DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5750
Ser N4/0651
08 DEC 2017

CERTIFIED NO: 7015 0640 0002 4677 9534

Mr. Bob Pallarino
U.S. Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105

CERTIFIED NO: 7015 0640 0002 4677 9541

Mrs. Roxanne Kwan
State of Hawaii Department of Health
Solid and Hazardous Waste Branch
2827 Waimano Home Road
Pearl City, Hawaii 96782

Dear Mr. Pallarino and Mrs. Kwan:

SUBJECT: ADMINISTRATIVE ORDER ON CONSENT STATEMENT OF WORK SECTION 3.3 TANK UPGRADE ALTERNATIVES REPORT, RED HILL BULK FUEL STORAGE FACILITY (RED HILL), JOINT BASE PEARL HARBOR-HICKAM, OAHU, HAWAII

The Tank Upgrade Alternatives Report for Red Hill pursuant to the Administrative Order on Consent ("AOC") Statement of Work ("SOW") Section 3.3, Tank Upgrade Alternatives is enclosed.

The U.S. Department of Navy ("Navy") and the Defense Logistics Agency ("DLA") are submitting this report in accordance with the conditional approval letter received from the U.S. Environmental Protection Agency ("EPA") and the Hawai'i Department of Health ("DOH") on December 8, 2016.

If you have any questions, please contact Mark S. Manfredi, the Red Hill Regional Program Director/Project Coordinator at (808) 473-4148 or at mark.manfredi@navy.mil.

Sincerely,

R. D. HAYES, III
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

Enclosure: Red Hill AOC SOW Section 3.3 Tank Upgrade Alternatives Report, December 08, 2017

Red Hill Administrative Order on Consent, Statement of Work (SOW)

Section: 3.3 Tank Upgrade Alternatives Report

In accordance with the Red Hill Administrative Order on Consent, paragraph 9, DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fines and imprisonment for knowing violation.

Signature: R.O.H

CAPT Richard Hayes, CEC, USN
Regional Engineer, Navy Region Hawaii

Date: 12/8/2017

AttributeContract N62742-13-D-0001, Delivery Order 0009

RED HILL AOC SOW SECTION 3.0 TANK UPGRADE ALTERNATIVES (TUA)

RED HILL FUEL STORAGE FACILITY
NAVSUP FLC PEARL HARBOR (PRL), HAWAII

Final Report
December 2017

Administrative Order on Consent
In the matter of Red Hill Bulk Fuel Storage Facility
EPA Docket No. RCRA 7003-R9-2015-01
DOH Docket No. 15-UST-EA-01

Contract Agency:

NAVFAC Pacific
258 Makalapa Drive, Suite 100
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Prime Contract:

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EEI Project No. 8290

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Red Hill AOC SOW SECTION 3.0
TANK UPGRADE ALTERNATIVES (TUA)

Red Hill Fuel Storage Facility
NAVSUP Fleet Logistics Center (FLC) Pearl Harbor, HI

ABSTRACT

The Red Hill AOC Statement of Work (SOW), Section 3.3, requires a report to identify and evaluate various Tank Upgrade Alternatives (TUAs) that can be applied to the tanks at Red Hill.

Enterprise Engineering, Inc. (EEI), under contract to HDR (Prime Contractor for NAVFAC PAC; Contract N62742-13-D-001, Delivery Order 0009), identified several available tank upgrade technologies which were screened and developed into several tank upgrade alternatives for the Red Hill tanks.

During the December 2015 scoping meeting, stakeholders screened the tank upgrade alternatives identified by EEI and selected six alternatives (three single wall and three double wall/secondarily contained tank options) for further evaluation.

- Alternative 1A - Restoration of Existing Tank
- Alternative 1B - Restoration of Existing Tank plus Interior Coating
- Alternative 1D - Remove Existing Steel Liner, Install New Steel Liner with Interior Coating
- Alternative 2A - Composite Tank (Double Wall) Carbon Steel, with Interior Coating
- Alternative 2B - Composite Tank (Double Wall) Stainless Steel
- Alternative 3A - Tank within a Tank (Carbon Steel), full Interior and Exterior Coating

EEI prepared this report on our evaluation of the six tank upgrade alternatives that can be implemented at Red Hill to reduce the risk of releases to the environment while maintaining operational capabilities. In this report EEI describes, evaluates, and rates the specific attributes for each selected alternative, but makes no attempt at ranking one alternative against another. We provide concept level details (descriptions and graphics) of these six alternatives, a rating of each alternative for specific attributes, planning level cost estimates to implement the alternatives, construction duration estimates, and a life cycle cost analysis (LCCA) for each alternative. Construction level design and details are the responsibility of an Engineer of Record selected by the Government or prescribed in a Government solicitation.

The data and analysis contained in this report is informational in nature with a focus on presenting relevant factors for decision makers for their analysis and eventual selection of the Best Available Practicable Technology (BAPT) tank upgrade that meets the stakeholders' objectives.

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ABBREVIATIONS AND ACRONYMS

AC	Quality Control
AE	Architectural Engineering
AOC	Administrative Order on Consent
API	American Petroleum Institute
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
AWS	American Welding Society
BAPT	Best Available Practicable Technologies
Bbl	Barrels
BFET	Balanced Field Electromagnetic Technique
CATEX	Categorical Exclusion
CFR	Code of Federal Regulations
CFM	cubic feet per minute
CIR	Clean, Inspect, and Repair
DFSP	Defense Fuel Support Point
DLA	Defense Logistics Agency
DoD	Department of Defense
DOH	Department of Health
EEI	Enterprise Engineering, Inc.
EPA	Environmental Protection Agency
FAR	Federal Acquisition Regulation
FLC	Fleet Logistics Center
FLCY	Fleet Logistics Center, Yokosuka
FML	Flexible Membrane Liner
GLS	Global Logistics Support
HAR	Hawaii Administrative Rule
HECO	Hawaiian Electric Company
HDPE	High Density Polyethylene
HI	Hawaii
HSS	Hollow Structural Section
IFB	Invitation for Bid

IFP	Internal Floating Plan
JFIP	Japanese Facility Improvement Program
JP	Jet Propellant
KVA	Kilovolt-Amperes (unit of apparent electrical power)
LCCA	Life Cycle Cost Analysis
LED	Light Emitting Diode
LFET	Low Frequency Electromagnetic Technique
LLDPE	Linear Low-Density Polyethylene
LNG	Liquefied Natural Gas
MILCON	Military Construction
NACE	National Association of Corrosion Engineers
NATO	North Atlantic Treaty Organization
NAVFAC EXWC	Naval Facilities Expeditionary and Warfare Center
NAVSUP	Naval Supply Systems Command
NDE	Non-destructive Examination
NEPA	National Environmental Policy Act
NETOPS	Naval Engineering Training and Operating Procedures and Standards
NIOSH	National Institute for Occupational Safety and Health
NPV	Net Present Value
NRL	Naval Research Lab
NS	Naval Station
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
PACOM	Pacific Command
PP	Polypropylene
PVC	Poly Vinyl Chloride
QA	Quality Assurance
QC	Quality Control
RDS	Release Detection System
ROI	Return on Investment
ROM	Rough Order of Magnitude Cost
RP	Recommended Practice
SAES	Scope of Architect-Engineer Services

SCR	Selective Catalytic Reduction
SIOH	Supervision, Inspection, and Overhead
SMART	Simple Multi Attribute Rating System
SME	Subject Matter Expert
SOW	Statement of Work
SPA	State Program Approval
SRM	Sustainment Restoration Modernization
SSPC	Steel Structures Painting Council
TBD	To Be Determined
TIRM	Tank Inspection Repair and Maintenance
TUA	Tank Upgrade Alternative
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification
US	United States
USACE	United States Army Corps of Engineers
UST	Underground Storage Tank
VOC	Volatile Organic Compound

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Red Hill AOC SOW SECTION 3.0
TANK UPGRADE ALTERNATIVES (TUA)

Red Hill Fuel Storage Facility
NAVSUP Fleet Logistics Center (FLC) Pearl Harbor, HI

PART A - INTRODUCTION

The Red Hill AOC Statement of Work (SOW), Section 3.3, requires a report to identify and evaluate various tank upgrade alternatives (TUAs) that can be applied to the tanks at Red Hill.

This report presents and evaluates six tank upgrade alternatives (three single wall and three double wall/secondarily contained tank options) that can be applied to the tanks at Red Hill to reduce the risk of releases to the environment while maintaining operational capabilities.

- Alternative 1A - Restoration of Existing Tank
- Alternative 1B - Restoration of Existing Tank plus Interior Coating
- Alternative 1D - Remove Existing Steel Liner, Install New Steel Liner with Interior Coating
- Alternative 2A - Composite Tank (Double Wall) Carbon Steel with Interior Coating
- Alternative 2B - Composite Tank (Double Wall) Stainless Steel
- Alternative 3A - Tank within a Tank (Carbon Steel), full Interior and Exterior Coating

This report describes, evaluates, and rates the selected alternatives for specific attributes. We provide concept level details (descriptions and graphics) of these six alternatives, a rating of each alternative for specific attributes, planning level cost estimates to implement the alternatives, construction duration estimates, and a life cycle cost analysis (LCCA) for each alternative. Construction level design and details are the responsibility of an Engineer of Record selected by the Government or prescribed in a Government solicitation.

Definitions of various terms in this report are provided at the end of this report in the Section entitled “Definitions”.

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PART B - EXISTING TANK CONSTRUCTION AND CONFIGURATION

1.0 BACKGROUND

The FLC Pearl Harbor Red Hill Bulk Fuel Storage Facility was constructed during August 1940 to September 1943. The facility consists of twenty underground vertical cylindrical reinforced concrete fuel storage tanks (Tanks 1 to 20) with a dome top and dome bottom, internal steel liner, fuel piping, mechanical and ventilation systems, electrical systems, Upper Tunnel, Lower Tunnel, Adits 3, 4, 5, and 6, and associated infrastructure. A 3+ mile long tunnel connects the Tank Gallery area to the Underground Pumphouse at Joint Base Pearl Harbor Hickam.

The Upper Tunnel provides access to the tank manholes and gauging platforms. The Lower Tunnel provides access to the tank piping and valves. Adit 4 (located at Tanks 1 and 2) and Adit 5 (located between Tanks 13 and 15) provide access to the Upper Tunnel. Adit 3 provides access to the Lower Tunnel at Tanks 1 and 2. Access into the tanks is via an 8-feet diameter manhole at the Upper Tunnel level.

Each tank has a steel framed tower in the center of the tank extending from the floor of the lower dome to the top of the upper dome with a walkway from the manhole at the Upper Tunnel level to the tower. The center tower was used during original construction to construct the tanks and remains in the tanks to provide access into the tanks via stairs and booms with personnel platforms on the center tower and a hoist within the tower.

Eighteen tanks (Tanks 2 to 18, and 20) are currently in service and are used to store military fuel. Tank 1 and Tank 19 are not in service.

2.0 TANK CONSTRUCTION AND CONFIGURATION

Tanks 1 to 4 are 100 feet 0 inches diameter, 238 feet 6 inches overall height, and have a nominal storage capacity of 285,148 barrels (Bbl) each. Tanks 5 to 20 are 100 feet 0 inches diameter, 250 feet 6 inches overall height, and have a nominal storage capacity of 301,934 Bbl each. The top of the tanks (top of the upper dome) is 110 feet to 175 feet below ground. The bottoms of the tanks range in elevation from 123 feet to 151 feet above sea level. The tanks are arranged in two rows of 10 tanks, spaced 200 feet on center. 100 feet of lava rock separates the tanks from each other. The primary structure of the tanks consists of an upper dome, barrel, and lower dome.

Tanks 1 to 20 were constructed by excavating the lava rock formation of Red Hill to create a cavity for each tank which was then lined with Gunite, reinforced concrete, and a 1/4-inch thick steel liner. The upper dome was constructed first. The lava rock was excavated to create a cavity for the upper dome. Steel framing and liner plates were then installed, followed by filling the cavity between the liner plates and lava rock with reinforced concrete, 4 feet thick.

After the upper dome was constructed, the barrel and lower dome were excavated. The rock face was lined with 6 inches of Gunite (i.e. spray-applied concrete, also known as shotcrete) to seal the rock face. In some locations additional grouting into the lava was required to fill voids. The barrel is constructed of reinforced concrete (2 feet 6 inches thick minimum at the top, 4 feet thick minimum at the bottom). The steel liner plates on the barrel are arranged 5-feet tall horizontal courses and served as forms for placing concrete. Horizontal steel angles were welded to the backside of the steel plates at the top and bottom of the plates. All horizontal and vertical joints in the steel liner are butt welded plates. Reinforcing steel for concrete was then placed in the forms. The horizontal angles were then anchored to the reinforcing steel with 3/4-inch diameter anchor rods. Concrete was placed in the forms in 5-feet lifts. After the concrete cured, water was injected between the concrete and Gunite layer to check for gross leaks in the steel liner. If no gross leaks were identified, the barrel was prestressed by injecting grout between the reinforced concrete and Gunite layer. Grout was injected via tubes that penetrated the steel liner and extended through the concrete to the Gunite layer. Grouting pressure was monitored with stain gauges in strain gain tubes in the Barrel. The strain gauge tubes penetrate the steel liner and extend through the concrete and Gunite and into the lava rock. Grout tube and stain gauge tube penetrations in the steel liner were sealed with plates welded over the penetrations.

The lower dome is similarly constructed of reinforced concrete and lined with 1/4-inch thick steel plates. The floor of the lower dome (20-foot diameter) is flat and consists of 1/2-inch thick steel plates.

Major features of a Red Hill Tank include:

- Upper Tunnel
- Upper Dome
- Barrel
- Expansion joint at top of barrel
- Barrel extension above expansion joint (Tanks 5 to 20)
- Lower Dome
- Lower Dome/Barrel junction
- Lower Tunnel
- Center Tower
- Tank Manhole at 200 ft. elevation to the Upper Tunnel
- Walkway from Tank Manhole to Center Tower
- Gauging gallery above Upper Dome
- Tank vapor space venting
- Tell-tale piping system inside tank (presently removed in some tanks and inactive in tanks where the tell-tale piping remains). The tell-tales exited the tank through the concrete plug at the bottom of the tank and terminated at a sampling station in the Lower Tunnel.
- Tank liquid level and temperature sensors (Automatic Tank Gauge System).

- Fill/issue piping (aka nozzle) from the Lower Dome to the Lower Tunnel through the under-tank concrete plug.
- Sampling lines in the Lower Dome to the Lower Tunnel inside a variety of casings (repurposed original nozzles).
- Slop (or drain) lines (aka nozzles) in the Lower Dome to the Lower Tunnel, some original, some repurposed from other services.
- Originally installed casings from the Lower Dome to the Lower Tunnel for steam and condensate lines have all been closed off, or repurposed for other use.
- Original installed tell-tale lines (12) from the Lower Dome to the Lower Tunnel have all been closed off.
- Grout tubes and strain gain tubes in the Barrel (strain gauge tube penetrate the steel liner and extend through the concrete and Gunite and into the lava rock. The tubes are covered by plates, or pipe caps inside the tank.

Major features of a Red Hill tank are shown in the following graphics.

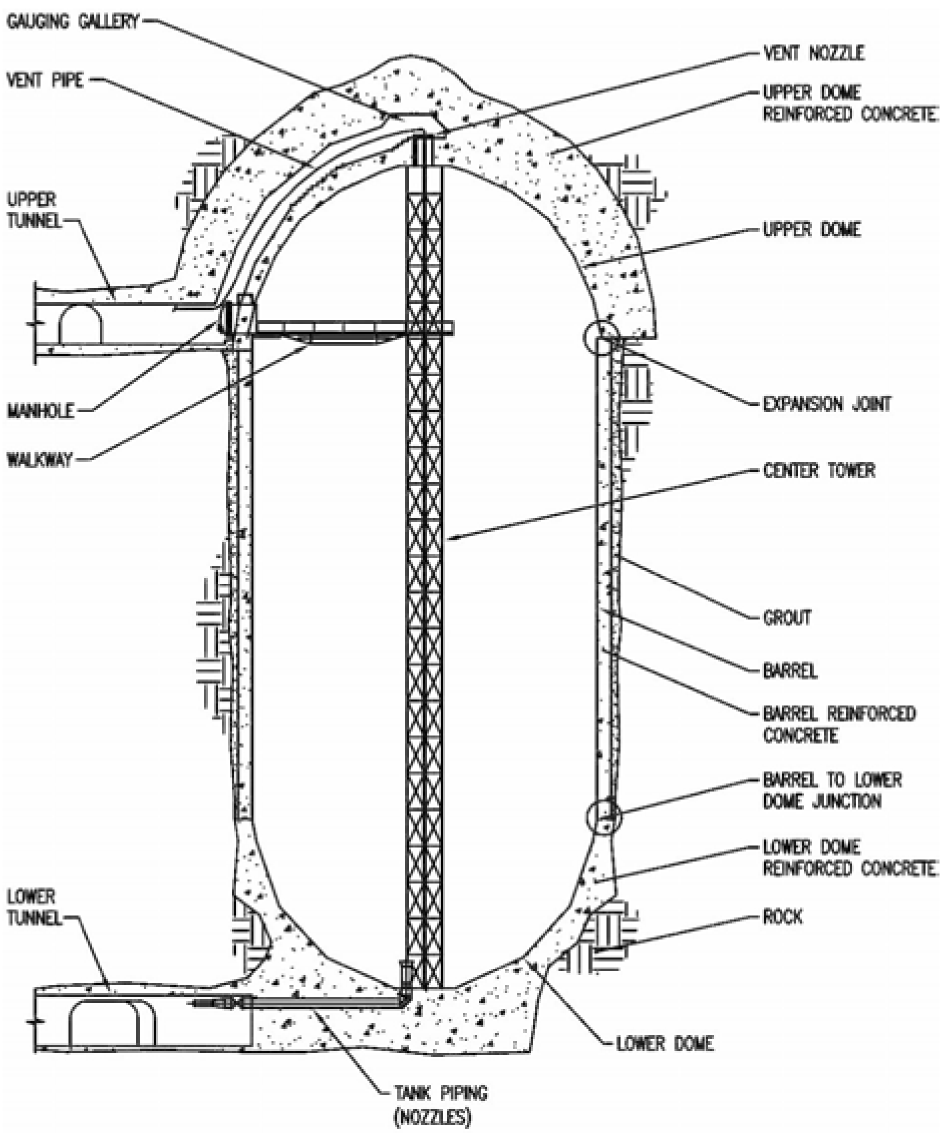

Figure B-1.0-1 Existing Tanks 1 - 4 Elevation

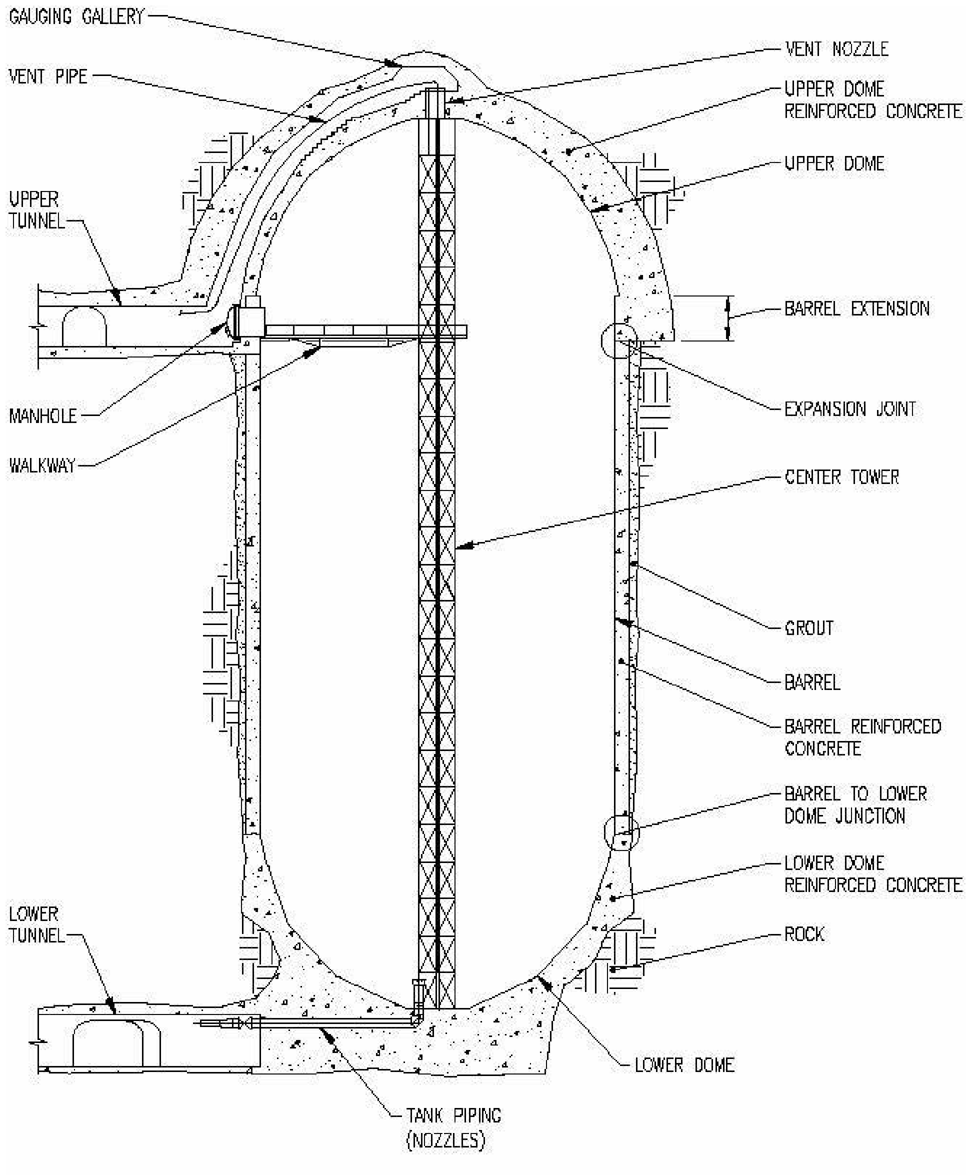

Figure B-1.0-2 Existing Tanks 5 - 20 Elevation

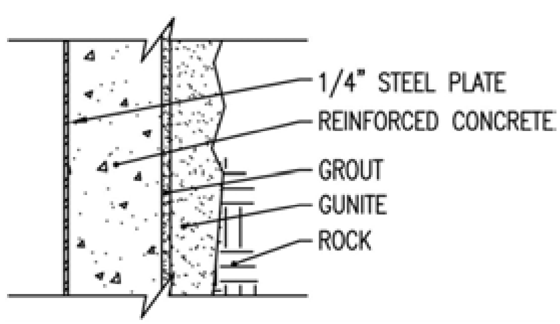

Figure B-1.0-3 Existing Barrel Wall Section

3.0 ORIGINAL AND MODIFIED TANK TELL-TALE SYSTEM

The originally installed tank tell-tale system provided a means to detect a fuel breach in the tank steel liner by conveying leaking fuel between the steel liner and concrete barrel to the lower tunnel through a series of collector pipes inside the tank. The tell-tale system also provided a means to air test the tank liner for hydraulic integrity during tank construction.

