / 35)^2))) * TANH((0.866 * (180.1142 / 35)))
Ni = 7,268.3512 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0642 * 1 * (180.1142^2) * COSH(((3.68 * (35 - 35)) / 180.1142))) / COSH(((3.68 * 35) / 180.1142))
Nc = 1,612.0366 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (35 - 0) * 180.1142 * 1
Nh = 16,390.3892 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (16,390.3892 + SQRT(((7,268.3512^2) + (1,612.0366^2) + (((0.1674 * 16,390.3892) / 2.5)^2)))) / MAX((1.37 - 0) , 0.0001)
S_T+ = 17,456.8024 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (16,390.3892 - SQRT(((7,268.3512^2) + (1,612.0366^2) + (((0.1674 * 16,390.3892) / 2.5)^2)))) / MAX((1.37 - 0) , 0.0001)
S_T- = 6,470.773 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 60,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((17,456.8024 * (1.37 - 0)) / 19,950.0) + 0
ts = 1.1988 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 1.0927 , 1.1988)
t-min = 1.1988 in

Course # 2 Design
CA = Corrosion allowance (in)
D2 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-2 = Shell Course Nominal Weight (lb)
W-2-corr = Shell Course Nominal Weight (lb)
h2 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 27.0 ft
JE = 1
Ma = A573-58
h2 = 8.0 ft
loc = 8.0 ft
t = 0.99 in

Shell Course Center of Gravity (CG-2) = 12.0 ft

D2 = ID + t

D2 = 2,160.0 + 0.99
D2 = 2,160.99 in

W-2 = pi * D2 * t * h2 * d
W-2 = pi * 2,160.99 * 0.99 * 96.0 * 0.2833
W-2 = 182,791.3465 lb

W-2-corr = pi * D2 * (t - CA) * h2 * d
W-2-corr = pi * 2,160.99 * (0.99 - 0) * 96.0 * 0.2833
W-2-corr = 182,791.3465 lb

Material Properties
Material = A573-58
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 32,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 27.0
hp = 27.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.1142 * 27.0 * 1) / (1 * 15,000)) + 0
td = 0.8429 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 27.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.1142 * 35 * ((27.0 / 35) - (0.5 * ((27.0 / 35)^2))) * TANH((0.866 * (180.1142 / 35)))
Ni = 6,888.6169 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0642 * 1 * (180.1142^2) * COSH(((3.68 * (35 - 27.0)) / 180.1142))) / COSH(((3.68 * 35) / 180.1142))
Nc = 1,633.6186 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (27.0 - 0) * 180.1142 * 1
Nh = 12,644.0145 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)

S_T+ = (12,644.0145 + SQRT(((6,888.6169^2) + (1,633.6186^2) + (((0.1674 * 12,644.0145) / 2.5)^2)))) / MAX((0.99 - 0) , 0.0001)
S_T+ = 19,973.8694 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (12,644.0145 - SQRT(((6,888.6169^2) + (1,633.6186^2) + (((0.1674 * 12,644.0145) / 2.5)^2)))) / MAX((0.99 - 0) , 0.0001)
S_T- = 5,569.5942 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 32,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((19,973.8694 * (0.99 - 0)) / 19,950.0) + 0
ts = 0.9912 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.8429 , 0.9912)
t-min = 0.9912 in

t < t-min ==> FAIL

***** WARNING *** :** Course 2 thickness, 0.99 in, is less than the required value of 0.9912 in

Course # 3 Design
CA = Corrosion allowance (in)
D3 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-3 = Shell Course Nominal Weight (lb)
W-3-corr = Shell Course Nominal Weight (lb)
h3 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 19.0 ft
JE = 1
Ma = A36
h3 = 8.0 ft
loc = 16.0 ft
t = 0.79 in