The previously released Red Hill AOC Section 2.2 TIRM Report (11 October 2016), and supplemental Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document (24 April 2017) contain historical research and in-depth discussion of original and modified tell-tale systems. See Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document ¶17-7.2a, and TIRM Report Attachment BF. The following discussion is a summary and is presented as a basis for possible consideration of the reinstallation of a tell-tale system as a part of the single wall (Alternative 1) options. It also can be used to compare against the proposed interstitial monitoring system, which provides a similar purpose for the Alternative 2 tank options.

The original tell-tale system was configured differently for the upper dome, the barrel, and the lower dome. The upper domes were such that liquid would freely drain down the backside of the steel liner, and pool just above the expansion joint. This liquid was drained to 11 zones of barrel tell-tales via a liner penetration and connecting piping. The barrel tell-tale system consisted of 11 vertical pipes the height of the barrel, with pipe penetrations every 5 feet through the shell liner, to correspond with the horizontal shell plate width, and embedded angles in the concrete, that in effect is a horizontal “dam” at each of the 26 or 28 shell courses. Thus, there are approximately 352 shell penetrations. The liner plates in the lower dome are fully surrounded by embedded angles, thus each shell plate has a jumper at its lowest point, to the top of the next plate (a total of 165 jumper liner penetrations). At the bottom of the lower dome, a circular pipe is connected to each of the lowest plates to collect any liquid. The 12 in-tank tell-tale collector pipes penetrated the tank liner, and extended through the tank bottom concrete plug to outlets in the Lower Tunnel. By monitoring the 12 valved outlets in the Lower Tunnel, a breach of any tank surface would be detected. Likewise, any water buildup between the steel shell liner and concrete barrel could be drained off.

The original tell-tale system was constructed with 3/4-inch schedule 40 pipe. It experienced plugging, as well as exterior corrosion induced failure from the salt water inherent with tanker delivered fuel. The tell-tale pipe exterior corrosion was near the floor of the lower dome.

Tanks 17-20 received a replacement tell-tale system between 1960-62, consisting of 1.5-inch schedule 80 lines. Tanks 1-16 received a similar upgrade in 1970-72. The upgraded tell-tale systems reportedly performed well. For undocumented reasons, the tell-tale system was removed in Tanks 1-16 in 1978-1982, and more recently in tanks 17 and 20.

4.0 HISTORICAL STRUCTURAL AND INTEGRITY ISSUES

This discussion summarizes typical structural and integrity issues. Details of tank histories are provided in Red Hill AOC SOW Section 2.2, TIRM Report, and Red Hill AOC SOW Section 5, Corrosion and Metal Fatigue Practices.

Structural and integrity issues relevant to repairing the tanks for a future use consist of:

- Internal (product side) corrosion and pitting in the steel liner
- External (back side) corrosion in the steel liner
- Fabricated penetrations in the steel liner requiring repair
- Dents and bulges in liner plates that would interfere with repairs
- Indications in welds in the upper dome (pitting, corrosion, lack of fusion, porosity, and slag inclusions). The upper domes in some tanks were repaired in the past by welding formed steel channels over the welds. Some tanks were repaired by re-welding the welds.
- Rejectable indications in welds in the barrel and lower dome requiring repair
- Failures (breaches) and external corrosion in the tell-tale piping (tell-tale piping in some of the tanks has been removed, tell-tale piping that remains in some tanks is inactive). Currently no tell-tale piping extends from inside the tank, to the lower tunnel.
- Repairs to the center tower
- Internal corrosion in the tank piping (nozzles) leading to the main headers in the Lower Tunnel requiring repair or life extension considerations (coatings).
- Integrity of original welding on tank piping (nozzles) requiring repair.

Note: See Definitions at the end of this report for definition of "indications".

5.0 RELEASE DETECTION

Technology based release detection, gauging, and release detection system upgrades are discussed in Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report.

6.0 CURRENT TANK UPGRADE PROCEDURES

Current approach consists of performing an out-of-service inspection of the tank interior (including LFET scanning the steel liner plates and BFET scanning of welds for corrosion and other indications) and repairing rejectable indications identified during the inspection. Under this approach select indications such as pits and corrosion in welds are repaired and areas in the steel liner plates having a remaining thickness below a predetermined minimum thickness are repaired (0.170 inches minimum thickness was used on Tanks 2 and 20). Repair costs are highly variable depending on the condition of the tank and the indications identified.

7.0 IMPACT OF TANK CONSTRUCTION AND CONFIGURATION ON UPGRADES

Important and related issues of actual execution of inspections, repairs, and upgrades for the Red Hill tanks are unique, but have been addressed in other construction projects.

- Inspecting the barrel involves working from personnel baskets suspended from booms erected on the center tower, or as currently being used on latest tank inspection and repair projects at Red Hill, via moveable platforms suspended from a monorail inside the tanks and via a dome truss movable scaffold system.
- Repairs to the existing steel liner on the barrel involves working from personnel baskets suspended from booms erected on the center tower, as currently being used on latest tank inspection and repair projects at Red Hill, via moveable platforms suspended from a monorail inside the tanks.
- Inspecting the upper dome involves working from a dome truss movable scaffold system suspended from booms erected on the center tower.
- Repairs to the upper dome involves working from a dome truss movable scaffold system suspended from booms erected on the center tower.
- Materials for tank repairs and upgrades must be brought into the tanks via the Upper Tunnel, and must fit through the tunnel bulkhead doors (approximately 7-feet high) and tank manhole 8-feet diameter).
- Recent tank cleaning, inspection, and repair projects at Red Hill tanks identified critical deficiencies in obtaining power for construction which were mitigated by the contractor providing a power service entrance directly connected to Hawaii Electric Company (HECO). However, the scale of the current projects may be less than some of the more aggressive Alternatives in this report.
- The piping (tank nozzles) from the Lower Dome is encased in the concrete base (plug) below each tank. Providing new piping would require boring though approximately 45 feet of concrete to the Lower Tunnel. Multiple integrity assessment steps will be taken to assure the present nozzles are suitable for continued service.

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PART C - TANK UPGRADES SELECTED FOR EVALUATION

1.0 PROCESS TO SELECT ALTERNATIVES FOR EVALUATION

The overall methodology of developing candidate BAPT solutions was established and discussed extensively with Stakeholders, documented in Appendix B. The first step in the formal Red Hill AOC SOW Section 3.0 Tank Upgrade Alternative assessment was the identification of "Tank Upgrade Technologies." This process is further described in Appendix C. Through a process of elimination, the list of candidates was reduced to a manageable level for further assessment.

Candidate Alternatives in Appendix D were screened with input from stakeholders at the Red Hill AOC SOW Section 3.0 Tank Upgrade Alternative, Scoping Meetings on December 3 and 4, 2015 which resulted in six final candidates (three single wall tank alternatives and three double wall tank/secondary containment alternatives) for the detailed BAPT assessment.

2.0 TANK UPGRADES SELECTED FOR EVALUATION

The six selected alternatives are:

Single Wall Tank Alternatives

- Alternative 1A - Restoration of Existing Tank and Nozzles
- Alternative 1B - Restoration of Existing Tank and Nozzles plus Interior Coating
- Alternative 1D - Restoration of Existing Nozzles, Remove Existing Steel Liner, Install New Steel Liner with Interior Coating

Double Wall Tank/Secondary Containment Alternatives

- Alternative 2A - Composite Tank (Double Wall) Carbon Steel Tank with Interior Coating, new Double Wall Nozzles
- Alternative 2B - Composite Tank (Double Wall) Stainless Steel Tank, new Double Wall Nozzles
- Alternative 3A - Tank within a Tank (Carbon Steel), full Interior and Exterior Coating, new Double Wall Nozzles

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PART D - ATTRIBUTE DEFINITIONS AND RATING SYSTEM FOR ALTERNATIVES

1.0 INTRODUCTION

To evaluate the six Alternatives that were selected in Part E for further evaluation, eighteen attributes were identified, and a rating system was developed to rate the Alternatives for the various attributes.

2.0 ATTRIBUTE DEFINITION

An attribute is a quality or feature regarded as a characteristic used to evaluate an Alternative's compliance with the criteria.

3.0 RANKING SYSTEM VERSUS RATING SYSTEM

A rating system compares different items using a common scale (e.g., Rate each of the following items on a scale of 1-10, where 1 is 'not at all important' and 10 is 'very important') while a ranking system compares different items directly to one another (e.g., Rank each of the following items in order of importance, from the #1 most important item through the #10 least important item). (1) One primary difference is a rating system permits the same response for different alternatives, whereas a ranking system does not.

As decided during the Red Hill AOC SOW Section 3.0 scoping meetings and follow-on discussions, this report does not rank Alternatives against each other; but rates Alternatives using a non-numerical "Rating" system of attributes to rate the same attribute for each alternative.

4.0 RATING SYSTEM

EEI developed the following non-numerical 5-scale system for rating the Alternatives. (2) Each Alternative is rated as meeting or deviating from the attribute criteria by applying a rating to each attribute.

The rating system is not weighted and does not compare one Alternative to another. However, various group screening/decision making approaches (performed by others) can utilize the information to weight the attributes and rank the Alternatives and achieve closure on making decisions.

- Meets Criteria
- Mostly Meets Criteria
- Somewhat Meets Criteria
- Mostly does not Meet Criteria
- Does not Meet Criteria

To rate an attribute consistently across the six Alternatives, definitions were developed for the above ratings to define the meaning of the rating. For example, “Meets Criteria”, “Mostly Meets Criteria”, etc. are defined for each attribute so that an attribute can be rated consistently across the six Alternatives.

For some attributes, a simpler 2-scale binary rating is used. For example, for “Provides Secondary Containment”, the following rating system is used:

Meets Criteria

Does not Meet Criteria

5.0 ATTRIBUTE RATING DEFINITIONS

The following defines the attributes and attributing ratings used in evaluating the Alternatives

Refer to the individual sections in Part E, on each of the six alternatives for discussion on how and why an attribute was rated for each Alternative.

Attributes and ratings for each Alternative are detailed in Part F Table F-1.

5.1 Constructible

Alternative can be constructed in field at Red Hill using practicable construction means and methods. Practicable must recognize the difficulty in bringing construction materials into the tanks through the limited access Upper Tunnel, or other methods as may be developed for individual alternatives, as well as the degree of difficulty in accessing the tank surfaces for the inspection and repair process.

- **Meets Criteria:** Has been done before at Red Hill, can be constructed within the confines of Red Hill with no impact/modification to the Red Hill infrastructure or physical arrangement.
- **Mostly Meets Criteria:** Has been done elsewhere but not at Red Hill, requires some impact/modification to the interior of Red Hill tanks and/or infrastructure such removal or installation of steel liner plates, or as boring through the Lower Dome to install new tank nozzles.
- **Somewhat Meets Criteria:** Has been done elsewhere but not at Red Hill, requires extensive modification to Red Hill infrastructure such as drilling shaft down to the top of the tank to bring power/concrete into tank, new access to tunnel system, new access to tanks.
- **Mostly does Not Meet Criteria:** Has not been done before elsewhere, plus requires same major infrastructure or physical modification as defined above.
- **Does not Meet Criteria: Rating not applicable.**

5.2 Testable

Alternative can be tested and shown acceptable during construction prior to filling and during startup/commissioning when filling.

Note: "Testable" further refined by Attribute 13.

- **Meets Criteria:** Alternative can be shown to meet hydraulic and structural integrity standards prior to being place into service.
- **Does not Meet Criteria:** Alternative cannot be shown to meet hydraulic and structural integrity standards prior to being place into service.

5.3 Inspectable

Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service.

Note: Inspection requirements for each TUA further refined in the TIRM and Attributes 14 and 15.

- **Meets Criteria:** TIRM can be developed using industry standard inspection techniques.
- **Does not Meet Criteria:** Inspection techniques not readily available.

5.4 Repairable

Alternative can be repaired in field at Red Hill using standard, traditional construction/repair means and methods.

- **Meets Criteria:** Removal or modification of the Red Hill infrastructure is not required to gain access to the tank. All interior surfaces of the primary tank, tank nozzles, internal components, and secondary containment are accessible for repair. Repairs can be performed from inside the tank or secondary containment without having to remove part of the primary tank or internal component to access an area for repair.
- **Mostly Meets Criteria:** Removal or modification of the Red Hill infrastructure is not required to gain access to the tank. Interior and exterior surfaces of the primary tank, internal components, and secondary containment are accessible for repair. Repairs can be performed from inside the tank or secondary containment. Requires removal of part of the primary tank or component to access an area for repair.
- **Somewhat Meets Criteria:** Removal or modification of the Red Hill infrastructure is required to gain access to the tank. Only interior surfaces of the primary tank and internal components are accessible for repair. Repairs can only be performed from inside the primary tank or component to access an area for repair.
- **Mostly does Not Meet Criteria:** Removal or modification of the Red Hill infrastructure is required to gain access to the tank. Only select areas of the tank can be repaired.
- **Does not Meet Criteria:** No area of the tank is accessible for repair.

5.5 Practicable

Alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters.

- **Meets Criteria:** Alternative can be constructed within the confines of Red Hill with no impact/modification to the Red Hill infrastructure or physical arrangement at a cost within 250% of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.
- **Mostly Meets Criteria:** Alternative can be constructed within the confines of Red Hill with minimal impact/modification to the Red Hill infrastructure or physical arrangement at a cost between 250% and 500% of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.
- **Somewhat Meets Criteria:** Alternative can be constructed within the confines of Red Hill with moderate impact/modification to the Red Hill infrastructure or physical arrangement at a cost between 500% and 1,000% of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.
- **Mostly does Not Meet Criteria:** Alternative can be constructed within the confines of Red Hill with significant impact/modification to the Red Hill infrastructure or physical arrangement at a cost between 1,000 and 2,000% of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.
- **Does not Meet Criteria:** Alternative cannot be constructed within the confines of Red Hill without detrimental impact/modification to the Red Hill infrastructure or physical arrangement at a cost that exceeds 2,000% of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.

5.6 Corrosion Damage Mechanism

Alternate has a coating system that provides corrosion protection or is constructed of a corrosion resistant material.

- **Meets Criteria:**
  - 100% of the interior (product side) of the tank is coated or is constructed of corrosion resistant material.
  - Interior of existing nozzles is 100% coated or is constructed of new piping designed for a 70+ year life.
- **Mostly Meets Criteria:**
  - 100% of the interior (product side) of the tank is coated or is constructed of corrosion resistant material.
  - Interior of existing nozzles is not coated or is not constructed of new piping designed for a 70+ year life.
- **Somewhat Meets Criteria:**

- The lower dome (product side) of the tank is coated or is constructed of corrosion resistant material.
- Interior of existing nozzles is 100% coated or is constructed of new piping designed for a 70+ year life.
- The barrel and upper dome are not coated or constructed of corrosion resistant material.

- **Mostly does Not Meet Criteria:**
  - The lower dome (product side) of the tank is coated or is constructed of corrosion resistant material.
  - Interior of existing nozzles is not coated or is not constructed of new piping designed for a 70+ year life.
  - The barrel and upper dome are not coated or constructed of corrosion resistant material.
- **Does not Meet Criteria:**
  - The lower dome, barrel, upper dome are not coated and are not corrosion resistant material.
  - Interior of existing nozzles is not coated or is not constructed of new piping designed for a 70+ year life.

5.7 Successful Implementation Elsewhere

Alternative has been put into place at other large fuel depots and is successful in preventing leaks to the environment and/or detecting leaks.

- **Meets Criteria:** Alternative used at other large fuels depots, would be successful in preventing leaks and would be successful in detecting leaks at Red Hill.
- **Mostly Meets Criteria:** Alternative used at other large fuels depots and would be successful in preventing leaks at Red Hill.
- **Somewhat Meets Criteria:** Alternative used at other large fuels depots and would be successful in detecting leaks at Red Hill.
- **Mostly does Not Meet Criteria:** Alternative not used at other large fuels depots, but would be successful in preventing leaks and/or detecting leaks.
- **Does not Meet Criteria:** Alternative not used at other large fuels depots and would not be successful in preventing leaks and/or detecting leaks.

5.8 Reliability

Ability of Alternative to perform its required function (hold product) under stated conditions for a specified minimum period, which is defined as the next out-of-service internal inspection interval.

- **Meets Criteria:** Can be relied upon to perform its function until the next inspection at a minimum.
- **Does not Meet Criteria:** Cannot be relied upon to perform its function until the next inspection.

5.9 Impact on Storage Volume

If the Alternative results in a reduction in volume, the reduction is presented as a percent reduction in volume compared to the existing overall facility volume and the reduction in volume is presented.

- **The impact on volume is not rated.**

5.10 Provides Secondary Containment

Alternative provides secondary containment of a release from the primary tank. The primary tank is the wall of the tank that provides primary containment, e.g. the wall of a single wall tank or the inner wall of a double wall tank.

Note: Under 2015 EPA 40 CFR 280 final rule, secondary containment is not required for field-erected tanks larger than 50,000 gallons.

Note: For the purpose of evaluation, a tank that is configured such that the exterior surface of the shell/roof if visibly inspectable, is considered an aboveground tank.

- **Meets Criteria:**
  - UST: Meets 40 CFR 280 criteria for secondary containment (i.e. has an inner and outer barrier with an interstitial space that is monitored for leaks).
  - AST: Meets 40 CFR 112 requirements for secondary containment (i.e. sufficiently impermeable barrier and contains the full volume of the container plus precipitation).
- **Does not Meet Criteria:** Does not meet either of the above criteria.

5.11 Dependency on Existing Tank Steel Liner

Alternative is not dependent on the hydraulic integrity of the existing tank liner to contain product (primary tank) or provide a barrier between a breach of the primary tank, and the environment (i.e. interstitial space boundary, or dike wall/floor secondary containment boundary.

- **Meets Criteria:** Alternative does not rely on the hydraulic integrity of the existing tank liner to contain product.
- **Mostly Meets Criteria:** Alternative does not rely on the hydraulic integrity of the existing tank liner to contain product, but relies on existing tank liner to serve as the outer barrier of an interstitial space or as secondary containment.
- **Somewhat Meets Criteria:** Alternative relies on both the hydraulic integrity of the existing tank liner and the hydraulic integrity of the tank upgrade.

- **Mostly does Not Meet Criteria:** Alternative relies on the hydraulic integrity of the existing tank liner to contain product, but includes an upgrade such as an internal lining to enhance the hydraulic integrity of tank to contain product.
- **Does not Meet Criteria:** Alternative is solely dependent on the hydraulic integrity of the existing tank to contain product.

5.12 Release Detection Integral to Construction

Alternative has release detection capability that is integral to (i.e. is physically part of) the upgrade construction such as an interstitial space with monitoring, or visible / inspectable space such as a dike surrounding the tank. The complexity and ability to confirm integrity of the system are factored into the rating of the alternative

Note: This attribute does not address the use of tank internal (volume and/or mass based technology) leak detection systems.

- **Meets Criteria:** The tank surfaces are nearly 100% visually inspectable for integrity and operability.
- **Mostly Meets Criteria:** A leak from the shell is visibly observable. A release detection system from the tank floor / lower dome is present, and can be tested by leak simulation.
- **Somewhat Meets Criteria:** A release detection system (interstitial space) for the shell and floor is present, but cannot be directly observed for integrity. A means is present to simulate a leak or otherwise test the integrity of the release detection system operability.
- **Mostly does Not Meet Criteria:** A release detection system (interstitial space) for the shell and floor is present, and it cannot be directly observed for integrity, and cannot be integrity tested using a leak simulation method.
- **Does Not Meet Criteria:** No release detection system is a part of the tank construction thereby triggering the necessity for alternative leak detection methods as mandated by 40 CFR 280.43.

5.13 Testing and Commissioning Procedures

Alternative does not require rigorous level of testing and commissioning procedures to return the tank repair/upgrade to service.

In this case, "placing the tank in service" are actions necessary for the first filling with fuel, performing commissioning steps, and determining the tank repair process was successful, declared liquid tight, and suitable for turning over to the Red Hill operator for use.

The Release Detection System must be included in the testing process.

- **Meets Criteria:** The tank can be filled while continuously visually monitoring the shell surfaces for a breach of hydraulic integrity or evidence of structural failure, and the floor that cannot be directly visually monitored, can be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping).

- **Mostly Meets Criteria:** The tank can be filled while floor and shell that cannot be directly visually monitored, can be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping).
- **Somewhat Meets Criteria:** The tank does not have a shell or floor secondary containment system with release detection piping, that can be continuously monitored for hydraulic integrity. Tank filling must be performed with numerous "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.5 is required prior to turning the tank over to the operator.
- **Mostly does Not Meet Criteria:** No means/procedures are possible to evaluate hydraulic integrity as a part of the filling process using the installed inventory system. A separate hydraulic integrity test meeting the requirements of Red Hill AOC SOW Section 4.1 is required at multiple filling "hold points" to determine hydraulic integrity during filling and prior to turning the tank over to the operator.
- **Does not Meet Criteria:** The tank cannot be monitored for hydraulic or structural failure during, or immediately after filling.

5.14 TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Upgrade

Alternative requires a level of inspection and repair of existing tank as specified in Red Hill AOC SOW Section 2.2 TIRM Procedures Report Appendix BD: UFGS 33 56 17.00 20 Inspection of Fuel Storage Tanks and Appendix BE UFGS 33 56 18.00 20 Repair of Red Hill Fuel Storage Tanks.

- **Meets Criteria:** Alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report.
- **Mostly Meets Criteria:** Alternative relies on the integrity of the existing steel liner. As the existing steel liner cannot be inspected at future integrity inspections, Alternative requires a higher level of repair than Red Hill AOC SOW Section 2.2 TIRM Report.
- **Somewhat Meets Criteria:** Alternative relies considerably on the integrity of the existing shell, which can be re-evaluated on a periodic (20 year) re-inspection cycle. Alternative requires inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of rejectable indications identified.
- **Mostly does Not Meet Criteria:** Alternative does not require same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report. Alternative has limited dependence on integrity of existing steel liner. Alternative involves inspection of the existing steel liner following industry standards using only visual inspection and ultrasonic examination at spot locations. Repair of rejectable indications identified limited to repair of existing welds and isolated areas of the steel liner.
- **Does not Meet Criteria:** Alternative does not rely on the integrity of the steel liner.

5.15 TIRM Requirements for Future Integrity Inspections

Alternative does not require rigorous level of inspection, and/or access provisions to complete integrity inspections and maintain the system.

- **Meets Criteria:** Tank welds, shell and roof can be competently inspected visually, from outside the tank, and floor welds and steel liner can be inspected from inside the tank visually and with conventional floor scanning equipment, all following traditional integrity investigation protocol outlined in API 653.
- **Mostly Meets Criteria:** Tank Shell and roof can be competently inspected visually, from outside the tank, and floor welds and steel liner can be inspected from inside the tank visually and with modified conventional equipment and procedures, all following traditional integrity investigation protocol outlined in API 653.
- **Somewhat Meets Criteria:** Tank shell, upper dome and lower dome welds and liner must be inspected from inside the tank visually and with modified conventional equipment and procedures, all following traditional integrity investigation protocol outlined in API 653. Access to all surfaces requires special procedures.
- **Mostly does Not Meet Criteria:** Tank primary shell including upper dome, barrel and lower dome welds and liner require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces.
- **Does not Meet Criteria:** Inspection to determine integrity is not possible.

5.16 Impact on Operating and Maintenance Requirements and Procedures

Current means of filling, emptying, or management of a static tank condition, or tank periodic testing is not impacted by the Alternative upgrade.

If the Alternative results in an impact to operational requirements, the increase is presented as a percent growth in required resources compared to the existing overall facility sustainment requirements. The impact on any operational parameter is rated in accordance with the resource requirement estimates as provided during interviews with NAVSUP.

Note: This attribute is not intended to address long term "non-routine" maintenance that is evaluated under the TIRM approach.

- **Meets Criteria:** Has little to no impact to the current means of filling, emptying, or management of a static tank condition, operational requirements for periodic tank testing or expenses towards labor or material for operations and/or maintenance.
- **Mostly Meets Criteria:** Requires <5% increase in operational requirements (i.e. filling, emptying or management of a static tank condition) such as additional expenses for labor and materials for operations and/or maintenance.
- **Somewhat Meets Criteria:** Requires 5-10% increase in operational requirements (i.e. filling, emptying or management of a static tank condition) such as additional expenses for labor and materials for operations and/or maintenance.

- **Mostly does Not Meet Criteria:** Requires >10% increase in operational requirements (i.e. filling, emptying or management of a static tank condition) such as additional expenses for labor and materials for operations and/or maintenance.
- **Does not Meet Criteria:** Tank cannot be operated or maintained.

5.17 Tank Upgrade Construction Cost Estimate (Planning Level)

An execution cost estimate of one tank constructed as a part of a multiple tank repair contract. Government costs, design costs, construction contingencies, Title II, and release detection system costs are not included.

- **No rating applied:** Cost is reported for decision makers to evaluate.

5.18 Tank Upgrade Duration

An estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037).

Note: Baseline estimation parameters designate each upgrade cycle to be considered as three tanks undergoing upgrade at a time with two 10-hour shifts per day at six days a week. Actual cycle times will be determined by specific TUA requirements and may overlap if/when feasible.

- **Meets Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame utilizing a three tanks per cycle phasing with two 10-hour shifts per day at six days a week.
- **Mostly Meets Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame utilizing a four tanks per cycle phasing with two 10-hour shifts per day at six days a week.
- **Somewhat Meets Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame utilizing a five tanks per cycle phasing with two 10-hour shifts per day at six days a week.
- **Mostly does Not Meet Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame requiring more than a five tanks per cycle phasing with two 10-hour shifts per day at six days a week.
- **Does not Meet Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame requiring more than a five tanks per cycle phasing and additional parameter alterations.

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PART E - DETAILED DISCUSSION AND RATING OF ALTERNATIVES

The following discussions and graphics on each Alternative is concept level to convey ideas. Construction level design and details will be the responsibility of an Engineer of Record selected by the Government, or prescribed in a Government solicitation.

1.0 ALTERNATIVE 1A - RESTORATION OF TANK

1.1 General Description

Alternative 1A is similar to the current approach to inspect and repair the tanks but with TIRM procedures established to assure the full integrity of the existing steel liner is investigated for long term life extension repairs. Tank repairs include repairing rejectable indications in welds and pitting and rejectable indications in the existing steel liner. Alternative 1A also includes integrity inspection and pressure testing of the existing single wall concrete encased tank nozzles from the tank to the first valve outside tank.

Overall the inspection and repair is considered conventional construction, with the emphasis placed on thoroughness, appropriate contractor Quality Control (QC), with government Oversight and Quality Assurance.

This alternative includes recoating the lower dome and the interior of the tank nozzles with DoD approved polysulfide modified epoxy novolac coating system.

1.2 Features of Alternative

Specific features of Alternative 1A include:

- Inspection of the existing steel liner following requirements in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document. This document in turn, refers to materials developed under the Red Hill AOC SOW Section 2.2 TIRM Report. This is an enhanced inspection process compared to a conventional API 653 Inspection, using best available inspection technology and complementary and redundant technologies in a two-step process to detect corrosion.
- Inspection and pressure testing of the existing single wall concrete encased tank nozzles from the tank to the first valve outside tank. The repair requirements, if any, identified in the inspection will be completed.
- Re-coat the lower dome and interior of nozzles.
- Release detection as identified in Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report.

1.3 Release Detection

Alternative 1A as currently proposed does not provide release detection that is integral to the tank such as a tell-tale system like the original tanks, or monitoring the interstitial space of a double wall tank (there is no interstitial space to monitor) or monitoring of secondary containment (there is no secondary containment to monitor). As such, at least one of the following release detection methods is required Under 40 CFR 280.43:

a. Inventory Control
b. Manual Tank Gauging
c. Tank Tightness Testing
d. Automatic Tank Gauging
e. Vapor Monitoring
f. Groundwater Monitoring
g. Statistical Inventory Reconciliation

See Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report for discussion on release detection. It is a basic presumption that a technology based sensitive leak detection system will be provided for all Alternative 1 tanks.

The prospect of providing a tell-tale system, in concept similar to the original or upgraded system is discussed in Chapter 12 of the Red Hill AOC Section 2.4 TIRM Procedure Decision Document. The Red Hill AOC Section 2.2 TIRM Report ¶17-7.2a describes the concept as follows:

> *"The Tell-tale leak detection system provides a real-time, analog tool for identifying potential releases, collects product trapped in the reinforced concrete shell to steel liner interstice, and provide[s] a pathway to relieve product from the interstice."*

Red Hill AOC SOW Section 4 Release Detection and Collection/Tank Tightness Testing is further evaluating the possibility of installing a tell-tale system. In theory, if implemented, a tell-tale system would provide a means of direct leak detection on par with the Alternative 2 and 3 concepts.

The findings and recommendations within this Red Hill AOC SOW Section 3.0 (TUA) report may require modification depending on the Red Hill AOC SOW Section 4.0 Release Detection and Collection/Tank Tightness Testing recommendations.

1.4 Tank Nozzles

The existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank will be inspected and pressure tested. Repairs will be provided as needed. The current tanks have a variety of nozzle conditions. As a part of the repairs, all nozzles that penetrate from the Lower Dome, to the Lower Tunnel, will be repaired and upgraded consistent with the single wall tank concept, as they are considered an extension of the tank hydraulic boundary. Some existing nozzles (such as steam and condensate) are no longer used, and will be blinded off, or repurposed, such as used for casings the sample lines. In such cases, they will not be subject to the tank product, and thus not considered an extension of the tank boundary.

In the interest of preventing internal corrosion on the primary fill, issue and drain (slop) lines, they will be coated with the same coating system as the Lower Dome. The Red Hill AOC SOW Section 2.2 TIRM Report, ¶17-6.2.1 discusses the benefits of using the UFGS Section 09 97.13.15 Polysulfide Epoxy Coating System. Principle to the nozzles, the coating qualifies as a "thick film" system under API 652 criteria. It also easily fills pits/voids, and is highly surface tolerant in application.

Consideration was given to replacement of the tank nozzles. To do so would require boring through the concrete plug below the tank, from the Lower Dome, to the lower access tunnel. If this were accomplished, the use of a double wall piping system could be considered. However, integrity inspections to date on existing nozzles has resulted in determining their integrity and suitability for continued service, with modest repairs. The nozzles in each tank will be individually assessed, and appropriate action taken as needed.

The concept of the nozzles remaining as single wall pipe is consistent with Alternative 1 as it is an extension of the single wall tank, and subject to all release detection schemes that may be applied.

1.5 Engineering Considerations

The engineering of the tank inspection process, and repair designs is considered a specialty and should be completed by an individual and organization with requisite experience with major structures, construction logistics, fuel storage tank integrity inspection and repair.

There is no level of engineering considered beyond having the prior experience to complete.

1.6 Preparatory Inspection and Repair of Existing Tank Liner

Inspection and repair of the existing steel liner will follow the requirements in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document and its references to Red Hill AOC SOW Section 2.2 TIRM Report.

1.7 Testing and Commissioning Procedures

Refer to specific attributes for discussion on testing and commissioning procedures.

1.8 Construction Logistics

Refer to Part G for discussion on construction logistics.

1.9 TIRM

After startup and being placed into service, future integrity inspections, repairs, and maintenance will follow the requirements in Red Hill AOC SOW Section 2.2 TIRM Report and Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document.

The goal is for the tank to have a 20-year in-service period between outages for internal tank inspections and repairs. As the process of clean-inspect-repair can take 2-3 years, the development of an appropriate inspection protocol is required in order to meet a 20-year in-service goal.

1.10 Attributes

The following discusses whether/how Alternative 1A meets the criteria for each attribute as defined in the attribute definition and EEI's rating of the Alternative for each attribute.

1.10.1 Constructible

Alternative 1A can be constructed in the field at Red Hill using practicable construction means and methods. Alternative 1A will follow standard industry tank cleaning, inspection, and repair techniques adapted to the Red Hill tank configurations, followed by coating the lower dome and nozzle piping. The greatest challenge is logistics and restrictions working at Red Hill, inside the fuel storage facility and inside the tanks.

This alternative is nearly identical to the efforts conducted to inspect and repair the Red Hill tanks over the last 13 years.[1] A total of 6 tanks (2, 5, 6, 15, 16, 20) have gone through a cleaning, inspection (including shell/weld scanning), repair, bottom dome recoating, and return to service. All tank repairs are considered to have been successfully completed, with the one exception being Tank 5. All in-service tanks have been subject to annual tightness testing multiple times with no negative findings. While each NAVFAC contract since 2004 has had some differences, they have tended to improve integrity inspection and repairs requirements with each new contract, based on lessons learned.

Two 2016 contract awards for a total of five tank inspections include new requirements based on a continuous improvement of the process. The failure to satisfactorily execute the repairs to Tank 5 is now known (poor contractor workmanship and lack of QC), and further improvements are considered on a post award basis wherever possible or appropriate. The improvement to the requirements are centered around enhanced inspection, increased record keeping, submittal requirements and contractor quality control protocols.

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[1] See Final TIRM report dated OCT 2016, ¶1-3.9 to ¶1-3.14 for documentation on the recent efforts to inspect and repair tanks, with full shell surface and weld scanning. Prior efforts did not include full shell scanning.

[1] See Final TIRM report dated OCT 2016 for documentation on original tank construction

As this alternative uses commonly available inspection and tank repair methods that have been customized for 11 tanks at Red Hill (including current efforts) without undue impact to existing tank configuration or infrastructure Alternative 1A, has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

1.10.2 Testable

To determine if an Alternative can be shown to meet hydraulic and structural integrity standards prior to being placed into service, this attribute defines whether the tank upgrade can be tested during construction for acceptability prior to filling and during startup/commissioning when filling. This attribute focuses on the industry standard practices for testing the material, joints, welds, etc. used in repair/construction of steel tanks. This attribute also examines the ability of whether an alternative can be tested for integrity during construction prior to being filled. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 13 – Commissioning and Testing Procedures was developed to rate the degree of rigor required for the testing and commissioning procedures necessary to place the tank repair/upgrade in service and includes the details of that process in the criteria established for that attribute.

As Alternative 1A meets the criteria for testable during construction, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

1.10.3 Inspectable

To determine if an Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service, this attribute defines criteria as to whether a tank upgrade is inspectable. This attribute focuses on the industry standard practices for inspection during construction. Attribute 14 - TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade and Attribute 15 - TIRM Requirements for Future Integrity Inspections were developed to rate the degree of rigor required to develop a TIRM using industry standard inspection methods and procedures necessary to place the tank repair/upgrade back in service and includes the details of those criterion as established for the respective attributes.

For Alternative 1A, the interior of the primary shell (hydraulic boundary) can be inspected and rejectable indications repaired, resulting in the issue of a Suitability for Service testament as determined by the tank's ability to meet structural and hydraulic integrity criteria.

As Alternative 1A is inspectable during construction, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

1.10.4 Repairable

While most bulk tank systems are repairable to some degree, various levels of effort can be undertaken to effect similar repairs. These levels of effort are factored into the rating the ability to effect repairs for each alternative considered. The basis for this attribute centers around the aspects of capabilities for on-site repairs using standard/traditional construction/repair means and methods.

For Alternative 1A removal or modification of the Red Hill infrastructure is not required to gain access to the tank liner; all interior surfaces of the primary tank liner, tank nozzles, and internal components are accessible for repair, and all repairs can be performed from inside the tank without having to remove part of the primary tank or internal component to access an area for repair.

While the mechanisms for effecting any repairs in these Red Hill tanks are quite unique and complex, they have been used for many years and innovations/improvements are being incorporated into the standards with each successive repair effort. All actions are well within the norm of repair method considerations, are feasible to execute, and require no special equipment that render these options unreasonable.

For reasons stated above, Alternative 1A has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

1.10.5 Practicable

This attribute rates the degree to which an alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters. Given the complexities and interactive dependencies of multiple attributes and their associated importance among stakeholders, this attribute is used to combine several factors to provide a cost/benefit basis for the decision makers.

The three major determinable factors are:

- The extent of the impact/modification to the Red Hill infrastructure or physical arrangement as determined in Attribute 1,
- The cost per tank depicted in the cost analysis associated with Attribute 17 as compared to the current CIR estimates of $7.5M per tank, and
- The ability to complete the upgrades by the mandated timeframe set by the Red Hill AOC SOW as derived from the duration modeling for Attribute 18.

Alternative 1A can be constructed within the confines of Red Hill with no impact/modification to the Red Hill infrastructure or physical arrangement. The construction cost of this alternative is estimated to be [redacted] per tank and falls within the 0% to 250% range. The duration modeling data indicates that all tank work is expected to be completed within the compliance timeframe set by the Red Hill AOC SOW using a three-tank execution strategy.

For reasons stated above, Alternative 1A has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

1.10.6 Corrosion Damage Mechanism

Alternative 1A has a coating applied to the Lower Dome same as is the current practice for all Red Hill tank repairs. In addition, it is recommended that the piping (tank nozzles) receive an internal coating system same as the Lower Dome. These coatings provide protection from corrosion in the most susceptible areas where water (including salt water) may be present.

Alternative 1A has been assigned a "Somewhat Meets Criteria" rating, as the Lower Domes and piping are coated, but the tank barrel and upper dome remain as is, mostly uncoated.

Rating: Somewhat Meets Criteria

1.10.7 Successful Implementation Elsewhere

Concrete cut and cover and mined concrete tanks with single wall carbon steel liners are currently in operation at other large fuel depots around the globe. When constructed and maintained properly they have been very successful in detecting leaks and/or preventing leaks to the environment. The status quo at Red Hill is an example.

Alternative 1A has been used at Red Hill and other large fuels depots and would be successful in detecting leaks at Red Hill. However, the lack of secondary containment or any other physical leak detection/capture devices would prevent this tank upgrade from detecting leaks without the use of release detection equipment. Therefore, the alternative has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

1.10.8 Reliability

For all TUAs being evaluated, reliability is defined as the measure of a tank's ability to perform its required function under stated conditions for a specified period (i.e. level of confidence). The rudimentary functional requirement of most any storage tank is to maintain hydraulic integrity and prevent the contained product from unintentionally exiting the vessel. The stated conditions are the manner and environment in which the storage tank is operated and maintained. The specified period is the designated interval of uninterrupted operations, i.e. the next out-of-service internal inspection.

Each alternative relies on a steel shell as its primary hydraulic boundary. In all cases, the integrity of the primary shell is designed to meet the definition of reliability as stated above. While a certain amount of variability may be introduced in the type of steel used, coatings applied, and construction techniques, these elements drive the different tank upgrade alternatives into various levels of confidence above and beyond basic reliability.

With regards to system reliability, considering tank upgrade alternatives with enhancements that include secondary containment extends beyond the discussion of reliability of the primary tank and towards the reliability of the tank system to minimize the extent of the effects stemming from a failure in the primary shell. Those added enhancements are addressed in other attributes within this document and the merits of the different systems are detailed with multiple factors beyond the limits of this attribute, which specifically targets the reliability of the primary shell to perform as designed.

In that Alternative 1A is inspected and repaired in accordance with industry standards and the Red Hill AOC SOW Section 2.2 TIRM Report, it can be relied upon to perform its required function under the stated conditions until, at a minimum, the next inspection interval and thus has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

1.10.9 Impact on Storage Volume

Alternative 1A provides for fuel storage in the lower dome, tank barrel, and the upper dome. Alternative 1A provides the same storage volume as existing; thus, there is no reduction in storage volume compared to the existing tanks.

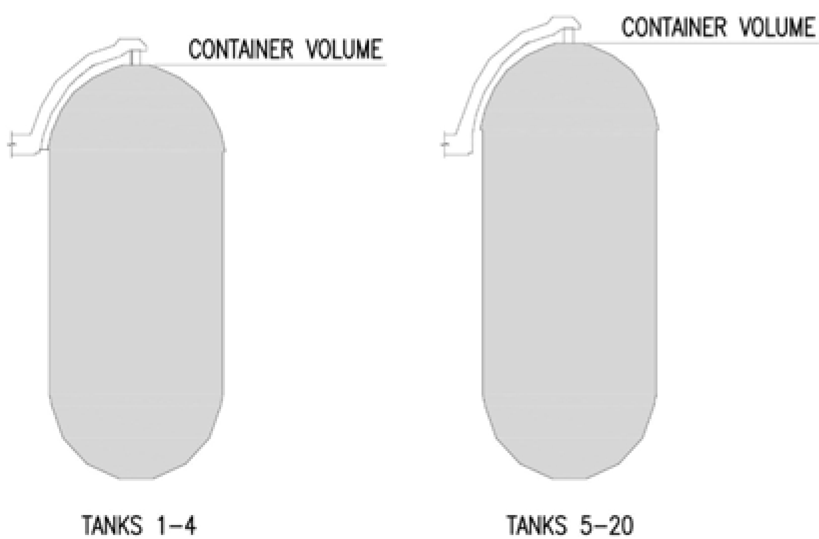

Figure E-1.0-1 TUA 1A Existing Container Volume

Shaded area indicates volume of product in tank

The existing container volumes of the tanks are as follows:

- Tanks 2 to 4: 285,148 Bbls (238'-6" tall)
- Tanks 5 to 18 and 20: 301,934 Bbls (250'-6" tall)
- Tanks 1 and 19: Out of Service
- System (Tanks 2-18 and 20): 5,384,454 Bbls

The container volume represents maximum volume. Working storage volumes are typically less than maximum volumes to accommodate safety, liquid expansion from temperature change, regulatory limitations, etc., per Navy policy.

Conclusion: Alternative 1A results in no reduction of container volume compared to existing tanks.

Rating: Not Rated

1.10.10 Provides Secondary Containment

The original circa 1940s construction consists of the primary tank being the steel liner inside the structural concrete of the lower dome, barrel and upper dome. From a regulatory/engineering perspective, the concrete is not considered secondary containment from an overall impervious basis due to unknown liquid tight condition. There are numerous penetrations (reinforcements, anchors, structures) inherent in the construction of the tank. Additionally, there is not an inspectable interstitial space between the concrete and liner. However, it needs to be pointed out that the original construction of the tanks took many steps that lead to an assumption that the designers of the tanks took extra construction steps to make the concrete barrel as liquid tight as possible. Steps included using Gunite to assure sealing of the volcanic rock, grouting between the Gunite and reinforced concrete, and actual testimony from the construction team leader. Further information can be found in the Red Hill AOC SOW Section 2.2 TIRM Report.

The original design included a physical tell-tale system to detect if any fuel breaches in the steel liner reached the concrete structure. The concrete walls were designed for structure, not liquid integrity. Considerable care was taken in the design to maximize hydraulic integrity, including sealing of the lava face, and use of pressure injected grout after the concrete cured. Due to its current unknown condition, the concrete cannot be considered a secondary containment feature, therefore, any fuel entering the tell-tale system is considered a release to the environment, irrespective of whether it penetrates the concrete structure. The tell-tale system has been removed from some tanks currently in service, and is inactive in tanks where not removed.

This alternative includes inspecting and pressure testing tank nozzles from the tank to the first valve outside tank. In the event the inspections find the nozzles to be of less than satisfactory condition, repairs would be required. There is no intention to replace the existing nozzles, or convert the nozzles to provide a secondary containment double wall configuration, as the tank is single wall.

Given the above information, Alternative 1A cannot be considered to have secondary containment meeting current EPA requirements specified in 40 CFR 280 being an inner and outer barrier with an interstitial space that is monitored for leaks, for this reason Alternative 1A has been assigned a rating of “Does Not Meet Criteria”.

Rating: Does Not Meet Criteria

1.10.11 Dependency on Existing Tank Steel Liner Integrity

Alternative 1A relies solely on the hydraulic integrity of the existing repaired tank liner to contain product as the primary boundary, as such, Alternative 1A has been assigned a “Does Not Meet Criteria” rating.

Rating: Does Not Meet Criteria

1.10.12 Release Detection Integral to Tank Construction

This attribute defines whether an Alternative has release detection capability that is integral to (i.e. is part of) the tank upgrade construction such as an interstitial space with monitoring.

As noted in Attribute 10 – Secondary Containment, this Alternative does not include a secondary containment with interstitial monitoring system. Accordingly, under 40 CFR 280.43, at least one of the following release detection methods is required:

a. Inventory Control
b. Manual Tank Gauging
c. Tank Tightness Testing
d. Automatic Tank Gauging
e. Vapor Monitoring
f. Groundwater Monitoring
g. Statistical Inventory Reconciliation

Tank tightness testing formally is the primary current response to the regulation. Red Hill AOC SOW Section 4.0 Release Detection/Tank Tightness Testing is in the process of refining the performance of Tank Tightness Testing to determine if the present approach is acceptable, or if a modified approach will be required. This section is also addressing the merits if any of installing a tell-tale system similar in concept to the original/modified systems that have been removed or taken out of service.

Irrespective of what permissible method is ultimately chosen, Alternate 1A will require meeting a minimum of one method of release detection methods listed above, thus has been assigned a "Does Not Meet Criteria" rating.

Rating: Does Not Meet Criteria

1.10.13 Testing and Commissioning Procedures

This attribute is used to rate the level of rigor necessary for testing and commissioning procedures required to return the tank to service after repair/upgrade. These procedures are based on the final verifications prior to filling, and considerers the different methods available to monitor the tank for hydraulic and structural integrity during and immediately after filling.

"Returning the tank to service" includes actions necessary to prepare the tank for the first filling with fuel, performing commissioning steps, determining the tank repair was successful, and determining the tank to be liquid tight and suitable for returning the tank to service.

In accordance with the NAVFAC Naval Engineering Training and Operating Procedures and Standards (NETOPS) 34 and the NAVSUP GLS Instruction 10345.1 [(3)], coordination and proper review of the following elements is mandatory prior to a transfer of custody of the tank back to the operator:

- A statement signed by an appropriately certified API 653 tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service. The statement shall include due dates for the next applicable formal inspections (internal, external) and any repairs required prior to those next inspections. Next inspection due dates shall be the maximum allowable by API 653, calculated from the hydraulic barrier integrity assessment, including scanning for corrosion and number of years used in the corrosion rate calculation for remaining thickness at the next inspection. The date shall be based upon the actual return to service date so long as the API 653 Inspector of Record, and Engineer of Record participate in the repair process and final documentation of repairs, and the number of years used in corrosion rate calculations equal or exceeds the number of years from hydraulic barrier scanning, and return to service to next inspection.
- For the purposes of this report, EEI recommends the next inspection interval for Alternative 1A to be established as follows. Utilize an assumed desired duration of 25 years for the corrosion rate calculation to check for minimum plate thickness now, to not result in less than a 0.10-inch thickness at the next inspection interval. Then utilize a next inspection interval of 20 years from the return to service date, but not to exceed 25 years from the shell scanning date. EEI believes this approach is consistent with Chapter 19 in the Red Hill SOW Section 2.2 TIRM Report.
- The Statement shall also note that as a final test, the tank shall be given a 3rd party certified leak test upon reaching its first full height liquid fill, is required by NAVSUP policy.
- A completed inspection report including all required calculations and analysis. Preliminary or field reports cannot be substituted for this requirement.
- A list of repairs identified during inspection, including completed repairs and repairs that are still pending. All pending repairs shall be annotated with a due date.
- Third-party certified calibration (“strapping”) charts when a tank is first placed in service when certified calibration charts did not previously exist, or when repairs were made that would be reasonably expected to change the tank’s calibration.
- A statement signed by agents of the Execution/Construction Agent and repair contractor that custody of the tank is returned to the activity and that the above items have been provided to the operator.