Shell Course Center of Gravity (CG-3) = 20.0 ft

D3 = ID + t
D3 = 2,160.0 + 0.79
D3 = 2,160.79 in

W-3 = pi * D3 * t * h3 * d

W-3 = pi * 2,160.79 * 0.79 * 96.0 * 0.2833
W-3 = 145,850.302 lb

W-3-corr = pi * D3 * (t - CA) * h3 * d
W-3-corr = pi * 2,160.79 * (0.79 - 0) * 96.0 * 0.2833
W-3-corr = 145,850.302 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi
Maximum Thickness (t-max) = 0.75 in

t > t-max ==> FAIL

***** WARNING *** :** Course-3, installed thickness , 0.79 in, is greater than the maximum allowable thickness of 0.75 in for A36 material

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 19.0
hp = 19.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.1142 * 19.0 * 1) / (1 * 15,000)) + 0
td = 0.5932 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 19.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.1142 * 35 * ((19.0 / 35) - (0.5 * ((19.0 / 35)^2))) * TANH((0.866 * (180.1142 / 35)))
Ni = 5,749.4141 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0642 * 1 * (180.1142^2) * COSH(((3.68 * (35 - 19.0)) / 180.1142))) / COSH(((3.68 * 35) / 180.1142))
Nc = 1,698.9425 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (19.0 - 0) * 180.1142 * 1
Nh = 8,897.6398 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (8,897.6398 + SQRT(((5,749.4141^2) + (1,698.9425^2) + (((0.1674 * 8,897.6398) / 2.5)^2)))) / MAX((0.79 - 0) , 0.0001)
S_T+ = 18,889.0503 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (8,897.6398 - SQRT(((5,749.4141^2) + (1,698.9425^2) + (((0.1674 * 8,897.6398) / 2.5)^2)))) / MAX((0.79 - 0) , 0.0001)
S_T- = 3,636.6202 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((18,889.0503 * (0.79 - 0)) / 19,950.0) + 0
ts = 0.748 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.5932 , 0.748)
t-min = 0.748 in

Course # 4 Design
CA = Corrosion allowance (in)
D4 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-4 = Shell Course Nominal Weight (lb)
W-4-corr = Shell Course Nominal Weight (lb)
h4 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 11.0 ft
JE = 1
Ma = A36
h4 = 8.0 ft
loc = 24.0 ft
t = 0.59 in

Shell Course Center of Gravity (CG-4) = 28.0 ft

D4 = ID + t
D4 = 2,160.0 + 0.59
D4 = 2,160.59 in

W-4 = pi * D4 * t * h4 * d
W-4 = pi * 2,160.59 * 0.59 * 96.0 * 0.2833
W-4 = 108,916.0929 lb

W-4-corr = pi * D4 * (t - CA) * h4 * d
W-4-corr = pi * 2,160.59 * (0.59 - 0) * 96.0 * 0.2833
W-4-corr = 108,916.0929 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 11.0
hp = 11.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.1142 * 11.0 * 1) / (1 * 15,000)) + 0
td = 0.3434 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 11.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.1142 * 35 * ((11.0 / 35) - (0.5 * ((11.0 / 35)^2))) * TANH((0.866 * (180.1142 / 35)))
Ni = 3,850.7428 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0642 * 1 * (180.1142^2) * COSH(((3.68 * (35 - 11.0)) / 180.1142))) / COSH(((3.68 * 35) / 180.1142))
Nc = 1,809.7573 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (11.0 - 0) * 180.1142 * 1
Nh = 5,151.2652 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (5,151.2652 + SQRT(((3,850.7428^2) + (1,809.7573^2) + (((0.1674 * 5,151.2652) / 2.5)^2)))) / MAX((0.59 - 0) , 0.0001)
S_T+ = 15,966.1653 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (5,151.2652 - SQRT(((3,850.7428^2) + (1,809.7573^2) + (((0.1674 * 5,151.2652) / 2.5)^2)))) /

MAX((0.59 - 0) , 0.0001)
S_T- = 1,495.7505 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((15,966.1653 * (0.59 - 0)) / 19,950.0) + 0
ts = 0.4722 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.3434 , 0.4722)
t-min = 0.4722 in

Course # 5 Design
CA = Corrosion allowance (in)
D5 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-5 = Shell Course Nominal Weight (lb)
W-5-corr = Shell Course Nominal Weight (lb)
h5 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = 3.0 ft
JE = 1
Ma = A36
h5 = 8.0 ft
loc = 32.0 ft
t = 0.4 in

Shell Course Center of Gravity (CG-5) = 36.0 ft

D5 = ID + t
D5 = 2,160.0 + 0.4
D5 = 2,160.4 in

W-5 = pi * D5 * t * h5 * d
W-5 = pi * 2,160.4 * 0.4 * 96.0 * 0.2833
W-5 = 73,834.9254 lb

W-5-corr = pi * D5 * (t - CA) * h5 * d
W-5-corr = pi * 2,160.4 * (0.4 - 0) * 96.0 * 0.2833
W-5-corr = 73,834.9254 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi

Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = 3.0
hp = 3.0 ft

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.1142 * 3.0 * 1) / (1 * 15,000)) + 0
td = 0.0937 in

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = 3.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.1142 * 35 * ((3.0 / 35) - (0.5 * ((3.0 / 35)^2))) * TANH((0.866 * (180.1142 / 35)))
Ni = 1,192.6029 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0642 * 1 * (180.1142^2) * COSH(((3.68 * (35 - 3.0)) / 180.1142))) / COSH(((3.68 * 35) / 180.1142))
Nc = 1,969.0303 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (3.0 - 0) * 180.1142 * 1
Nh = 1,404.8905 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (1,404.8905 + SQRT(((1,192.6029^2) + (1,969.0303^2) + (((0.1674 * 1,404.8905) / 2.5)^2)))) / MAX((0.4 - 0) , 0.0001)
S_T+ = 9,272.1261 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (1,404.8905 - SQRT(((1,192.6029^2) + (1,969.0303^2) + (((0.1674 * 1,404.8905) / 2.5)^2)))) / MAX((0.4 - 0) , 0.0001)
S_T- = -2,247.6736 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((9,272.1261 * (0.4 - 0)) / 19,950.0) + 0

ts = 0.1859 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0.0937 , 0.1859)
t-min = 0.3125 in

Course # 6 Design
CA = Corrosion allowance (in)
D6 = Shell Course Centerline Diameter (in)
H = Design Liquid Level (ft)
JE = Joint efficiency
Ma = Course Material
W-6 = Shell Course Nominal Weight (lb)
W-6-corr = Shell Course Nominal Weight (lb)
h6 = Course Height (ft)
hp = Effective Design Liquid Level per AWWA-D100-11 3.7 (ft)
loc = Course Location (ft)
t = Installed Thickness (in)
t-min = Minimum Required Thickness (in)
td = Course Design Thickness per AWWA-D100-11 3-40 (in)

CA = 0 in
H = -5.0 ft
JE = 1
Ma = A36
h6 = 8.0 ft
loc = 40.0 ft
t = 0.35 in

Shell Course Center of Gravity (CG-6) = 44.0 ft

D6 = ID + t
D6 = 2,160.0 + 0.35
D6 = 2,160.35 in

W-6 = pi * D6 * t * h6 * d
W-6 = pi * 2,160.35 * 0.35 * 96.0 * 0.2833
W-6 = 64,604.0645 lb

W-6-corr = pi * D6 * (t - CA) * h6 * d
W-6-corr = pi * 2,160.35 * (0.35 - 0) * 96.0 * 0.2833
W-6-corr = 64,604.0645 lb

Material Properties
Material = A36
Minimum Tensile Strength (Sut) = 58,000 psi
Minimum Yield Strength (Sy) = 36,000 psi
Allowable Design Stress (Sd) = 15,000 psi

Thickness Required by Erection
As per AWWA-D100-11 3.10.3 and Table 16, Thickness Required by Erection (t-erec) = 0.3125 in

Thickness Required by Design
hp = H
hp = -5.0

hp = -5.0 ft

Design liquid level is below the design point under consideration

td = ((2.6 * D * hp * SG) / (JE * Sd)) + CA
td = ((2.6 * 180.1142 * -5.0 * 1) / (1 * 15,000)) + 0
td = -0.1561 (Set to 0 in since it cannot be less than 0)