Once the tank has been declared suitable to receive product, the filling protocols must be authorized by the commanding officer. These protocols, required by NAVSUP mandate, are specifically for the type of tank being filled and verified by SMEs at the NAVSUP Energy Office. The operators will then develop a tank specific operations order in accordance with the above stated protocol and mandate. This specific operations order, reviewed and approved by the commanding officer, will consider the unique requirements associated with the tank being filled. Mandatory elements include:

- Tank filling procedures with appropriately defined incremental fill levels and hold times;
- Physical inspection, gauging, and trend analysis as appropriate upon reaching each incremental fill level; and
- Emergency drain-down plan in the event the tank needs to be emptied, including specific triggers as to when the drain-down plan should be activated.

The development and implementation of this operations order is predicated on the parameters presented by the specifics of the tank being filled. Other factors taken into consideration include:

- Ability to continuously visually monitor the shell and/or floor surfaces for a breach of hydraulic integrity or evidence of structural failure;
- Ability of the shell and/or floor that cannot be directly visually monitored, to be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with interstitial monitoring system to a point of physical outlet outside the tank boundary for inspection);
- Ability of the installed tank inventory control system to reasonably determine unacceptable variances during tank filling when performed using the requisite number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity when the tank does not have a shell or floor secondary containment system with interstitial monitoring system outside the tank boundary that can be continuously monitored for hydraulic integrity; and/or
- Ability to conduct a final hydraulic integrity test to meet the approved tank tightness testing requirements prior to placing the tank in routine operations.

Alternative 1A does not have a secondary containment system with tell-tales or interstitial monitoring, that can be continuously monitored for hydraulic integrity. Therefore, tank filling would be performed using the applicably determined number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using the tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report would be required prior to turning the tank over to the operator for operation. For these reasons, Alternative 1A has been assigned a "Somewhat Meets Criteria" rating.

Rating: Somewhat Meets Criteria

1.10.14 TIRM Requirements for Inspection of Existing Tank prior to application of Tank Upgrade

Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document specifies the level of inspection and repair necessary for the current tanks in service at Red Hill, by cross referencing to the Red Hill AOC SOW Section 2.2 TIRM Report. Each of the alternatives require varying degrees of inspection and repair criteria as compared to the TIRM specifications (for existing tank inspections) published in Red Hill AOC SOW Section 2.2 TIRM Report, Appendix BE, UFGS Specification SECTION 33 56 17.00 20 INSPECTION OF FUEL STORAGE TANKS and Appendix BD, SECTION 33 56 18.00 20 REPAIR OF FUEL STORAGE TANKS.

Depending on the level of dependency each TUA has on the integrity of existing shell/dome, considerations are given to the level and type of inspection and repair of the existing tank structure, liner, and nozzles. If there is no dependency on the existing steel liner, a visual inspection of the existing tank structure is the primary requirement to meet criteria for steel liner repairs. With limited dependence on the integrity of the existing steel liner, inspection of the existing tank steel liner and tank nozzles following industry standards would be required, resulting in the least requirements and thus not meeting the established criteria.

As the reliance on the integrity of the existing steel liner increases, the ability to access the original liner for inspection and repair becomes paramount to meeting criteria. The ideal situation would include unfettered access for inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, weld scanning and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of all rejectable indications identified. However, if an alternative relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, it would result in a less favorable scoring in meeting the requirements of this criteria.

If an alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report or Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document, it would fully meet the criteria of this attribute as the rating system used is oriented towards a higher rating meeting the TIRM Report, and a lower rating for larger departures from the TIRM Report.

In that Alternative 1A requires the same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report, it has been assigned a “Meets Criteria” rating.

Rating: Meets Criteria

1.10.15 TIRM Requirements for Future Integrity Inspections

Red Hill AOC SOW Section 2.0 states that the purpose of the TIRM Report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/Hawaii DOH in the Red Hill AOC SOW for future integrity inspections at Red Hill. The Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document provides the final recommendations for implementation of future projects. It is important that the processes of the future inspection, repair, and maintenance of the Red Hill tanks are well defined to ensure that the goal of keeping the tanks permanently leak-free can be met going forward. The report examines the pros and cons of past, current, and emerging means and methods for work on the tanks to provide the basis for decisions on a strategy that can best achieve the goal of leak-free tanks.

To meet the conditions of Red Hill AOC SOW Section 2.0 (TIRM), each alternative has been rated to determine the level of rigor necessary to conduct future integrity inspections and/or the access provisions required to complete the mandatory inspections and properly maintain the system. The basis for determination of ratings for each alternative examine the ability to competently inspect visually all shell and roof (dome) surfaces and welds from inside or outside the tank, and welds and steel liner from inside the tank and with conventional scanning equipment.

As alternative designs prove to be less accessible or require special procedures for access to all surfaces and welds to be competently inspected, the rating declines. Rating continues to decline for primary shells, including upper dome, barrel and lower dome welds and liner, that require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces. An alternative that is incapable of undergoing integrity inspections of any kind fails to meet this criterion.

Alternative 1A utilizes the original steel liner which requires a very rigorous visual and scanning inspection protocol using special equipment and procedures to examine the surfaces of the primary shell including upper dome, barrel and lower dome welds and liner. For this reason, Alternative 1A has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

1.10.16 Impact on Operating and Maintenance Requirements and Procedures

Alternative 1A represents current operations with minimal changes to the status quo and thus, results in little to no impact to the current operating and maintenance requirements and procedures. This alternative includes the present day operational efforts conducted to operate and maintain the Red Hill facility. A total of 18 tanks have been included in the routine operational procedures and basic operator level maintenance for more than a decade.

Operating and maintaining a UST facility is significantly less intensive than an AST facility. For Red Hill specifically, the manning for operations and maintenance is minimal due to the high level of automation associated with the facility's systems and the inherent design of the structures. The operator level maintenance of the physical tanks is centered around the skin valves, ventilation systems, and bottom water draw off. For comparison, an extensive list of AST and UST operational and maintenance requirements can be found in the UFC 3-460-03 [(4),] Appendix C. There are currently no requirements for fire protection systems on USTs. The unique design of the Red Hill tanks negates the need for cathodic protection systems. [(5)] See Red Hill AOC SOW Section 5.0 Corrosion and Metal Fatigue Practices report for documentation.

In accordance with current federal regulations, annual tank tightness testing is required due to the lack of secondary containment. Therefore, facility operations are impacted by several weeks of set up and testing of each tank each year. However, this alternative will include an upgraded inventory / leak detection system that can be operated more frequently, but will not have to absorb the onerous mobilization and set-up workload. This results in a virtual net zero impact to operational and maintenance requirements and procedures.

Standard Operating Procedures currently written for the Red Hill tanks would remain in place and require minimal alterations, primarily to accommodate the enhanced in situ release detection. In that the combined results associated with labor and material maintenance cost, annual leak detection requirements, interruption to service, etc. nets out to a near status quo level of effort, this alternative has been assigned a "Meets Criteria" rating.

Note: In the event the results of the Red Hill AOC SOW Section 4.0, Release Detection / Tank Tightness Testing, results in an increase in requirements or procedures associated with Alternative 1A, this rating may need to be revisited.

Rating: Meets Criteria

1.10.17 Tank Upgrade Construction Cost Estimate (Planning Level)

This attribute provides stakeholders with pertinent information on overall construction execution cost, for the number of total tanks in a given upgrade alternative. These estimates are derived by compiling the projected cost for one tank constructed as a part of multiple tank repair contracts. The single tank cost is then used to develop the cost of each group of tanks, escalated to the midpoint of construction of each group of tanks. Government costs, design costs, construction contingencies, and Title II costs are not included. These estimates are for the physical tank upgrade portion of the overall project and do not include any electronic, volumetric / mass measurement type release detection system or fiber optic communication system.

Details of the explicit cost derivation for each TUA is presented in PART I - Cost Estimates. The cost of Alternative 1A is estimated to be [redacted] per tank NPV.

This attribute is for informational purposes, no ratings are applied.

Rating: Not Rated

1.10.18 Tank Upgrade Duration

Upgrade duration is determined as an estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). For rating purposes, the Navy designated the baseline for each upgrade cycle as **three** tanks undergoing upgrade at a time utilizing two 10-hour shifts per day for six days a week.

Any TUA that cannot meet the Red Hill AOC SOW deadline for compliance without changing any of these parameters will receive a rating commensurate with the level of change. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one parameter as the determining rating factor for any TUA not meeting compliance with the above stated parameters. However, with the overarching mandate to maintain at least 15 tanks in service at all times during upgrade execution, the tanks per cycle variant is capped at five tanks per cycle and other parameters would require adjustment accordingly.

PART G - Construction Execution Considerations, provides the details by which the project execution duration conclusions were estimated.

The specific tank and cycle times for Alternative 1A upgrades, inclusive of all contingency factors, are estimated at 0.7 years per tank or 1.8 effective years per **three**-tank cycle. Taking all contingency factors into consideration, the estimated compliance date for all in-service tanks to be upgraded via the Alternative 1A concept is 2029.5. The project duration is approximately 12.8 years with a project completion date of 2031.2.

Rating: Meets Criteria

2.0 ALTERNATIVE 1B - RESTORATION OF TANK PLUS INTERIOR COATING

2.1 General Description

Alternative 1B is the same as Alternative 1A, except Alternative 1B incudes coating the existing steel liner on the barrel and upper dome.

2.2 Features of Alternative

Specific features of Alternative 1B include:

- Inspection of the existing steel liner following requirements in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document. This document in turn, refers to materials developed under the Red Hill AOC SOW Section 2.2 TIRM Report. This is an enhanced inspection process compared to a conventional API 653 Inspection, using best available inspection technology and complementary and redundant technologies in a two-step process to detect corrosion.
- Inspection and pressure testing of the existing single wall concrete encased tank nozzles from the tank to the first valve outside tank. The repair requirements, if any, identified in the inspection will be completed.
- Re-coat the lower dome and interior of nozzles.
- Coating the existing steel liner on the barrel and upper dome with polysulfide modified epoxy novolac coating.
- Release detection as identified in Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report.

2.3 Release Detection

Alternative 1B as currently proposed does not provide release detection that is integral to the tank such as a tell-tale system like the original tanks, or monitoring the interstitial space of a double wall tank (there is no interstitial space to monitor) or monitoring of secondary containment (there is no secondary containment to monitor). As such, at least one of the following release detection methods is required Under 40 CFR 280.43:

a. Inventory Control
b. Manual Tank Gauging
c. Tank Tightness Testing
d. Automatic Tank Gauging
e. Vapor Monitoring
f. Groundwater Monitoring
g. Statistical Inventory Reconciliation

See Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report for discussion on release detection. It is a basic presumption that a technology based sensitive leak detection system will be provided for all Alternative 1 tanks.

The prospect of providing a tell-tale system, in concept similar to the original or upgraded system is discussed in Chapter 12 of the Red Hill AOC Section 2.4 TIRM Procedure Decision Document. The Red Hill AOC Section 2.2 TIRM Report ¶17-7.2a describes the concept as follows:

> *"The Tell-tale leak detection system provides a real-time, analog tool for identifying potential releases, collects product trapped in the reinforced concrete shell to steel liner interstice, and provide[s] a pathway to relieve product from the interstice."*

Red Hill AOC SOW Section 4.0 Release Detection and Collection/Tank Tightness Testing is further evaluating the possibility of installing a tell-tale system. In theory, if implemented, a tell-tale system would provide a means of direct leak detection on par with the Alternative 2 and 3 concepts.

The findings and recommendations within this Red Hill AOC SOW Section 3.0 (TUA) may require modification depending on the Red Hill AOC SOW Section 4.0 Release Detection and Collection/Tank Tightness Testing recommendations.

2.4 Tank Nozzles

The existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank will be inspected and pressure tested. Repairs will be provided as needed. The current tanks have a variety of nozzle conditions. As a part of the repairs, all nozzles that penetrate from the Lower Dome, to the Lower Tunnel, will be repaired and upgraded consistent with the single wall tank concept, as they are considered an extension of the tank hydraulic boundary. Some existing nozzles (such as steam and condensate) are no longer used, and will be blinded off, or repurposed, such as used for casings the sample lines. In such cases, they will not be subject to the tank product, and thus not considered an extension of the tank boundary.

In the interest of preventing internal corrosion on the primary fill, issue and drain (slop) lines, they will be coated with the same coating system as the Lower Dome. The Red Hill AOC Section 2.2 TIRM Report, ¶17-6.2.1 discusses the benefits of using the UFGS Section 09 97.13.15 Polysulfide Epoxy Coating System. Principle to the nozzles, the coating qualifies as a "thick film" system under API 652 criteria. It also easily fills pits/voids, and is highly surface tolerant in application.

Consideration was given to replacement of the tank nozzles. To do so would require boring through the concrete plug below the tank, from the Lower Dome, to the lower access tunnel. If this were accomplished, the use of a double wall piping system could be considered. However, integrity inspections to date on existing nozzles has resulted in determining their integrity and suitability for continued service, with modest repairs. The nozzles in each tank will be individually assessed, and appropriate action taken as needed.

The concept of the nozzles remaining as single wall pipe is consistent with Alternative 1 as it is an extension of the single wall tank, and subject to all release detection schemes that may be applied.

2.5 Engineering Considerations

The engineering of the tank inspection process, and repair designs is considered a specialty and should be completed by an individual and organization with requisite experience with major structures, construction logistics, fuel storage tank integrity inspection and repair.

There is no level of engineering considered beyond having the prior experience to complete.

2.6 Preparatory Inspection and Repair of Existing Tank Liner

Inspection and repair of the existing steel liner will follow the requirements in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document and its references to Red Hill AOC SOW Section 2.2 TIRM Report.

For Alternative 1B, the tank liner in the barrel, and upper dome will also get a full coating system using the latest DoD approved system for internal coating of fuel storage tanks. The Red Hill AOC Section 2.2 TIRM Report, ¶17-6.2.1 discusses the benefits of using the UFGS Section 09 97.13.15 Polysulfide Epoxy Coating System. The coating qualifies as a "thick film" system under API 652 criteria. It also easily fills pits/voids, and is highly surface tolerant in application. An additional benefit of using the tank coating system is making the next tank cleaning somewhat easier.

2.7 Testing and Commissioning Procedures

Refer to specific attributes for discussion on testing and commissioning procedures.

2.8 Construction Logistics

Refer to Part G for discussion on construction logistics.

2.9 TIRM

After startup and being placed into service, future integrity inspections, repairs, and maintenance will follow the requirements in Red Hill AOC SOW Section 2.2 TIRM Report and Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document.

The goal is for the tank to have a 20-year in-service period between outages for internal tank inspections and repairs. As the process of clean-inspect-repair can take 2-3 years, the development of an appropriate inspection protocol is required in order to meet a 20-year in-service goal.

2.10 Attributes

The following discusses whether/how Alternative 1B meets the criteria for each attribute as defined in the attribute definition and EEI's rating of the Alternative for each attribute.

2.10.1 Constructible

Alternative 1B can be constructed in the field at Red Hill using practicable construction means and methods. Alternative 1B will follow standard industry tank cleaning, inspection, and repair techniques adapted to the Red Hill tank configurations, followed by coating the lower dome and nozzle piping. The greatest challenge is logistics and restrictions working at Red Hill, inside the fuel storage facility and inside the tanks.

This alternative is nearly identical to the efforts conducted to inspect and repair the Red Hill tanks over the last 13 years.[2] A total of 6 tanks (2, 5, 6, 15, 16, 20) have gone through a cleaning, inspection (including shell/weld scanning), repair, bottom dome recoating, and return to service. All tank repairs are considered to have been successfully completed, with the one exception being Tank 5. All in service tanks have been subject to annual tightness testing multiple times with no negative findings. While each NAVFAC contract since 2004 has had some differences, they have tended to improve integrity inspection and repairs requirements with each new contract, based on lessons learned.

Two 2016 contract awards for a total of five tank inspections include new requirements based a continuous improvement of the process. The failure to satisfactorily execute the repairs to Tank 5 is now known, and further improvements are considered on a post award basis wherever possible or appropriate. The improvement to the requirements are centered around enhanced inspection, increased record keeping, submittal requirements and contractor quality control protocols.

Regarding tank interior coatings, Tanks 17-20 were extensively upgraded in 1960-1962, including 100% sandblasting and coating of the domes and shell using a first-generation Naval Research Lab (NRL) thin film urethane coating system.[3] The system consisted of a wash primer, and three applications of polyurethane. This coating system remains and is now 57 years old. Similarly, Tanks 1-16 received a 100% NRL coating system between 1978 and 1984.[4]

Based on internal inspections over the last 10+ years, the coating in some tanks is degraded, but other in tanks it is still in serviceable condition. Based on limited observation, it may be a result of initial application surface preparation and application of this systems "wash primer", however

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[2] See Final TIRM report dated OCT 2016, ¶1-3.9 to ¶1-3.14 for documentation on the recent efforts to inspect and repair tanks, with full shell surface and weld scanning. Prior efforts did not include full shell scanning.
[2] See Final TIRM report dated OCT 2016 for documentation on original tank construction
[3] See Final TIRM report dated OCT 2016, ¶1-3.3
[4] See Final TIRM report dated OCT 2016 ¶1-3.5

a positive determination of degradation/failure mechanism would require an assessment beyond the current limitations of the Red Hill AOC SOW Section 3.0 TUA process.

The proposed polysulfide modified epoxy novolac coating system is a commercially product meeting strict formulation requirements established UFGS Specification 09 97 13.15, Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks. Application and quality control requirements are more advanced than the coating system applied in the last round of coating.

As this alternative uses commonly available inspection and tank repair methods that have been customized for 11 tanks at Red Hill (including current efforts) without undue impact to existing tank configuration or infrastructure Alternative 1B, has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

2.10.2 Testable

To determine if an Alternative can be shown to meet hydraulic and structural integrity standards prior to being placed into service, this attribute defines whether the tank upgrade can be tested during construction for acceptability prior to filling and during startup/commissioning when filling. This attribute focuses on the industry standard practices for testing the material, joints, welds, etc. used in repair/construction of steel tanks. This attribute also examines the ability of whether an alternative can be tested for integrity during construction prior to being filled. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 13 – Commissioning and Testing Procedures was developed to rate the degree of rigor required for the testing and commissioning procedures necessary to place the tank repair/upgrade in service and includes the details of that process in the criteria established for that attribute.

As Alternative 1B meets the criteria for testable during construction, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

2.10.3 Inspectable

To determine if an Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service, this attribute defines criteria as to whether a tank upgrade is inspectable. This attribute focuses on the industry standard practices for inspection during construction. Attribute 14 - TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade and Attribute 15 - TIRM Requirements for Future Integrity Inspections were developed to rate the degree of rigor required to develop a TIRM using industry standard inspection techniques for the inspection procedures necessary to place the tank repair/upgrade back in service and includes the details of those criterion as established for the respective attributes.

For Alternative 1B, the interior of the primary shell (hydraulic boundary) can be inspected and rejectable indications repaired, resulting in the issue of a Suitability for Service testament as determined by the tank's ability to meet structural and hydraulic integrity criteria.

As Alternative 1B is inspectable during construction, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

2.10.4 Repairable

While most bulk tank systems are repairable to some degree, various levels of effort can be undertaken to effect similar repairs. These levels of effort are factored into the rating the ability to effect repairs for each alternative considered. The basis for this attribute centers around the aspects of capabilities for on-site repairs using standard/traditional construction/repair means and methods.

For Alternative 1B removal or modification of the Red Hill infrastructure is not required to gain access to the tank liner; all interior surfaces of the primary tank liner, tank nozzles, and internal components are accessible for repair, and all repairs can be performed from inside the tank without having to remove part of the primary tank or internal component to access an area for repair.

While the mechanisms for effecting any repairs in these Red Hill tanks are quite unique and complex, they have been used for many years and innovations/improvements are being incorporated into the standards with each successive repair effort. All actions are well within the norm of repair method considerations, are feasible to execute, and require no special equipment that render these options unreasonable.

For reasons stated above, Alternative 1B has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

2.10.5 Practicable

This attribute rates the degree to which an alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters. Given the complexities and interactive dependencies of multiple attributes and their associated importance among stakeholders, this attribute is used to combine several factors to provide a cost/benefit basis for the decision makers.

The three major determinable factors are:

- The extent of the impact/modification to the Red Hill infrastructure or physical arrangement as determined in Attribute 1,

- The cost per tank depicted in the cost analysis associated with Attribute 17 as compared to the current CIR estimates of $7.5M per tank, and
- The ability to complete the upgrades by the mandated timeframe set by the Red Hill AOC SOW as derived from the duration modeling for Attribute 18.

Alternative 1B can be constructed within the confines of Red Hill with minimal impact/modification to the Red Hill infrastructure or physical arrangement. The coating system drives a significant additional factor to the construction cost of this alternative which increases the estimate to be [redacted] per tank and falls within the 250% to 500% range. The duration modeling data indicates that all tank work is expected to be completed within the compliance timeframe set by the Red Hill AOC SOW using a three-tank execution strategy.

Due to the measurable cost increase, Alternative 1B has been assigned a “Mostly Meets Criteria” rating.

Rating: Mostly Meets Criteria

2.10.6 Corrosion Damage Mechanism

Alternative 1B has a coating applied to the Lower Dome, barrel, and Upper Dome, which is an enhancement over the current practice for all Red Hill tank repairs. In addition, it is recommended that the piping (tank nozzles) receive an internal coating system same as the remainder of the tank. These coatings provide protection from corrosion in the most susceptible areas where water (including salt water) may be present (Lower Dome and nozzles), and additional protection in the barrel and Upper Dome.

Alternative 1B has been assigned a “Meets Criteria” rating, as the tank and piping are 100% coated.

Rating: Meets Criteria

2.10.7 Successful Implementation Elsewhere

Concrete cut and cover and mined concrete tanks with single wall carbon steel liners are currently in operation at other large fuel depots around the globe. When constructed and maintained properly they have been very successful in detecting leaks and/or preventing leaks to the environment. The status quo at Red Hill is an example.

Alternative 1B has been used at Red Hill and other large fuels depots and would be successful in detecting leaks at Red Hill. However, the lack of secondary containment or any other physical leak detection/capture devices would prevent this tank upgrade from detecting leaks without the use of release detection equipment. Therefore, the alternative has been assigned a “Mostly Meets Criteria” rating.

Rating: Mostly Meets Criteria

2.10.8 Reliability

For all TUAs being evaluated, reliability is defined as the measure of a tank's ability to perform its required function under stated conditions for a specified period (i.e. level of confidence). The rudimentary functional requirement of most any storage tank is to maintain hydraulic integrity and prevent the contained product from unintentionally exiting the vessel. The stated conditions are the manner and environment in which the storage tank is operated and maintained. The specified period is the designated interval of uninterrupted operations, i.e. the next out-of-service internal inspection.