Seismic Design Required Thickness
Nc = Convective Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Nh = Product Hydrostatic Membrane Force per API 650 Section E.6.1.4 and Section 5.6.3.2 (lbf/in)
Ni = Impulsive Hoop Membrane Unit Force per API 650 Section E.6.1.4 (lbf/in)
Sd-seismic = Maximum Allowable Hoop Tension Membrane Stress per API-650 E.6.2.4 (psi)
ts = Seismic Minimum Thickness per API 650 Section E.6.2.4 (in)

As per API 650 Section E.6.1.4, Shell Course Liquid Surface to Analysis Point Distance (Y) = -5.0 ft

Ni = 4.5 * Ai * SG * D * Lmax * ((Y / Lmax) - (0.5 * ((Y / Lmax)^2))) * TANH((0.866 * (D / Lmax)))
Ni = 4.5 * 0.5126 * 1 * 180.1142 * 35 * ((-5.0 / 35) - (0.5 * ((-5.0 / 35)^2))) * TANH((0.866 * (180.1142 / 35)))
Ni = -2,225.0055 lbf/in

Nc = (0.98 * Ac * SG * (D^2) * COSH(((3.68 * (Lmax - Y)) / D))) / COSH(((3.68 * Lmax) / D))
Nc = (0.98 * 0.0642 * 1 * (180.1142^2) * COSH(((3.68 * (35 - -5.0)) / 180.1142))) / COSH(((3.68 * 35) / 180.1142))
Nc = 2,181.0261 lbf/in

Nh = 2.6 * (Y - H_offset) * D * SG
Nh = 2.6 * (-5.0 - 0) * 180.1142 * 1
Nh = -2,341.4842 lbf/in

S_T+ = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)
S_T- = Total Combined Hoop Stress per API 650 Section E.6.1.4 (psi)

S_T+ = (Nh + SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T+ = (-2,341.4842 + SQRT(((-2,225.0055^2) + (2,181.0261^2) + (((0.1674 * -2,341.4842) / 2.5)^2)))) / MAX((0.35 - 0) , 0.0001)
S_T+ = 2,223.2805 psi

S_T- = (Nh - SQRT(((Ni^2) + (Nc^2) + (((Av * Nh) / 2.5)^2)))) / MAX((t - CA) , 0.0001)
S_T- = (-2,341.4842 - SQRT(((-2,225.0055^2) + (2,181.0261^2) + (((0.1674 * -2,341.4842) / 2.5)^2)))) / MAX((0.35 - 0) , 0.0001)
S_T- = -15,603.19 psi

Sd-seismic = MIN((1.33 * Sd) , (0.9 * Sy * JE))
Sd-seismic = MIN((1.33 * 15,000) , (0.9 * 36,000 * 1))
Sd-seismic = 19,950 psi

ts = ((S_T+ * (t - CA)) / Sd-seismic) + CA
ts = ((2,223.2805 * (0.35 - 0)) / 19,950.0) + 0
ts = 0.039 in

Minimum Required Thickness
t-min = MAX(t-erec , td , ts)
t-min = MAX(0.3125 , 0 , 0.039)
t-min = 0.3125 in

W-ins = ts-ins * ds-ins * pi * (OD + ts-ins) * Hs
W-ins = 0.0 * 8 * pi * (180.2283 + 0.0) * 48
W-ins = 0.0 lbf

W-shell-corr = W-1-corr + W-2-corr + W-3-corr + W-4-corr + W-5-corr + W-6-corr
W-shell-corr = 252,998.1623 + 182,791.3465 + 145,850.302 + 108,916.0929 + 73,834.9254 + 64,604.0645
W-shell-corr = 828,994.8935 lb

W-shell = W-1 + W-2 + W-3 + W-4 + W-5 + W-6
W-shell = 252,998.1623 + 182,791.3465 + 145,850.302 + 108,916.0929 + 73,834.9254 + 64,604.0645
W-shell = 828,994.8935 lb

CG-shell = ((CG-1 * W-1) + (CG-2 * W-2) + (CG-3 * W-3) + (CG-4 * W-4) + (CG-5 * W-5) + (CG-6 * W-6)) / W-shell
CG-shell = ((4.0 * 252,998.1623) + (12.0 * 182,791.3465) + (20.0 * 145,850.302) + (28.0 * 108,916.0929) + (36.0 * 73,834.9254) + (44.0 * 64,604.0645)) / 828,994.8935
CG-shell = 17.6995 ft

Shell Design Summary

Course	Height (ft)	Material	CA (in)	JE	Sy (psi)	Sut (psi)	Sd (psi)	St (psi)	t-erec (in)
6	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
5	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
4	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
3	8.0	A36	0	1	36,000	58,000	15,000	15,000	0.3125
2	8.0	A573-58	0	1	32,000	58,000	15,000	15,000	0.3125
1	8.0	A537-2	0	1	60,000	80,000	15,000	15,000	0.3125

Shell Design Summary (continued)

Course	t-design (in)	t-test (in)	t-seismic (in)	t-ext (in)	t-min (in)	t-installed (in)	Status	H-max-@-Pi (ft)	Pi-max-@-H (psi)
6	0	N/A	0.039	N/A	0.3125	0.35	PASS	52.2108	7.4612
5	0.0937	N/A	0.1859	N/A	0.3125	0.4	PASS	45.8124	4.6873
4	0.3434	N/A	0.4722	N/A	0.4722	0.59	PASS	43.8983	3.8575
3	0.5932	N/A	0.748	N/A	0.748	0.79	PASS	42.3045	3.1666
2	0.8429	N/A	0.9912	N/A	0.9912	0.99	FAIL	40.7107	2.4757
1	1.0927	N/A	1.1988	N/A	1.1988	1.37	PASS	44.8824	4.2842

Intermediate Stiffeners Design

Stiffeners Design For Wind Loading

D = Nominal Tank Diameter (ft)
N = Actual Wind Girders Quantity
Ns = Required Number of Girders per API 650 5.9.6.3 and 5.9.6.4
V = Wind velocity (mile/hr)
h = Maximum Unstiffened Transformed Shell Height per AWWA-D100-11 3.5.2 (ft)
ts_min = Thickness of the Thinnest Shell Course

D = 180.1142 ft
N = 0
V = 100.0 mile/hr

Shell Courses Heights (W) = [8.0 8.0 8.0 8.0 8.0 8.0] ft

ts_min = MIN(ts_corr_1 , ts_corr_2 , ts_corr_3 , ts_corr_4 , ts_corr_5 , ts_corr_6)
ts_min = MIN(1.37 , 0.99 , 0.79 , 0.59 , 0.4 , 0.35)
ts_min = 0.35

Stiffeners Required Quantity

HTS = Height of Transformed Shell per API 650 5.9.6.2 (ft)

Transformed shell courses heights

Variable	Equation	Value	Unit
Wtr_1	W_1 * SQRT(((ts_min / ts_corr_1)^5))	0.2639	ft
Wtr_2	W_2 * SQRT(((ts_min / ts_corr_2)^5))	0.5945	ft
Wtr_3	W_3 * SQRT(((ts_min / ts_corr_3)^5))	1.0452	ft
Wtr_4	W_4 * SQRT(((ts_min / ts_corr_4)^5))	2.1684	ft
Wtr_5	W_5 * SQRT(((ts_min / ts_corr_5)^5))	5.7294	ft
Wtr_6	W_6 * SQRT(((ts_min / ts_corr_6)^5))	8.0000	ft

HTS = Wtr_1 + Wtr_2 + Wtr_3 + Wtr_4 + Wtr_5 + Wtr_6
HTS = 0.2639 + 0.5945 + 1.0452 + 2.1684 + 5.7294 + 8.0
HTS = 17.8014 ft

h = (10.625 * (10^6) * ts_min) / (PWS * ((D / ts_min)^1.5))
h = (10.625 * (10^6) * 0.35) / (18.0 * ((180.1142 / 0.35)^1.5))
h = 17.6972 ft

Ns = CEILING(((HTS / h) - 1))
Ns = CEILING(((17.8014 / 17.6972) - 1))
Ns = 1

N < Ns ==> FAIL

***** WARNING *** :** Number of intermediate stiffeners, 0, is less than the required number of 1