Each alternative relies on a steel shell as its primary hydraulic boundary. In all cases, the integrity of the primary shell is designed to meet the definition of reliability as stated above. While a certain amount of variability may be introduced in the type of steel used, coatings applied and construction techniques, these elements drive the different tank upgrade alternatives into various levels of confidence above and beyond basic reliability.

With regards to system reliability, considering alternatives with enhancements that include secondary containment extends beyond the discussion of reliability of the primary tank shell and move towards the reliability of the tank system to minimize the extent of the effects stemming from a failure in the primary shell. Those added enhancements are addressed in other attributes within this document and the merits of the different systems are detailed with multiple factors beyond the limits of this attribute, which specifically targets the reliability of the primary shell to perform as designed.

In that Alternative 1B is inspected and repaired in accordance with industry standards and the Red Hill AOC SOW Section 2.2 TIRM Report, it can be relied upon to perform its required function under the stated conditions until, at a minimum, the next inspection interval and thus has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

2.10.9 Impact on Storage Volume

Alternative 1B provides for fuel storage in the lower dome, tank barrel, and the upper dome. Alternative 1B provides the same storage volume as existing; thus, there is no reduction in storage volume compared to the existing tanks.

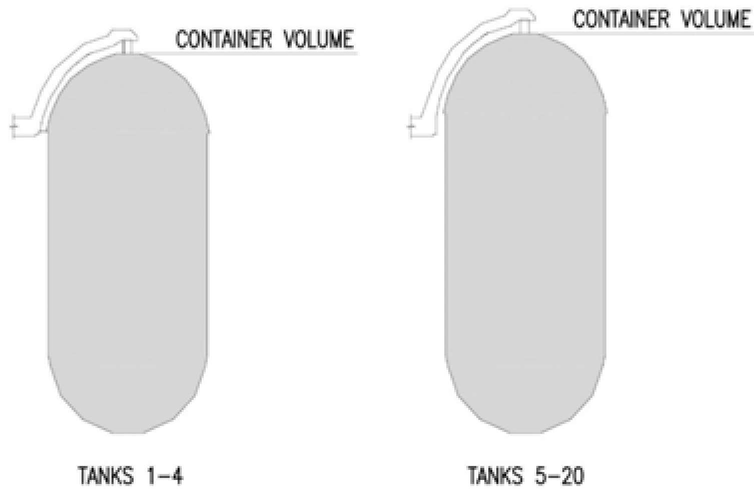

Figure E-2.0-1 TUA 1B Existing Container Volume

Shaded area indicates volume of product in tank

The existing container volumes of the tanks are as follows:

- Tanks 2 to 4: 285,148 Bbls (238'-6" tall)
- Tanks 5 to 18 and 20: 301,934 Bbls (250'-6" tall)
- Tanks 1 and 19: Out of Service
- System (Tanks 2-18 and 20): 5,384,454 Bbls

The container volume represents maximum volume. Working storage volumes are typically less than maximum volumes to accommodate safety, liquid expansion from temperature change, regulatory limitations, etc. per Navy policy.

Conclusion: Alternative 1B results in no reduction of container volume compared to existing tanks.

Rating: Not Rated

2.10.10 Provides Secondary Containment

The original circa 1940s construction consists of the primary tank being the steel liner inside the structural concrete of the lower dome, barrel and upper dome. From a regulatory/engineering perspective, the concrete is not considered secondary containment from an overall impervious basis due to unknown liquid tight condition. There are numerous penetrations (reinforcements, anchors, structures) inherent in the construction of the tank. Additionally, there is not an inspectable interstitial space between the concrete and liner. However, it needs to be pointed out that the original construction of the tanks took many steps that lead to an assumption that the designers of the tanks took extra construction steps to make the concrete barrel as liquid tight as possible. Steps included using Gunite to assure sealing of the volcanic rock, grouting between the Gunite and reinforced concrete, and actual testimony from the construction team leader. Further information can be found in the Red Hill AOC SOW 2.2 TIRM Report.

The original design included a physical tell-tale system to detect if any fuel breaches in the steel liner reached the concrete structure. The concrete walls were designed for structure, not liquid integrity. Considerable care was taken in the design to maximize hydraulic integrity, including sealing of the lava face, and use of pressure injected grout after the concrete cured. Due to its current unknown condition, the concrete cannot be considered a secondary containment feature, therefore, any fuel entering the tell-tale system is considered a release to the environment, irrespective of whether it penetrates the concrete structure. The tell-tale system has been removed from some tanks currently in service, and is inactive in tanks where not removed.

This alternative includes inspecting and pressure testing tank nozzles from the tank to the first valve outside tank. In the event the inspections find the nozzles to be of less than satisfactory condition, repairs would be required. There is no intention to replace the existing nozzles, or convert the nozzles to provide a secondary containment double wall configuration, as the tank is single wall.

Given the above information, Alternative 1B cannot be considered to have secondary containment meeting current EPA requirements specified in 40 CFR 280 being an inner and outer barrier with an interstitial space that is monitored for leaks, for this reason Alternative 1B has been assigned a rating of “Does Not Meet Criteria”.

Rating: Does Not Meet Criteria

2.10.11 Dependency on Existing Tank Steel Liner Integrity

Alternative 1B relies on the hydraulic integrity of the existing repaired tank liner to contain product as the primary boundary, but also adds the DoD standard thick-film polysulfide modified epoxy novolac coating system to the lower dome, barrel and upper dome, and as such, Alternative 1B has been assigned a “Mostly Does Not Meet Criteria” rating.

Rating: Mostly Does Not Meet Criteria

2.10.12 Release Detection Integral to Tank Construction

This attribute defines whether an Alternative has release detection capability that is integral to (i.e. is part of) the upgrade construction such as an interstitial space with monitoring.

As noted in Attribute 10 – Secondary Containment, this Alternative does not include a secondary containment with interstitial monitoring system. Accordingly, under 40 CFR 280.43, at least one of the following release detection methods is required:

a. Inventory Control
b. Manual Tank Gauging
c. Tank Tightness Testing
d. Automatic Tank Gauging

e. Vapor Monitoring

f. Groundwater Monitoring

g. Statistical Inventory Reconciliation

Tank tightness testing formally is the primary current response to the regulation. Red Hill AOC SOW Section 4.0 is in the process of refining the performance of Tank Tightness Testing to determine if the present approach is acceptable, or if a modified approach will be required.

Irrespective of what permissible method is ultimately chosen, Alternate 1B will require meeting a minimum of one method of release detection methods listed above, thus has been assigned a "Does Not Meet Criteria" rating.

Rating: Does Not Meet Criteria

2.10.13 Testing and Commissioning Procedures

This attribute is used to rate the level of rigor necessary for testing and commissioning procedures required to return the tank to service after repair/upgrade. These procedures are based on the final verifications prior to filling, and considerers the different methods available to monitor the tank for hydraulic and structural integrity during and immediately after filling.

"Returning the tank to service" includes actions necessary to prepare the tank for the first filling with fuel, performing commissioning steps, determining the tank repair was successful, and determining the tank to be liquid tight and suitable for returning the tank to service.

In accordance with the NAVFAC Naval Engineering Training and Operating Procedures and Standards (NETOPS) 34 and the NAVSUP GLS Instruction 10345.1 (3), coordination and proper review of the following elements is mandatory prior to a transfer of custody of the tank back to the operator:

- A statement signed by an appropriately certified API 653 tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service. The statement shall include due dates for the next applicable formal inspections (internal, external) and any repairs required prior to those next inspections. Next inspection due dates shall be the maximum allowable by API 653, calculated from the hydraulic barrier integrity assessment, including scanning for corrosion and number of years used in the corrosion rate calculation for remaining thickness at the next inspection. The date shall be based upon the actual return to service date so long as the API 653 Inspector of Record, and Engineer of Record participate in the repair process and final documentation of repairs, and the number of years used in corrosion rate calculations equal or exceeds the number of years from hydraulic barrier scanning, and return to service to next inspection.
- For the purposes of this report, EEI recommends the next inspection interval for Alternative 1B to be established as follows. Utilize an assumed desired duration of 25 years for the corrosion rate calculation to check for minimum plate thickness now, to not result in less than a 0.10-inch thickness at the next inspection interval. Then utilize a next

inspection interval of 20 years from the return to service date, but not to exceed 25 years from the shell scanning date. EEI believes this approach is consistent with Chapter 19 in the Red Hill AOC SOW Section 2.2 TIRM Report.

- The Statement shall also note that as a final test, the tank shall be given a 3rd party certified leak test upon reaching its first full height liquid fill, is required by NAVSUP policy.
- A completed inspection report including all required calculations and analysis. Preliminary or field reports cannot be substituted for this requirement.
- A list of repairs identified during inspection, including completed repairs and repairs that are still pending. All pending repairs shall be annotated with a due date.
- Third-party certified calibration ("strapping") charts when a tank is first placed in service when certified calibration charts did not previously exist, or when repairs were made that would be reasonably expected to change the tank's calibration.
- A statement signed by agents of the Execution/Construction Agent and repair contractor that custody of the tank is returned to the activity and that the above items have been provided to the operator.

Once the tank has been declared suitable to receive product, the filling protocols must be authorized by the commanding officer. These protocols, required by NAVSUP mandate, are specifically for the type of tank being filled and verified by SMEs at the NAVSUP Energy Office. The operators will then develop a tank specific operations order in accordance with the above stated protocol and mandate. This specific operations order, reviewed and approved by the commanding officer, will consider the unique requirements associated with the tank being filled. Mandatory elements include:

- Tank filling procedures with appropriately defined incremental fill levels and hold times;
- Physical inspection, gauging, and trend analysis as appropriate upon reaching each incremental fill level; and
- Emergency drain-down plan in the event the tank needs to be emptied, including specific triggers as to when the drain-down plan should be activated.

The development and implementation of this operations order is predicated on the parameters presented by the specifics of the tank being filled. Other factors taken into consideration include:

- Ability to continuously visually monitor the shell and/or floor surfaces for a breach of hydraulic integrity or evidence of structural failure;
- Ability of the shell and/or floor that cannot be directly visually monitored, to be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with interstitial monitoring system to a point of physical outlet outside the tank boundary for inspection);
- Ability of the installed tank inventory control system to reasonably determine unacceptable variances during tank filling when performed using the requisite number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity

when the tank does not have a shell or floor secondary containment system with interstitial monitoring system outside the tank boundary that can be continuously monitored for hydraulic integrity; and/or

- Ability to conduct a final hydraulic integrity test to meet the approved tank tightness testing requirements prior to placing the tank in routine operations.

Alternative 1B does not have a secondary containment system with tell-tales or interstitial monitoring, that can be continuously monitored for hydraulic integrity. Therefore, tank filling would be performed using the applicably determined number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using the tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report would be required prior to turning the tank over to the operator for operation. For these reasons, Alternative 1B has been assigned a "Somewhat Meets Criteria" rating.

Rating: Somewhat Meets Criteria

2.10.14 TIRM Requirements for Inspection of Existing Tank prior to application of Tank Upgrade

Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document specifies the level of inspection and repair necessary for the current tanks in service at Red Hill, by cross referencing to the Red Hill AOC SOW Section 2.2 TIRM Report. Each of the alternatives require varying degrees of inspection and repair criteria as compared to the TIRM specifications (for existing tank inspections) published in Red Hill AOC SOW Section 2.2 TIRM Report, Appendix BE, UFGS Specification SECTION 33 56 17.00 20 INSPECTION OF FUEL STORAGE TANKS and Appendix BD, SECTION 33 56 18.00 20 REPAIR OF FUEL STORAGE TANKS.

Depending on the level of dependency each TUA has on the integrity of existing shell/dome, considerations are given to the level and type of inspection and repair of the existing tank structure, liner, and nozzles. If there is no dependency on the existing steel liner, a visual inspection of the existing tank structure is the primary requirement to meet criteria for steel liner repairs. With limited dependence on the integrity of the existing steel liner, inspection of the existing tank steel liner and tank nozzles following industry standards would be required, resulting in the least requirements and thus not meeting the established criteria.

As the reliance on the integrity of the existing steel liner increases, the ability to access the original liner for inspection and repair becomes paramount to meeting criteria. The ideal situation would include unfettered access for inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, weld scanning and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of all rejectable indications identified. However, if an alternative relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, it would result in a less favorable scoring in meeting the requirements of this criteria.

If an alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report or Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document, it would fully meet the criteria of this attribute as the rating system used is oriented towards a higher rating meeting the TIRM Report, and a lower rating for larger departures from the TIRM Report.

In that Alternative 1B requires the same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

2.10.15 TIRM Requirements for Future Integrity Inspections

Red Hill AOC SOW Section 2.0 (TIRM) states that the purpose of the TIRM report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/Hawaii DOH in the Red Hill AOC SOW for future integrity inspections at Red Hill. It is important that the processes of the future inspection, repair, and maintenance of the Red Hill tanks are well defined to ensure that the goal of keeping the tanks permanently leak-free going forward can be met. The report examines the pros and cons of past, current, and emerging means and methods for work on the tanks to provide the basis for decisions on a strategy that can best achieve the goal of leak-free tanks.

To meet the conditions of Red Hill AOC SOW Section 2.0 (TIRM), each alternative has been rated to determine the level of rigor necessary to conduct future integrity inspections and/or the access provisions required to complete the mandatory inspections and properly maintain the system. The basis for determination of ratings for each alternative examine the ability to competently inspect visually all shell and roof (dome) surfaces and welds from inside or outside the tank, and floor welds and steel liner from inside the tank and with conventional scanning equipment, all following traditional integrity investigation protocol outlined in API 653.

As alternative designs prove to be less accessible or require special procedures for access to all surfaces and welds to be competently inspected visually or require departure from standard methods for traditional integrity investigation protocols outlined in API 653, the rating declines. Rating continues to decline for primary shells, including upper dome, barrel and lower dome welds and liner, that require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces. An alternative that is incapable of undergoing integrity inspections of any kind will fail to meet this criterion.

Alternative 1B utilizes the original steel liner with the addition of a coating system. While the coatings will have its own specific inspection and repair considerations, the existing steel liner will still require a very rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces of the primary shell including upper dome, barrel and lower dome welds and liner. It should be noted that the presence of the coating on the steel shell does not impede the integrity inspection of the steel shell. Based on the conditions noted above, Alternative 1B has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

2.10.16 Impact on Operating and Maintenance Requirements and Procedures

Alternative 1B represents the current operations with minimal changes to the status quo and thus, results in little to no impact to the current operating and maintenance requirements and procedures. This alternative includes the present day operational efforts conducted to operate and maintain the Red Hill facility. A total of 18 tanks have been included in the routine operational procedures and basic operator level maintenance for more than a decade.

Operating and maintaining a UST facility is significantly less intensive than an AST facility. For Red Hill specifically, the manning for operations and maintenance is minimal due to the high level of automation associated with the facility's systems and the inherent design of the structures. The operator level maintenance of the physical tanks is centered around the skin valves, ventilation systems, and bottom water draw off. For comparison, an extensive list of AST and UST operational and maintenance requirements can be found in the UFC 3-460-03 [(4)], Appendix C. The unique design of the Red Hill tanks negates the need for cathodic protection systems. [(5)] See Red Hill AOC SOW Section 5.0 Corrosion and Metal Fatigue Practices report for documentation.

In accordance with current federal regulations, annual tank tightness testing is required due to the lack of secondary containment. Therefore, facility operations are impacted by several weeks of set up and testing of each tank each year. However, this alternative will include an upgraded inventory / leak detection system that can be operated more frequently, but will not have to absorb the onerous mobilization and set-up workload. These "puts and takes" will result in a virtual net zero impact to operational and maintenance requirements and procedures.

Standard Operating Procedures currently written for the Red Hill tanks would remain in place and require minimal alterations, primarily to accommodate the enhanced in situ release detection. In that the combined results associated with labor and material maintenance cost, annual leak detection requirements, interruption to service, etc. nets out to a near status quo level of effort, this alternative has been assigned a "Meets Criteria" rating.

Note: In the event the results of the Red Hill AOC SOW Section 4.0, Release Detection / Tank Tightness Testing, results in an increase in requirements or procedures associated with Alternative 1B, this rating may need to be revisited.

Rating: Meets Criteria

2.10.17 Tank Upgrade Construction Cost Estimate (Planning Level)

This attribute provides stakeholders with pertinent information on overall construction execution cost, for the number of total tanks in a given upgrade alternative. These estimates are derived by compiling the projected cost for one tank constructed as a part of multiple tank repair contracts. The single tank cost is then used to develop the cost of each group of tanks, escalated to the midpoint of construction of each group of tanks. Government costs, design costs, construction contingencies, and Title II costs are not included. These estimates are for the physical tank upgrade portion of the overall project and do not include any electronic, volumetric / mass measurement type release detection system or fiber optic communication system.

Details of the explicit cost derivation for each TUA is presented in PART I - Cost Estimates. The cost of Alternative 1B is estimated to be [redacted] per tank NPV.

This attribute is for informational purposes, no ratings are applied.

Rating: Not Rated

2.10.18 Tank Upgrade Duration

Upgrade duration is determined as an estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). For rating purposes, the Navy designated the baseline for each upgrade cycle as **three** tanks undergoing upgrade at a time utilizing two 10-hour shifts per day for six days a week.

Any TUA that cannot meet the Red Hill AOC SOW deadline for compliance without changing any of these parameters will receive a rating commensurate with the level of change. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one parameter as the determining rating factor for any TUA not meeting compliance with the above stated parameters. However, with the overarching mandate to maintain at least 15 tanks in service at all times during upgrade execution, the tanks per cycle variant is capped at five tanks per cycle and other parameters would require adjustment accordingly.

PART G - Construction Execution Considerations, provides the details by which the project execution duration conclusions were estimated.

The specific tank and cycle times for Alternative 1B upgrades, inclusive of all contingency factors, are estimated at 1.0 years per tank or 2.5 effective years per **three**-tank cycle. Taking all contingency factors into consideration, the estimated compliance date for all in-service tanks to be upgraded via the Alternative 1B concept is 2034.4. The project duration is approximately 18.4 years with a project completion date of 2036.9.

Rating: Meets Criteria

3.0 ALTERNATIVE 1D - REMOVE EXISTING STEEL LINER, INSTALL NEW LINER

3.1 General Description

Alternative 1D consists of removing the existing steel liner on the lower dome. barrel, and upper dome, and providing new steel liner plates. The existing steel liner is removed by cutting/grinding the welds joining the plates to each other, while leaving the existing backing/structural angles in place, inspecting the remaining structure for integrity and suitability for re-use, and installing new 1/4-inch thick carbon steel plates. The 1/2-inch thick plates (the bottom of the lower dome) will remain in place. The existing tank features such as tank nozzles and gauging will be the same as recommended for Alternatives 1A and 1B, including integrity inspection and pressure testing of the existing single wall concrete encased tank nozzles from the tank to the first valve outside tank.

Overall the inspection and repair is considered relatively conventional construction, with the emphasis placed on thoroughness, appropriate contractor Quality Control (QC), with government Oversight and Quality Assurance.

This alternative includes coating the lower dome, tank barrel, upper dome, and interior of the existing tank nozzles with DoD approved polysulfide modified epoxy novolac coating system.

3.2 Features of Alternative

Specific features of Alternative 1D include:

- Remove existing steel liner on lower dome, barrel, and upper dome. This will consist of welding lift tabs, air-arc gouging existing welds, and carefully removing the plates to not damage the underlying structure.
- Inspection of the embedded steel angles used for anchoring of the steel liner plates, and making repairs as required.
- Provide new 1/4-inch thick steel liner plates, in a pattern similar to existing plates. The plates will be the same shape and orientation as they need to be welded to the embedded structure.
- Inspection and pressure testing of the existing single wall concrete encased tank nozzles from the tank to the first valve outside tank. The repair requirements, if any, identified in the inspection will be completed.
- Provide 100% coating of the new steel liner on the lower dome, barrel, upper dome, and interior of the existing tank nozzles with polysulfide modified epoxy novolac coating.
- Release detection as identified in Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report.

3.3 Release Detection

Alternative 1D as currently proposed does not provide release detection that is integral to the tank such as a tell-tale system like the original tanks, or monitoring the interstitial space of a double wall tank (there is no interstitial space to monitor) or monitoring of secondary containment (there is no secondary containment to monitor). As such, at least one of the following release detection methods is required Under 40 CFR 280.43:

a. Inventory Control
b. Manual Tank Gauging
c. Tank Tightness Testing
d. Automatic Tank Gauging
e. Vapor Monitoring
f. Groundwater Monitoring
g. Statistical Inventory Reconciliation

See Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report for discussion on release detection. It is a basic presumption that a technology based sensitive leak detection system will be provided for all Alternative 1 tanks.

The prospect of providing a tell-tale system, in concept similar to the original or upgraded system is discussed in Chapter 12 of the Red Hill AOC Section 2.4 TIRM Procedure Decision Document. The Red Hill AOC Section 2.2 TIRM Report ¶17-7.2a describes the concept as follows:

> *"The Tell-tale leak detection system provides a real-time, analog tool for identifying potential releases, collects product trapped in the reinforced concrete shell to steel liner interstice, and provide(s) a pathway to relieve product from the interstice."*

Red Hill AOC SOW Section 4.0 Release Detection and Collection/Tank Tightness Testing is further evaluating the possibility of installing a tell-tale system. In theory, if implemented, a tell-tale system would provide a means of direct leak detection on par with the Alternative 2 and 3 concepts.

The findings and recommendations within this Red Hill AOC SOW Section 3.0 (TUA) may require modification depending on the Red Hill AOC SOW Section 4 Release Detection and Collection/Tank Tightness Testing recommendations.

3.4 Tank Nozzles

The existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank will be inspected and pressure tested. Repairs will be provided as needed. The current tanks have a variety of nozzle conditions. As a part of the repairs, all nozzles that penetrate from the Lower Dome, to the Lower Tunnel, will be repaired and upgraded consistent with the single wall tank concept, as they are considered an extension of the tank hydraulic boundary. Some existing nozzles (such as steam and condensate) are no longer used, and will be blinded off, or repurposed, such as used for casings the sample lines. In such cases, they will not be subject to the tank product, and thus not considered an extension of the tank boundary.

In the interest of preventing internal corrosion on the primary fill, issue and drain (slop) lines, they will be coated with the same coating system as the Lower Dome. The Red Hill AOC Section 2.2 TIRM Report, ¶17-6.2.1 discusses the benefits of using the UFGS Section 09 97.13.15 Polysulfide Epoxy Coating System. Principle to the nozzles, the coating qualifies as a "thick film" system under API 652 criteria. It also easily fills pits/voids, and is highly surface tolerant in application.

Consideration was given to replacement of the tank nozzles. To do so would require boring through the concrete plug below the tank, from the Lower Dome, to the lower access tunnel. If this were accomplished, the use of a double wall piping system could be considered. However, integrity inspections to date on existing nozzles has resulted in determining their integrity and suitability for continued service, with modest repairs. The nozzles in each tank will be individually assessed, and appropriate action taken as needed.

The concept of the nozzles remaining as single wall pipe is consistent with Alternative 1 as it is an extension of the single wall tank, and subject to all release detection schemes that may be applied.

3.5 Engineering Considerations

The engineering of the tank inspection process, and repair designs is considered a specialty and should be completed by an individual and organization with requisite experience with major structures, construction logistics, fuel storage tank integrity inspection and repair.

Alternative 1D presents some very different logistical, structural and corrosion prevention challenges not present in Alternatives 1A and 1B. An A/E firm with the specialized experience needed for the effort should be engaged to further assess design and construction challenges, and prepare a bidding package for competitive procurement of a construction contractor. Some special challenges that need to be assessed as a part of the design include:

- Erection of monorail trolley system and booms suitable for structural material handling.
- Degree of inspection required of existing embedded steel, and means to repair predicted failures.
- Because "new" steel (the plate) is anodic to "old" steel (embedded structure) special considerations need further assessment such as utilizing steel plates with mill scale removed by pickling, development of welding process/procedure to minimize corrosion and problems in heat affected areas. Refer to additional discussion in Red Hill AOC Section 2.4 TIRM Report, Chapter 17, for expansion on the new to old steel welding concerns.
- Quality control technology and degree of secondary quality assurance spot checking of all welds.

One interesting advantage of Alternative 1D over 1A and 1B is that the new steel liner will have fewer penetrations. This would include elimination of patches covering the former tell-tale system penetration as well as all the reinforcing rods/nuts, grout prestressing tubes, strain gauges, and other repair patches applied over the years.

3.6 Preparatory Inspection and Repair of Existing Tank Liner Structural Supports

The majority of inspection procedures in the Red Hill AOC Section 2.2 TIRM REPORT are not applicable to this alternative as the existing steel liner will be removed and a new steel liner will be provided. The existing embedded steel angles that serve to anchor the liner plates to the concrete, as well as serve as the backing bar for plate to plate butt welds will be inspected and repaired using a custom specification developed by the government or pre-bid engineer of record.

3.7 Testing and Commissioning Procedures

Refer to discussions on attributes for discussion on testing and commissioning procedures.

3.8 Construction Logistics

Construction logistics for Alternative 1D are of significantly more complicated and important than concepts developed, followed, and refined for projects over the last 10 years that executed repairs similar to Alternatives 1A and 1B. A more detailed discussion of logistics is found in Part G of this document. The significant issue here is the ability to successfully remove the present liner, move the plates through the tunnels to outside for disposal, move new plates into the tank, erect in place, and weld the plates under an industrial production line scale.

3.9 TIRM

After startup and being placed into service, future integrity inspections, repairs, and maintenance will follow the requirements in Red Hill AOC SOW Section 2.2 TIRM Report and Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document.

The goal is for the tank to have a 20-year in-service period between outages for internal tank inspections and repairs. As the process of clean-inspect-repair can take 2-3 years, the development of an appropriate inspection protocol is required in order to meet a 20-year in-service goal.

3.10 Attributes

The following discusses whether/how Alternative 1D meets the criteria for each attribute as defined in the attribute definition and EEI’s rating of the Alternative for each attribute.

3.10.1 Constructible

Alternative 1D can be constructed in the field at Red Hill using practicable construction means and methods. Alternative 1D will follow standard industry tank cleaning, inspection, and repair techniques, erection of the new tank liner, and followed by coating application to the lower dome, upper dome, and barrel. The greatest challenge for construction is logistics and restrictions working at Red Hill, inside the fuel storage facility and inside the tanks, and the movement of the old liner out, and new liner in to the tank.

In this alternative, the first step after cleaning is the removal of existing steel lining in the tank. Anytime a project includes substantial removals, inevitably unforeseen conditions are discovered, that must be addressed as a change order/contract modification. The cumulative effect is scope, cost and schedule creep, sometimes doubling or tripling the cycle time for each tank.

This alternative is substantially different than the efforts conducted to inspect and repair the Red Hill tanks over the last 13 years.[5] A total of 6 tanks (2, 5, 6, 15, 16, 20) have gone through a cleaning, inspection (including shell/weld scanning), repair, bottom dome recoating and return to service. All tank repairs are considered to have been successfully completed, with the one exception being Tank 5. In the case of this alternative, the similarity to existing efforts ends after cleaning.

EEI has not identified any case within DoD of a cut and cover or mined tank being repaired by removal of the present steel liner and installation of a new steel liner welded to the embedded steel structure in the concrete barrel. Risks are many, from groundwater table, to damaging the exiting embedded steel structure, making it more difficult to reuse. Relining of the upper dome may be the most difficult challenge, as it is overhead work. The original dome construction was early in the process and the steel liner was welded from the topside. This makes even removal of the existing liner quite a challenge, as the actual anchor weld is behind the existing liner plate. The actual relining of the tank barrel and lower dome is will be challenging, but is considered possible, given the improvements being implemented inside the tanks now for inspection of the liners. This effort would be similar or same as for Alternative 2B, as it is receiving a 100% interior coating system.

The movement, placement, and welding of the new liner present a considerable challenge. EEI believes the present contractor for the CIR of 5 tanks has established a viable method. For the tank inspection and repair, a monorail trolley beam is being erected within the tank just below the expansion joint. A minimum of two and easily adapted to up to four or more suspended platforms are being installed for workers to have full access to the shell, making inspection and repair efficient. For the Alternative 1D project, EEI believes installation of two concentric monorails would simplify construction. The outermost ring would be used for material movement, both removal of present shell, and installation of new shell. Steel plates of manageable prefabricated dimensions would be brought into the tank through the Upper Tunnel,

[5] See Final TIRM report dated OCT 2016, ¶1-3.9 to ¶1-3.14 for documentation on the recent efforts to inspect and repair tanks, with full shell surface and weld scanning. Prior efforts did not include full shell scanning.
[5] See Final TIRM report dated OCT 2016 for documentation on original tank construction

and transferred to the material handling trolley. The plate would then be moved and lowered into position for welding to the existing shell structure.

The basis of this Alternative, of welding new steel to the "old" steel (embedded angles) presents a practical problem of minimizing corrosion that could result from the process of welding new to old steel. As the backside, once the new plates are installed, is no longer inspectable other than with scanning, the potential for corrosion must be mitigated.

Regarding tank interior coatings, Tanks 17-20 were extensively upgraded in 1960-1962, including 100% sandblasting and coating of the domes and shell using a first generation Naval Research Lab (NRL) polyurethane coating system.[6] This coating system remains and is now 57 years old. The system consisted of a wash primer, and three applications of polyurethane. Similarly, Tanks 1-16 received a 100% NRL coating system between 1978 and 1984.[7]

Based on internal inspections over the last 10+ years, the coating in some tanks is degraded, but other tanks it is still in serviceable condition.

The proposed polysulfide modified epoxy novolac coating system is now a commercial product meeting strict formulation requirements established by NAVFAC EXWC and published in UFGS Specification 09 97 13.15, polysulfide modified epoxy novolac. Application requirements, QC and QA are much more advanced than the coatings applied in the last round of coating.

EEI has determined Alternative 1D be assigned a "Mostly Does Not Meet Criteria" rating. This is first based on the fact we cannot identify any case of a similar project anywhere, that successfully removed such a large area of shell and installed a new shell on an underground tank. The second, and more compelling reason is the risk this project presents for extensive scope, cost and schedule creep do to the possible unforeseen conditions identified behind the existing shell. This could be problems with the existing structure, damage caused by removal, or groundwater, any of which might result in a project shutdown to negotiate changes. If the risk of project delays and scope creep were determined to be low, EEI would have recommended a rating of "Somewhat Meets Criteria" as the work generally is similar to other projects.

Rating: Mostly Does Not Meet Criteria

3.10.2 Testable

To determine if an Alternative can be shown to meet hydraulic and structural integrity standards prior to being placed into service, this attribute defines the basic litmus test for acceptability during construction prior to filling and during startup/commissioning when filling. This macro approach to testability focuses on the industry standard practices for testing the material, joints, welds, etc. used in repair/construction of steel tanks. This attribute also examines the ability of

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[6] See Final TIRM report dated OCT 2016, ¶1-3.3
[7] See Final TIRM report dated OCT 2016 ¶1-3.5

whether an alternative can be tested for integrity during construction prior to being filled. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 13 – Commissioning and Testing Procedures was developed to demonstrate the degree of rigor required for the testing and commissioning procedures necessary to place the tank repair/upgrade in service and includes the details of that process in the criteria established for that attribute.

In that Alternative 1D results in a single wall UST, all applicable construction practices for USTs can be tested as dictated by applicable industry standards. The Navy's protocol for inventory monitoring and trend analysis required by their tank commissioning procedures meet the required standards for leak testing to determine hydraulic integrity.

Alternative 1D meets the criteria for testable during construction, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

3.10.3 Inspectable

To determine if an Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service, this attribute defines criteria as to whether a tank upgrade is inspectable. This attribute focuses on the industry standard practices for inspection during construction. Attribute 14 - TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade and Attribute 15 - TIRM Requirements for Future Integrity Inspections were developed to rate the degree of rigor required to develop a TIRM using industry standard inspection techniques for the inspection procedures necessary to place the tank repair/upgrade back in service and includes the details of those criterion as established for the respective attributes.

For Alternative 1D, the interior of the primary shell (hydraulic boundary) can be inspected and rejectable indications repaired, resulting in the issue of a Suitability for Service testament as determined by the tank's ability to meet structural and hydraulic integrity criteria.

As Alternative 1D is inspectable during construction, it has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

3.10.4 Repairable

While most bulk tank systems are repairable to some degree, various levels of effort can be undertaken to effect similar repairs. These levels of effort are factored into the rating the ability to effect repairs for each alternative considered. The basis for this attribute centers around the aspects of capabilities for on-site repairs using standard/traditional construction/repair means and methods.

For Alternative 1D removal or modification of the Red Hill infrastructure is not required to gain access to the tank liner, all interior surfaces of the primary tank liner, tank nozzles, and internal components are accessible for repair, and all repairs can be performed from inside the tank without having to remove part of the primary tank or internal component to access an area for repair.

While the mechanisms for effecting any repairs in these Red Hill tanks are quite unique and complex, they have been used for many years and innovations/improvements are being incorporated into the standards with each successive repair effort. All actions are well within the norm of repair method considerations, are feasible to execute, and require no special equipment that render these options unreasonable.

In that Alternative 1D results in an end-product that is practically identical to Alternative 1B, it also would utilize a level of effort that is representative of the status quo. And as with Alternative 1B, it introduces some additional elements for coating repairs, but it does not change the level of access requirements or non-standard equipment required to make the necessary repairs. Therefore, Alternative 1D has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

3.10.5 Practicable

This attribute rates the degree to which an alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters. Given the complexities and interactive dependencies of multiple attributes and their associated importance among stakeholders, this attribute is used to combine several factors to provide a cost/benefit basis for the decision makers.

The three major determinable factors are:

- The extent of the impact/modification to the Red Hill infrastructure or physical arrangement as determined in Attribute 1,
- The cost per tank depicted in the cost analysis associated with Attribute 17 as compared to the current CIR estimates of $7.5M per tank, and
- The ability to complete the upgrades by the mandated timeframe set by the Red Hill AOC SOW as derived from the duration modeling for Attribute 18.

Alternative 1D can be constructed within the confines of Red Hill, but it will have "major" impact/modification to the Red Hill infrastructure or physical arrangement. Demolition and removal of all steel plates currently in use as the primary shell plus the delivery and installation of all new steel plates for the primary shell is a significant undertaking. As with Alternative 1B, this alternative also includes a coating system, the cost of which is additive to the historical cost of Alternative 1A with the applicable inflation rates applied. In addition, the design element of this alternative somewhat impacts design timing and overall program cost.

The construction cost of this alternative is estimated to be [redacted] per tank and falls within the 1000% to 2000% range. The duration modeling data indicates that all tank work is not expected to be completed within the compliance timeframe set by the Red Hill AOC SOW, but by using a four-tank execution strategy, all in-service tanks will have been upgraded by the compliance deadline.

Due to the level of infrastructure impact, measurable cost increase, and necessity for a greater than three-tank execution strategy, Alternative 1D has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

3.10.6 Corrosion Damage Mechanism

Alternative 1D has a coating applied to the lower dome, barrel, and upper dome, which is an enhancement over the current practice for all Red Hill tank repairs. In addition, it is recommended that the piping (tank nozzles) receive an internal coating system same as the remainder of the tank. These coatings provide protection from corrosion in the most susceptible areas where water (including salt water) may be present (lower dome and nozzles), and additional protection in the barrel and upper dome.

On the other hand, there is an element of risk associated with the welding of the new steel liner to the old steel (embedded angles). Refer to additional discussion in Red Hill AOC Section 2.2 TIRM Report, Chapter 17, for expansion on the new to old steel welding concerns.

Alternative 1D has been assigned a "Mostly Meets Criteria" rating, as although the tank and piping are 100% coated, the difficulty in assuring a corrosion free environment on the backside at the new to old steel weld results in a reduction of the rating compared to Alternative 1B.

Rating: Mostly Meets Criteria

3.10.7 Successful Implementation Elsewhere

Concrete cut and cover and mined tanks with single wall carbon steel liners that have been completely removed and replaced is not known to exist in the DoD fuel tank inventory. However, if constructed and maintained properly, the upgraded tank would mirror those concrete cut and cover tanks with single wall carbon steel liners currently in service and would be very successful in detecting leaks and/or preventing leaks to the environment. There are no petroleum tank examples for shell plate replacement and one would have to investigate other industries for similar examples which is beyond the scope of this document.

Conclusion: The Alternative 1D concept has not been used at other large fuels depots, but would be successful in detecting leaks at Red Hill. However, the lack of secondary containment or any other physical leak detection/capture devices would prevent this design from detecting leaks without the use of internal, electronic sensing mechanisms. Therefore, the alternative has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

3.10.8 Reliability

For all TUAs being evaluated, reliability is defined as the measure of a tank's ability to perform its required function under stated conditions for a specified period (i.e. level of confidence). The rudimentary functional requirement of most any storage tank is to maintain hydraulic integrity and prevent the contained product from unintentionally exiting the vessel. The stated conditions are the manner and environment in which the storage tank is operated and maintained. The specified period is the designated interval of uninterrupted operations, i.e. the next out-of-service internal inspection.

Each alternative relies on a steel shell as its primary hydraulic boundary. In all cases, the integrity of the primary shell is designed to meet the definition of reliability as stated above. While a certain amount of variability may be introduced in the type of steel used, coatings applied and construction techniques, these elements drive the different tank upgrade alternatives into various levels of confidence above and beyond the qualifications of basic reliability.

With regards to system reliability, considering tank upgrade alternatives with enhancements that include secondary containment extends beyond the discussion of reliability of the primary tank shell and move towards the reliability of the tank system to minimize the extent of the effects stemming from a failure in the primary shell. Those added enhancements are addressed in other attributes within this document and the merits of the different systems are detailed with multiple factors beyond the limits of this attribute, which specifically targets the reliability of the primary shell to perform as designed.

In that Alternative 1D would be constructed in accordance to proven industry standards for single wall, steel tanks encased in concrete, it can be relied upon to perform its required function under the stated conditions until, at a minimum, the next inspection interval and thus has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

3.10.9 Impact on Storage Volume

Alternative 1D provides for fuel storage in the lower dome, tank barrel, and the upper dome. Alternative 1D provides the same storage volume as existing; thus, there is no reduction in storage volume compared to the existing tanks.

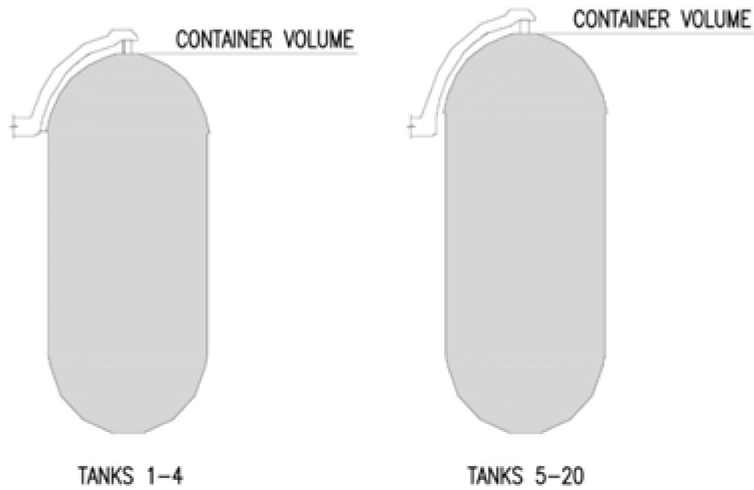

Figure E-3.0-1 TUA 1D Container Volume

Shaded area indicates volume of product in tank

The existing container volumes of the tanks are as follows:

- Tanks 2 to 4: 285,148 Bbls (238'-6" tall)
- Tanks 5 to 18 and 20: 301,934 Bbls (250'-6" tall)
- Tanks 1 and 19: Out of Service
- System (Tanks 2-18 and 20): 5,384,454 Bbls

Note that the container volume represents maximum volume. Working storage volumes are typically less than maximum volumes to accommodate safety, liquid expansion from temperature change, regulatory limitations, etc.

Conclusion: Alternative 1D results in no reduction of container volume compared to existing tanks.

Rating: Not Rated

3.10.10 Provides Secondary Containment

The original circa 1940s construction consists of the primary tank being the steel liner inside the structural concrete of the lower dome, barrel and upper dome. From a regulatory/engineering perspective, the concrete is not considered secondary containment from an overall impervious basis due to unknown liquid tight condition. There are numerous penetrations (reinforcements, anchors, structures) inherent in the construction of the tank. Additionally, there is not an inspectable interstitial space between the concrete and liner. However, it needs to be pointed out that the original construction of the tanks took many steps that lead to an assumption that the designers of the tanks took extra construction steps to make the concrete barrel as liquid tight as possible. Steps included using Gunite to assure sealing of the volcanic rock, grouting between the Gunite and reinforced concrete, and actual testimony from the construction team leader. Further information can be found in the Red Hill AOC SOW 2.2 TIRM Report.

The original design included a physical tell-tale system to detect if any fuel breaches in the steel liner reached the concrete structure. The concrete walls were designed for structure, not liquid integrity. Considerable care was taken in the design to maximize hydraulic integrity, including sealing of the lava face, and use of pressure injected grout after the concrete cured. Due to its current unknown condition, the concrete cannot be considered a secondary containment feature, therefore, any fuel entering the tell-tale system is considered a release to the environment, irrespective of whether it penetrates the concrete structure. The tell-tale system has been removed from some tanks currently in service, and is inactive in tanks where not removed.

This alternative includes inspecting and pressure testing tank nozzles from the tank to the first valve outside tank. In the event the inspections find the nozzles to be of less than satisfactory condition, repairs would be required. There is no intention to replace the existing nozzles, or convert the nozzles to provide a secondary containment double-wall configuration, as the tank is single wall.

Given the above information, Alternative 1D cannot be considered to have secondary containment meeting current EPA requirements specified in 40 CFR 280 being an inner and outer barrier with an interstitial space that is monitored for leaks, for this reason Alternative 1D has been assigned a rating of "Does Not Meet Criteria".

Rating: Does Not Meet Criteria

3.10.11 Dependency on Existing Tank Steel Liner Integrity

Alternative 1D removes the existing steel liner and constructs a new primary carbon steel liner in its place with a full coating system of all internal surfaces. This design would rely on the new tank liner with the added enhancement of the DoD standard thick-film polysulfide modified epoxy novolac coating system on the lower dome, barrel, and upper dome. Therefore, it does not rely on the hydraulic integrity of the existing tank liner to contain product. As per the rating system parameters, Alternative 1D has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

3.10.12 Release Detection Integral to Tank Construction

As noted in Attribute 10 – Secondary Containment, this Alternative does not include a secondary containment with interstitial monitoring system. Accordingly, under 40 CFR 280.43, at least one of the following release detection methods is required:

a. Inventory Control

b. Manual Tank Gauging

c. Tank Tightness Testing

d. Automatic Tank Gauging

e. Vapor Monitoring
f. Groundwater Monitoring
g. Statistical Inventory Reconciliation

Tank tightness testing formally is the primary current response to the regulation. Red Hill AOC SOW Section 4.0 Release Detection/Tank Tightness Testing is in the process of refining the performance of Tank Tightness Testing to determine if the present approach is acceptable, or if a modified approach will be required. This section is also addressing the merits if any of installing a tell-tale system similar in concept to the original/modified systems that have been removed.

Irrespective of what permissible method is ultimately chosen, Alternate 1D will require meeting a minimum of one method of release detection methods listed above, thus has been assigned a "Does Not Meet Criteria" rating.

Rating: Does Not Meet Criteria

3.10.13 Testing and Commissioning Procedures

This attribute is aimed at determining the level of rigor necessary for testing and commissioning procedures required to return the tank repair/upgrade to service. These procedures are based on the final verifications prior to filling, and considerers the different methods available to monitor the tank for hydraulic or structural integrity during and/or immediately after filling.

"Returning the tank to service" includes actions necessary to prepare the tank for the first filling with fuel, performing commissioning steps, determining the tank repair was successful, and determining the tank to be liquid tight and suitable for returning the tank to service.

In accordance with the NAVFAC Naval Engineering Training and Operating Procedures and Standards (NETOPS) 34 and the NAVSUP GLS Instruction 10345.1 (4), coordination and proper review of the following elements is mandatory prior to a transfer of custody of the tank back to the operator:

- A statement signed by an appropriately certified API 653 tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service. The statement shall include due dates for the next applicable formal inspections (internal, external) and any repairs required prior to those next inspections. Next inspection due dates shall be the maximum allowable by API 653. The normal interval under API 653 for a new tank is 10 years, based on the corrosion rates are not yet known. API 653, ¶6.4.2.1.1, however, permits a longer period by meeting certain characteristics in Table 6.1. One such characteristic permits increasing the next inspection interval by 5 years if the tank has a fiberglass liner per API RP 652. We consider the thick film coating system consisting of the polysulfide modified epoxy novolac to be a superior system to fiberglass, and thus qualifies. Thus, the next inspection interval for each of the 1D tanks will be 15 years from the time the tank shell/liner is installed. EEI believes this approach is consistent with Chapter 19 in the Red Hill SOW Section 2.2 TIRM Report.

- The Statement shall also note that as a final test, the tank shall be given a 3rd party certified leak test upon reaching its first full height liquid fill, is required by NAVSUP policy.
- A completed inspection report including all required calculations and analysis. Preliminary or field reports cannot be substituted for this requirement.
- A list of repairs identified during inspection, including completed repairs and repairs that are still pending. All pending repairs shall be annotated with a due date.
- Third-party certified calibration ("strapping") charts when a tank is first placed in service when certified calibration charts did not previously exist, or when repairs were made that would be reasonably expected to change the tank's calibration.
- A statement signed by agents of the Execution/Construction Agent and repair contractor that custody of the tank is returned to the activity and that the above items in have been provided to the operator.

Once the tank has been certified suitable to receive product, the filling protocols must be authorized by the commanding officer. These protocols, required by NAVSUP mandate, are drafted specifically for the type of tank being filled and verified by SMEs at the NAVSUP Energy Office. The operators will then develop a tank specific operations order in accordance with the above stated protocol and mandate. This specific operations order, reviewed and approved by the commanding officer, will consider the unique requirements associated with the tank being filled. Mandatory elements include:

- Tank filling procedures with appropriately defined incremental fill levels and hold times;
- Physical inspection, gauging, and trend analysis as appropriate upon reaching each incremental fill level; and
- Emergency drain-down plan in the event the tank needs to be emptied, including specific triggers as to when the drain-down plan should be activated.

The development and implementation of this operations order is predicated on the parameters presented by the specifics of the tank being filled. Other factors taken into considerations include:

- Ability to continuously visually monitor the shell and/or floor surfaces for a breach of hydraulic integrity or evidence of structural failure;
- Ability of the shell and/or floor that cannot be directly visually monitored, to be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with leak detection piping);
- Ability of the installed tank inventory control system to reasonably determine unacceptable variances during tank filling when performed using the requisite number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity when the tank does not have a shell or floor secondary containment system with leak detection piping that can be continuously monitored for hydraulic integrity; and/or

- Ability to conduct a final hydraulic integrity test to meet the approved tank tightness testing requirements prior to placing the tank in routine operations.

Alternative 1D does not have a secondary containment system with tell-tales such as the original 1942 system or interstitial monitoring, that can be continuously monitored for hydraulic integrity. Therefore, tank filling would be performed using the applicably determined number of “hold points” with a duration sufficient to perform trend analysis for hydraulic integrity using the tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.1 would be required prior to turning the tank over to the operator for routine operations. Therefore, Alternative 1D has been assigned a “Somewhat Meets Criteria” rating.

Rating: Somewhat Meets Criteria

3.10.14 TIRM Requirements for Inspection of Existing Tank prior to application of Tank Upgrade

Red Hill AOC SOW Section 2.0 specifies the level of inspection and repair necessary for the current tanks in service at Red Hill. Each of the alternatives require varying degrees of inspection and repair criteria as compared to the TIRM specifications published in Red Hill AOC SOW Section 2 Appendix BE, UFGS Specification SECTION 33 56 17.00 20 INSPECTION OF FUEL STORAGE TANKS and Appendix BD, SECTION 33 56 18.00 20 REPAIR OF FUEL STORAGE TANKS.

Centering on the level of dependency each TUA has on the integrity of existing shell/dome, considerations are given to the level and type of inspection and repair of the existing tank structure, liner and nozzles. If there is no dependency on the existing shell or dome, a visual inspection of the existing tank structure (such as embedded angles that support the steel liner) is the primary requirement to meet criteria. With limited dependence on the integrity of the existing shell/dome, inspection of the existing tank steel liner and tank nozzles following industry standards would be required, resulting in the least requirements and thus not meeting the established criteria.

As the reliance on the integrity of the existing steel liner increases, the ability to access the original liner for inspection and repair becomes paramount to meeting criteria. The ideal situation would include unfettered access for inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of all rejectable indications identified. However, if an alternative relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, it would result in a less favorable scoring in meeting the requirements of this criteria.

If an alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report or 2.4 TIRM Procedure Decision Document, it would fully meet the criteria of this attribute as the rating system used is oriented towards a higher rating meeting the TIRM Report, and a lower rating for larger departures from the TIRM Report.

In that Alternative 1D does not require any inspection and repair of the liner as described in Red Hill AOC SOW Section 2.2 TIRM Report, it has been assigned a “Does Not Meet Criteria” rating.

Rating: Does Not Meet Criteria

3.10.15 TIRM Requirements for Future Integrity Inspections

Red Hill AOC SOW Section 2.0 (TIRM) states that the purpose of the TIRM report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/Hawaii DOH in the Red Hill AOC SOW for future integrity inspections at Red Hill. It is important that the processes of the future inspection, repair, and maintenance of the Red Hill tanks are well defined to ensure that the goal of keeping the tanks permanently leak-free going forward can be met. The report examines the pros and cons of past, current, and emerging means and methods for work on the tanks to provide the basis for decisions on a strategy that can best achieve the goal of leak-free tanks.

To meet the conditions of Red Hill AOC Section 2.0, each alternative has been rated to determine the level of rigor necessary to conduct future integrity inspections and/or the access provisions required to complete the mandatory inspections and properly maintain the system. The basis for determination of ratings for each alternative examine the ability to competently inspect visually all shell and roof (dome) surfaces and welds from inside or outside the tank, and floor welds and steel liner from inside the tank and with conventional scanning equipment, all following traditional integrity investigation protocol outlined in API 653.

As alternative designs prove to be less accessible or require special procedures for access to all surfaces and welds be competently inspected visually or require departure from standard methods for traditional integrity investigation protocols outlined in API 653, the rating declines. Rating continues to decline for primary shells, including upper dome, barrel and lower dome welds and liner, that require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces. An alternative that is incapable of undergoing integrity inspections of any kind will fail to meet this criterion.

Alternative 1D replaces the original steel liner an adds a coating system. While the coatings will have its own specific inspection and repair considerations, the new steel liner will still require a rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces of the primary shell including upper dome, barrel and lower dome welds and liner. However, as the new liner will have been installed under a higher degree of quality control than the original 1942 liner, and the liner is expected to have smoother surface conditions, with no patches, the use of automated inspection equipment is expected. Taken together we believe this translates into a somewhat less rigorous inspection requirement than Alternatives 1A and 1B, therefore, Alternative 1D has been assigned a “Somewhat Meets Criteria” rating.

Rating: Somewhat Meets Criteria

3.10.16 Impact on Operating and Maintenance Requirements and Procedures

Alternative 1D represents the current operations with minimal changes to the status quo and thus, results in little to no impact to the current operating and maintenance requirements and procedures. The fact that the 1D alternative has a new liner, does not change the way in which the tank is operated when compared to Alternative 1A or 1B. This alternative includes the present day operational efforts conducted to operate and maintain the Red Hill facility. A total of 18 tanks have been included in the routine operational procedures and basic operator level maintenance for more than a decade.

Operating and maintaining a UST facility is significantly less intensive than an AST facility. For Red Hill specifically, the manning for operations and maintenance is minimal due to the high level of automation associated with the facility's systems and the inherent design of the structures. The operator level maintenance of the physical tanks is centered around the skin valves, ventilation systems and bottom water draw off. For comparison, an extensive list of AST and UST operational and maintenance requirements can be found in the UFC 3-460-03 [(4)], Appendix C. There are currently no requirements for fire protection systems on USTs. The unique design of the Red Hill tanks negates the need for Cathodic Protection systems. [(5)] See Red Hill AOC SOW Section 5.0 Corrosion and Metal Fatigue Practices report for documentation.

In accordance with current federal regulations, annual tank tightness testing is required due to the lack of secondary containment. Therefore, facility operations are impacted by several weeks of set up and testing of each tank each year. However, this alternative will include an upgraded inventory / leak detection system that can be operated more frequently, but will not have to absorb the onerous mobilization and set-up workload. These "puts and takes" will result in a virtual net zero impact to operational and maintenance requirements and procedures.

Standard Operating Procedures currently written for the Red Hill tanks would remain in place and require minimal alterations, primarily to accommodate the enhanced in situ release detection. In that the combined results associated with labor and material maintenance cost, annual leak detection requirements, interruption to service, etc. nets out to a near status quo level of effort, this attribute has been assigned a "Meets Criteria" rating.

Note: In the event the results of the Red Hill AOC SOW Section 4.0, Release Detection/ Tank Tightness Testing, results in an increase in requirements or procedures associated with Alternative 1D, this rating may need to be revisited.

Rating: Meets Criteria

3.10.17 Tank Upgrade Construction Cost Estimate (Planning Level)

This attribute provides stakeholders with pertinent information on overall construction execution cost, for the number of total tanks in a given upgrade alternative. These estimates are derived by compiling the projected cost for one tank constructed as a part of multiple tank repair contracts. The single tank cost is then used to develop the cost of each group of tanks, escalated to the midpoint of construction of each group of tanks. Government costs, design costs, construction contingencies, and Title II costs are not included. These estimates are for the physical tank upgrade portion of the overall project and do not include any electronic, volumetric / mass measurement type release detection system or fiber optic communication system.

Details of the explicit cost derivation for each TUA is presented in PART I - Cost Estimates. The cost of Alternative 1D is estimated to be [redacted] per tank NPV.

This attribute is for informational purposes, no ratings are applied to Attribute 20.

Rating: Not Rated

3.10.18 Tank Upgrade Duration

Upgrade duration is determined as an estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). For rating purposes, the Navy designated the baseline for each upgrade cycle as **three** tanks undergoing upgrade at a time utilizing two 10-hour shifts per day for six days a week.

Any TUA that cannot meet the Red Hill AOC SOW deadline for compliance without changing any of these parameters will receive a rating commensurate with the level of change. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one parameter as the determining rating factor for any TUA not meeting compliance with the above stated parameters. However, with the overarching mandate to maintain at least 15 tanks in service at all times during upgrade execution, the tanks per cycle variant is capped at five tanks per cycle and other parameters would require adjustment accordingly.

PART G - Construction Execution Considerations, provides the details by which the project execution duration conclusions were estimated.

The specific tank and cycle times for Alternative 1D upgrades, inclusive of all contingency factors, are estimated at 1.0 years per tank or 3.1 effective years per **four**-tank cycle. Taking all contingency factors into consideration, the estimated compliance date for all in-service tanks to be upgraded via the Alternative 1D concept is 2034.7. The project duration is approximately 19.3 years with a project completion date of 2037.8.

One additional complication will need to be addressed if this Alternative is selected. Because of the use of a new steel liner, and not having a release detection barrier (i.e., an interstitial area with monitoring system), each tank repaired under Alternative 1D will need its first re-inspection in 15 years. As the total execution cycle is 19.3 years, it is expected that several tanks will need to be sequentially taken out of service during the 1D repair process, which in theory would decrease the number of tanks in service to less than the required 15. If this is unacceptable to the government, one solution is to consider one or more cycles to include five tanks rather than a four-tank cycle.

Rating: Mostly Meets Criteria

4.0 ALTERNATIVE 2A - COMPOSITE TANK (DOUBLE WALL) CARBON STEEL

4.1 General Description

Alternative 2A creates a double wall tank with secondary containment and integral interstitial space monitoring and release detection. The lower dome and barrel will have a double-wall. The upper dome will be inspected and repaired to prevent infiltration of groundwater.

Alternative 2A consists of providing a 1/4-inch thick carbon steel liner inside the tank supported by structural steel angles welded to the existing steel liner. This new steel liner is the primary tank envelope and is separated from the existing steel liner by steel angles to create a 3-inch wide interstitial space for release detection. The interstitial space is filled with self-leveling concrete, non-shrink grout, or precast concrete panels to resist fluid pressure from tank contents. If not filled with concrete, grout, precast concrete, or other material, the new steel liner plates would need to be thicker, up to 1-1/2 inches thick at the bottom of the barrel and even thicker in the lower dome, to resist buckling from internal fluid pressure.

The product side of the primary steel liner will be coated with a polysulfide modified epoxy novolac in accordance with UFGS 09 97 13.15 “Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks”. The existing steel liner will be inspected and repaired and becomes secondary containment as well as the structural attachment for the new steel angles/steel liner plates. The existing steel liner on the lower dome and barrel behind the composite wall will not be coated.

Alternative 2A includes taking out of service the existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank and providing new nozzle piping within pipe sleeves (i.e. double-wall construction), as they are considered an extension of the tank. Most likely they will require boring from inside the tank, to the lower access tunnel, a distance of approximately 45 feet.

In this alternative, the composite tank construction will be below the barrel expansion joint near the upper dome, down the shell, and include the lower dome. The upper dome will not be used for fuel storage.

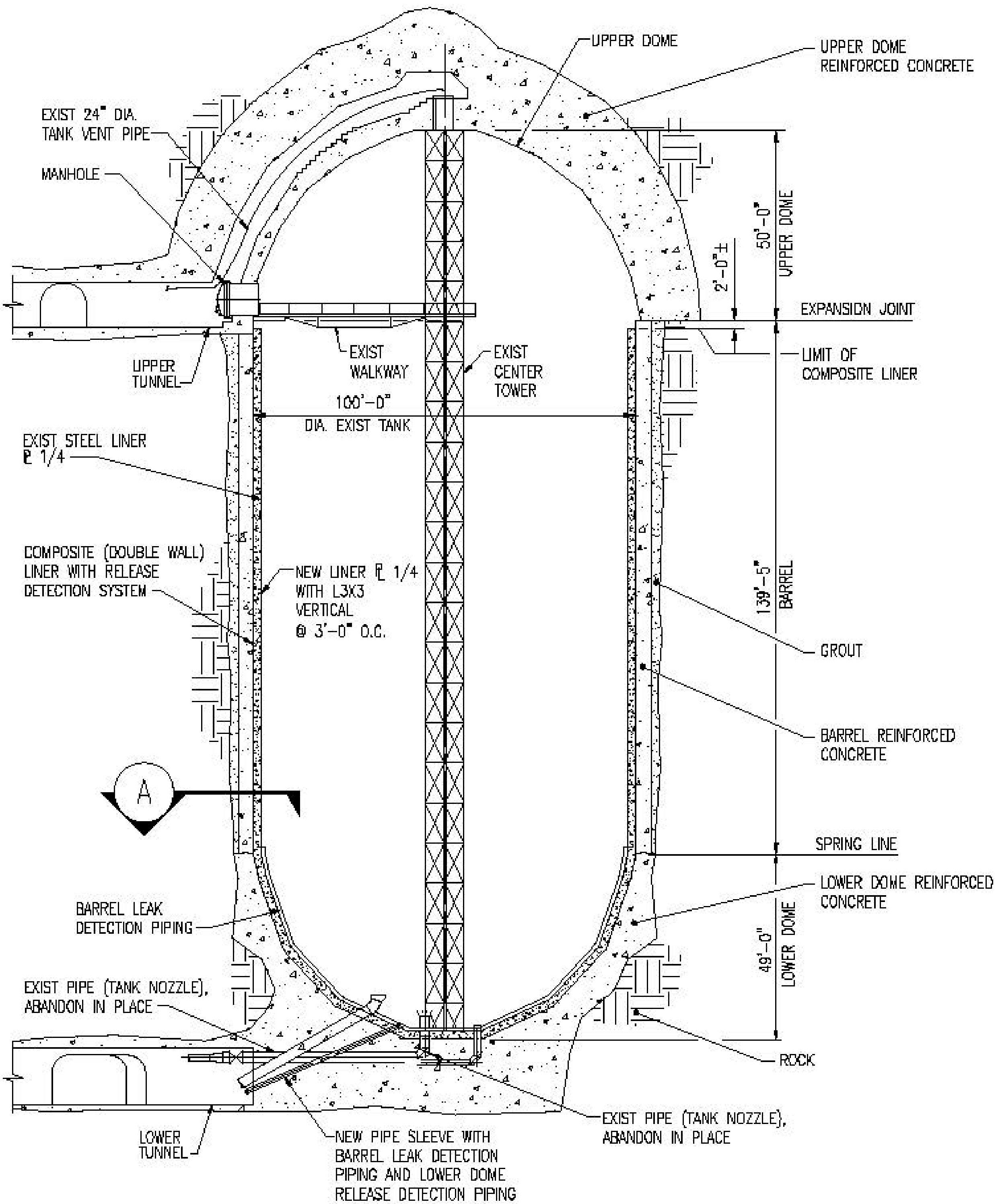

Figure E-4.0-1 TUA 2A Composite Tanks 1 - 4 Elevation

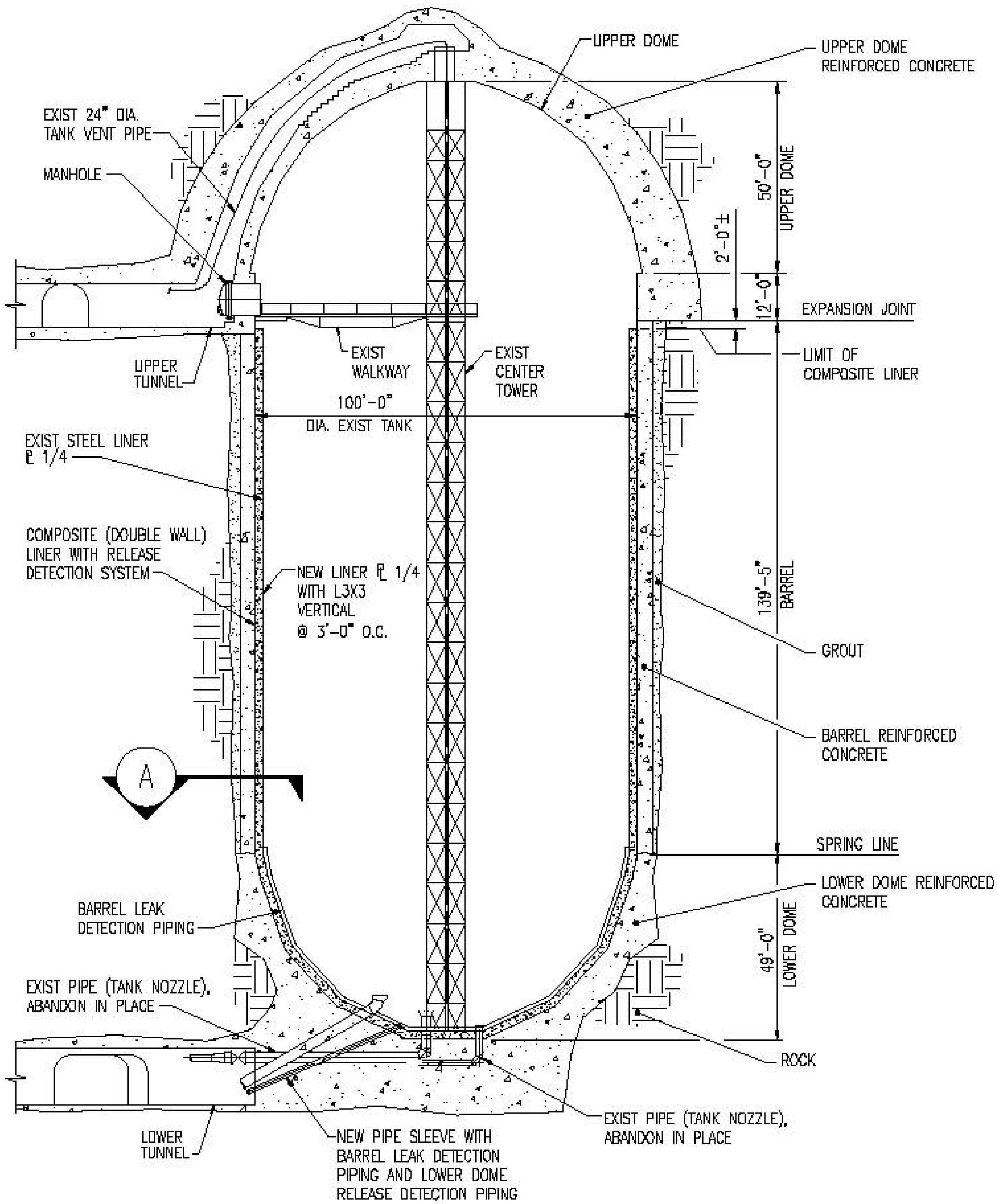

Figure E-4.0-2 TUA 2A Composite Tanks 5 - 20 Elevation

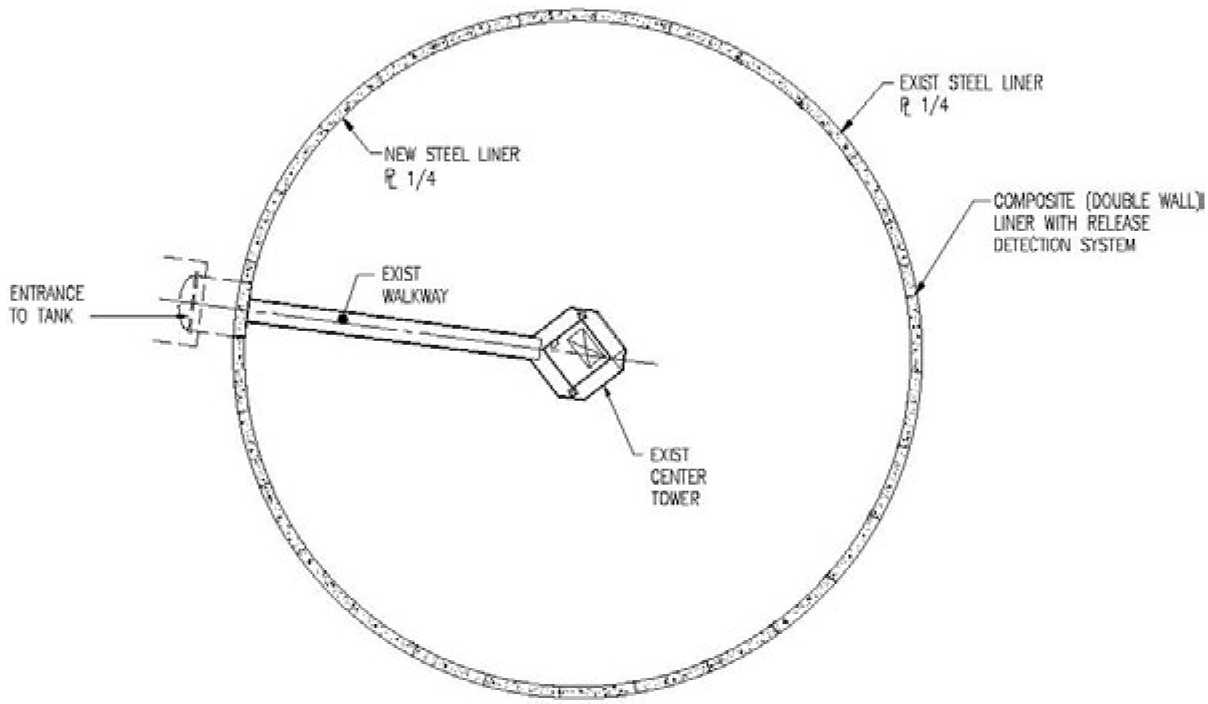

Figure E-4.0-3 TUA 2A Composite Tank Plan

4.2 Features of Alternative

This section summarizes the overall features of the alternative. See the following expanded sections with engineering discussions that support the descriptions and recommendations presented herein. Specific features of Alternative 2A are summarized as:

- Inspection of the existing steel liner following requirements in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document. This document in turn, refers to materials developed under the Red Hill AOC SOW Section 2.2 TIRM Report. This is an enhanced inspection process compared to a conventional API 653 Inspection, using best available inspection technology and complementary and redundant technologies in a two-step process to detect corrosion. In the case of Alternative 2A, the procedures and repair thresholds will be adjusted to reflect the fact that the existing barrel and lower dome will be used for secondary containment and structural support for the new liner, and thus not visible/accessible in the future during tank integrity inspections.
- Six-feet wide, 1/4-inch thick, 20-foot long carbon steel liner plates arranged vertically on the tank barrel.
- Liner plates supported by 3-inch x 3-inch x 1/4-inch thick carbon steel angles (L3x3x1/4) at 6’-0” on center, arranged vertically and welded to the existing steel liner, extending from the lower dome spring line to two feet below the expansion joint between the barrel and upper dome. This arrangement of the support angles compartmentalizes the interstitial space of the tank barrel into 52 vertical spaces for release detection and leak location.

- The width of the liner plates and spacing of the angles at 6’-0” on center is based on the maximum width of the liner plate that can be moved through the existing isolation doors in the Upper Tunnel to Tanks 17, 18, 19, and 20. Slightly wider sheets could be used for Tanks 1 to 16; however, the plates would still need to fit through the 8-feet diameter manhole of the tank. For this reason, 6’-0” wide x 20’-0” long plates were selected for all tanks for this alternative.
- Interstitial space between the new steel liner plates and existing steel liner filled with self-leveling concrete or non-shrink grout having a minimum compressive strength of 2,500 psi, or precast concrete panels. To resist fluid pressure in the interstitial space from concrete/grout without excessive bulging of the primary steel liner until the concrete/grout cures, the self-leveling concrete or grout must be placed in lifts not exceeding 5 feet and the liner plates need to be anchored continuously with vertical angles welded to the existing steel line at 3’-0” on center.

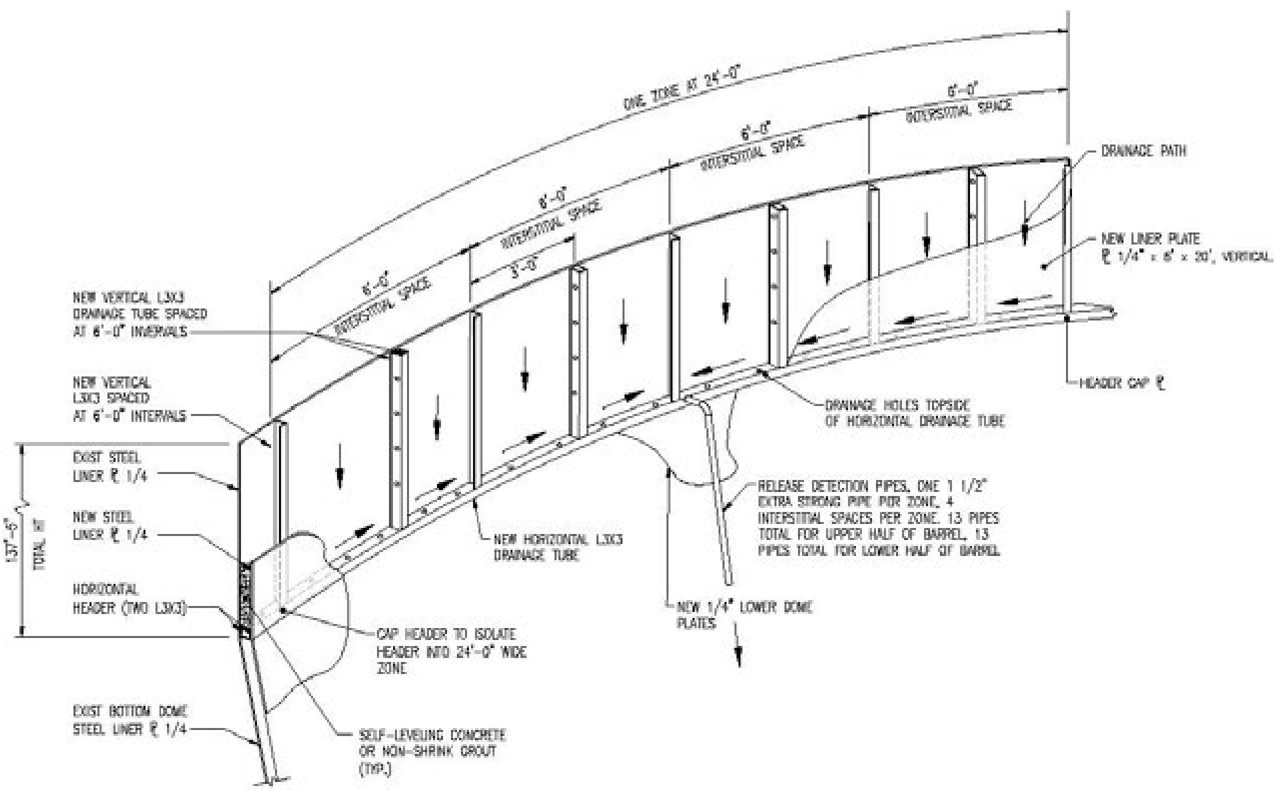

Figure E-4.0-4 TUA 2A Composite Tank Partial Isometric

- Two vertical angles arranged in the shape of a tube or hollow structural section (HSS 3x3x1/4) in the interstitial space at the center of the liner plate to support the liner plate and form a drainage path for release detection. To prevent compartmentalizing the interstitial spaces into 3’-0” wide spaces the two support angles or HHS section at the center of the liner plate which form the drainage tube are welded to the existing liner with intermittent fillet welds and will have drainage holes so that liquid (fuel or water) in the interstitial space can drain into the drainage space and into release detection pipes.

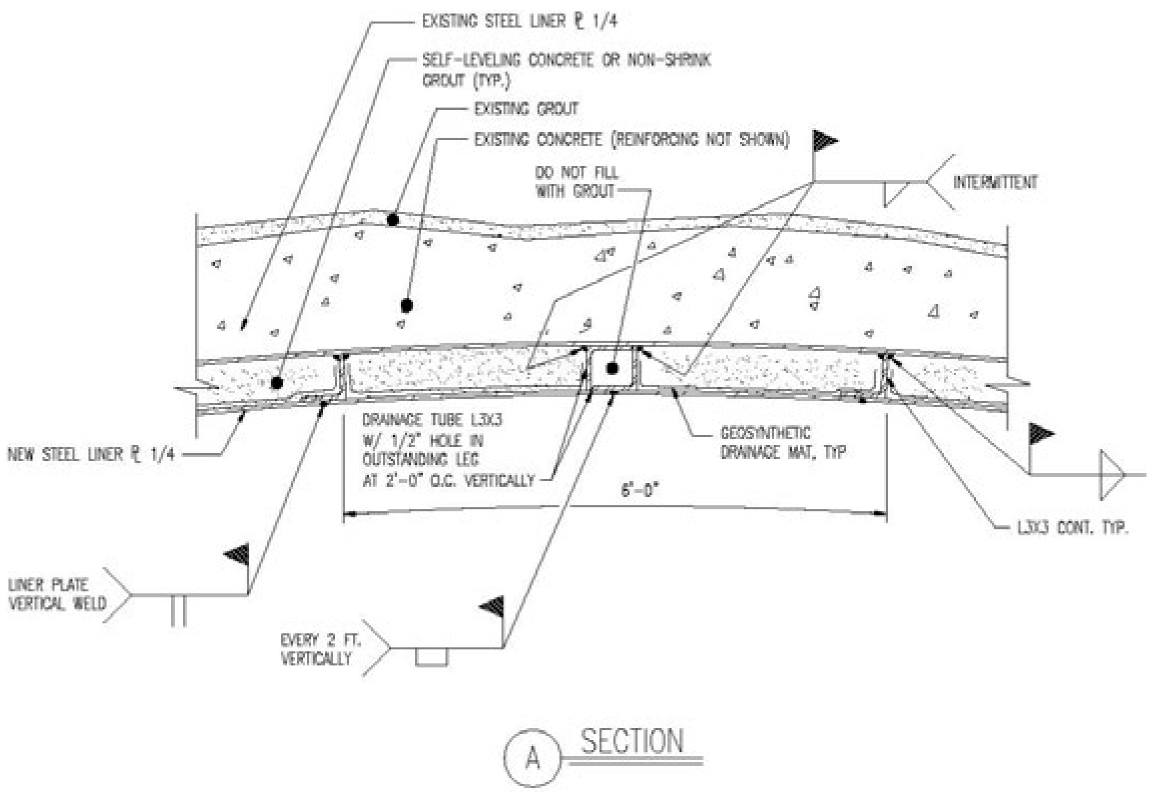

Figure E-4.0-5 TUA 2A Composite Tank Wall Section

- The composite liner/interstitial space of the lower dome will be similar to the composite liner/interstitial space on barrel except the support angles will extend radially from the center of the bottom of the dome up to the dome spring line. The new liner plates will be custom cut to fit the shape of the dome and radial spacing of the support angles. The interstitial space filled with self-leveling concrete or non-shrink grout.
- Connections between the tank, and the lower access tunnel configured as double-wall or in casings.
- Alternative 2A does not include a composite liner on the upper dome due to the very high incremental cost compared to the small increase in storage capacity of approximately 45,900 Bbls (based on a 3-inch wide interstitial space). The composite liner will terminate and be sealed approximately 2 feet below the expansion joint of the upper dome. The upper dome will be inspected and repaired to prevent infiltration of groundwater.

4.3 Release Detection

Alternative 2A includes an integral interstitial monitoring system (release detection system) that is part of the tank upgrade construction. Other release detection methods listed in 40 CFR 280.43 are thus not required. The integral release detection system consists of the following features:

- A 3-inch wide interstitial space in the barrel, between the primary steel liner and existing steel liner.
- Steel angles in the barrel interstitial space, arranged vertically at 6'-0' on center. The steel angles support the primary steel liner plates and compartmentalize the barrel interstitial space into 52 vertical interstitial spaces.
- A vertical drainage tube, constructed of steel angles or hollow structural section (HSS 3x3x1/4) with drainage holes, in each of the 52 interstitial spaces at the mid-plate, effectively 6-feet on center around the tank.
- To assure free drainage of release from breach, to collection channel, a geosynthetic drainage mat is provided after welding, before grouting, between the primary steel liner and the concrete-grout-precast concrete panels in the interstitial space. See discussion below on this concept in the engineering section.
- A horizontal drainage tube in the interstitial space at mid-height and at the bottom of the barrel. These horizontal tubes will be continuous around the tank and compartmentalized into 13 compartments each. The horizontal drainage tube at mid height of the barrel separates the upper half of the interstitial space of the barrel from the lower half.
- The vertical drainage tubes in the 52 interstitial spaces in the upper half of the barrel connect into the horizontal drainage tube at mid-height. The vertical drainage tubes in the 52 interstitial spaces in the lower half of the barrel connect into the horizontal drainage tube at the bottom of the barrel. Four 6'-0" wide interstitial spaces in the upper half of the barrel will connect into each compartment in the horizontal drainage tube at mid height of the barrel and four 6'-0" wide interstitial spaces in the lower half of the barrel will tie connect compartment in the horizontal drainage tube at the bottom of the barrel. This arrangement provides 13 release detection zones in the upper half of the barrel and 13 release detection zones in the lower half of the barrel (26 zones total in barrel). Thus, there is separate leak detection capability for approximately each 4% of the shell.

If there is a breach in the primary steel liner on the barrel, fuel will enter the interstitial space(s) and migrate to the vertical and horizontal drainage tubes and into the release detection interstitial monitoring system piping. If there is a breach in the existing steel liner, liquid outside the tank will enter the interstitial space(s) and migrate to the vertical and horizontal drainage tubes and into the release detection pipes.

As the interstitial space of the barrel has 13 release detection zones in the upper half of the barrel and 13 release detection zones in the lower half of the barrel, each zone with four 6 feet wide interstitial spaces connected, the search for the breach can be narrowed to a 24'-0" wide vertical area of the barrel consisting of 4 interstitial spaces. As the entire lower dome is one zone for release detection, a breach detected in the lower dome would involve inspecting the entire lower dome to locate and repair the breach.

4.4 Release Detection Piping System

A key element of the Alternative 2A is its means of conveying any breach of liquid into one of the interstitial spaces, into the Lower Tunnel, and its leak detection chamber. This conceptually is referred to as the release detection piping system.

The release detection piping system is similar in overall concept to the original tank construction telltale system, in that the space behind the primary tank liner is connected to a piping system that is connected to a sampling chamber in the Lower Tunnel. Any breach of the primary liner will be drained to the lower dome. The system is also useful in air testing of the construction of the liner. The biggest difference will be 56 penetrations in the tank, compared to over 500 in original construction.

Release detection piping inside the tank is connected to the 13 compartments in each horizontal drainage tube. Thus, there will be 26 leak release detection pipes for the barrel; 13 pipes for the upper half of the barrel and 13 pipes for the lower half of the barrel, each pipe providing release detection for four interstitial compartments of the barrel.

In addition to the 26 release detection zones in the tank barrel, the entire lower dome will be one release detection zone. The entire interstitial space of the lower dome will drain via a geosynthetic drainage mat between the primary steel liner and concrete to a sump in the interstitial space below the center of the lower dome floor. The release detection piping for the lower dome will be in the interstitial space of the lower dome and routed from the sump through the 18-inch pipe sleeve containing the release detection piping for the lower half of the barrel to the Lower Tunnel. The interstitial space of the dome bottom will have two leak detection pipes for redundancy.

The release detection pipes from the 26 zones of the barrel and the one zone of the lower dome will be grouped into a manifold in the Lower Tunnel.

Checking the release detection pipes in the Lower Tunnel for fluid will identify if there is a breach in the primary steel liner or existing steel liner. All lines would be connected to a leak detection vessel, which will have a sensor to automatically alarm if liquid has entered the vessel.

Another important feature of the release detection system is the ability to test the system for integrity and connectivity between the interstitial space and Lower Tunnel collection chamber. The general concept suggested is to connect the top of the interstitial space segments with piping inside the tank, with several lines to the upper gauging station above the dome roof, or to a penetration through the access manhole to the upper tunnel. By doing so, a gas inoculant could be introduced under low pressure, and each of the 28 leak detection lines leading to the lower tunnel chamber could be tested for inoculant gas. There are many details to be developed by the eventual design engineering firm. Specific technical requirements and system configuration is discussed in the engineering section below.

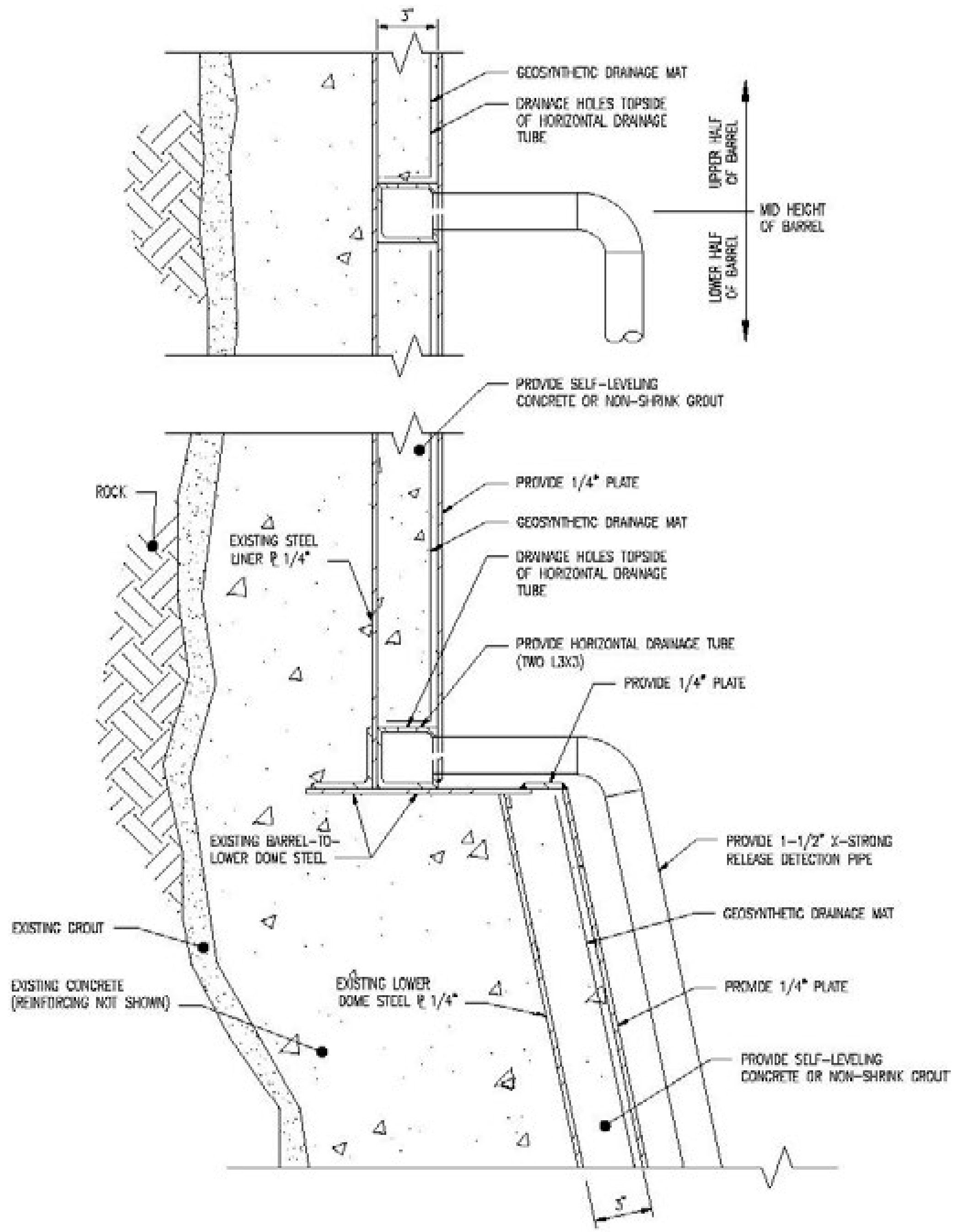

Figure E-4.0-6 TUA 2A Composite Tank Wall Section at Barrel and Lower Dome

4.5 Tank Nozzles

Alternative 2A includes taking out of service the existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank and providing new nozzle piping within pipe sleeves (i.e. double-wall construction). This will require boring through the present concrete plug and rock, between the tank, and the lower access tunnel. This has been done before on several tanks, including Tank 5, recently inspected.

Further discussion is required with NAVSUP FLC Pearl Harbor Operations to determine the required configuration of the tank connections, as to number of lines, sizes of lines (based on current/projected flow rates), and other factors. As a minimum, this assessment considers the following as most likely required:

- Primary fill-issue nozzle (most likely 18-24 inch)
- Tank bottom drain nozzle (most likely 8-10 inch)
- Sample lines (4-1/2-inch line in existing or new casing)
- Release detection piping (28-1.5 inch, in casing)
- Possible second fill-issue line

4.6 Engineering Considerations

Precast Concrete Panels

Precast concrete panels would need to be cast to fit the curvature of the barrel and fit between the steel support angles welded to the existing steel liner with no gap between the existing steel liner and the precast concrete panel and permit installation of a geosynthetic drainage mat between the primary steel liner and the precast concrete panels. While possible, we have not further developed using precast concrete panels for the reasons mentioned (fit curvature of barrel, no gap between the existing steel liner and the precast concrete panel, and allow installation of a geosynthetic drainage material). This concept however can be further assessed in the future by the full engineering design team.

Composite Lining of Upper Dome

In developing the Composite Tank alternative, we considered and ruled out providing a composite wall on the upper dome due to the very high incremental cost compared to the increase in storage capacity of approximately 45,900 Bbls (based on a 3-inch wide interstitial space). The new composite liner will terminate and be sealed approximately 2 feet below the expansion joint of the upper dome. The upper dome will be inspected and repaired to prevent infiltration of ground water.

Composite Lining of Barrel

We considered a composite wall concept on the barrel consisting of the new primary steel liner plates rolled to the radius of the barrel and arranged horizontally with rolled horizontal tee supports welded to the existing steel liner, and a concept of vertical plates with flat or rolled primary steel liner plate and vertical tee supports.

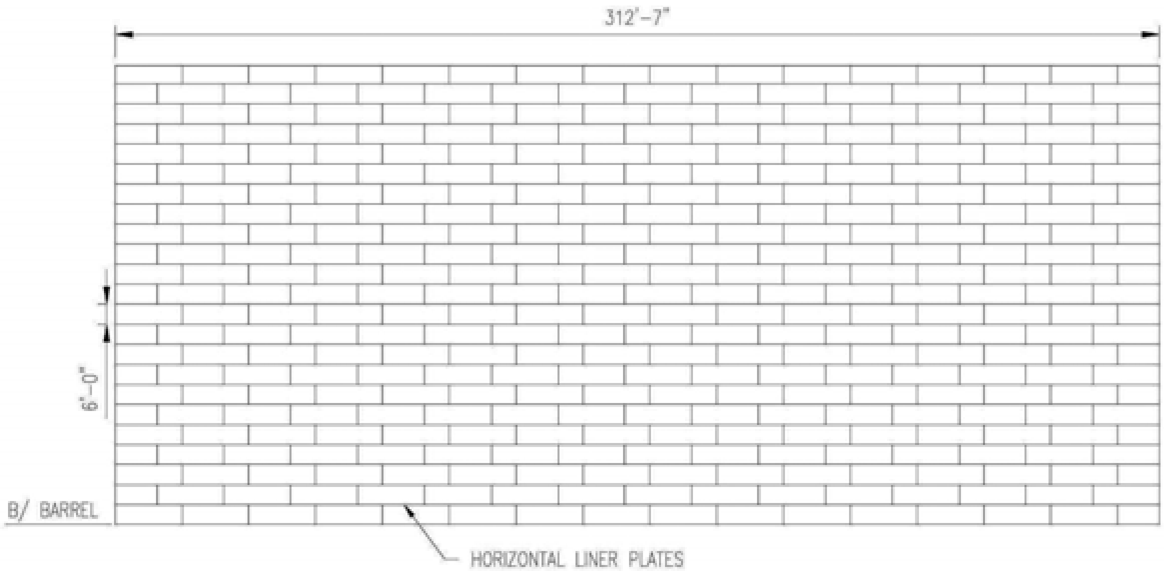

Figure E-4.0-7 TUA 2A Composite Tank Steel Liner Plates - Horizontal Courses

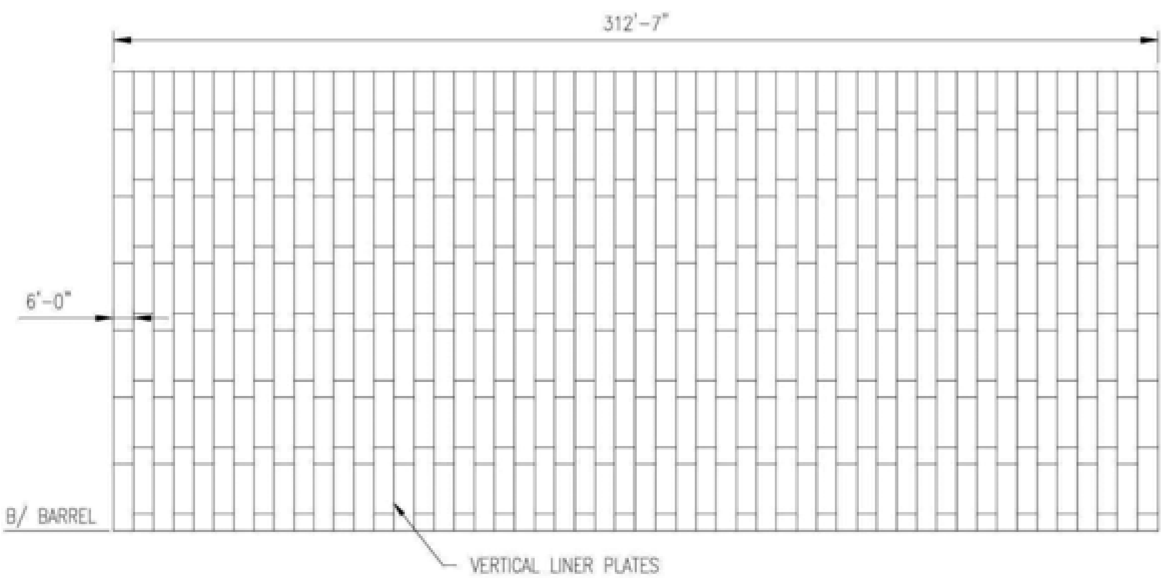

Figure E-4.0-8 TUA 2A Composite Tank Steel Liner Plates - Vertical Course Courses

We evaluated and ruled out the concept of horizontal liner plates for the following reasons:

1. For primary steel liner plates arranged horizontally (i.e. horizontal courses) with horizontal support angles or tees, the horizontal support angle or tees would act as a barrier in the leak detection system and isolate the interstitial space of the barrel into horizontal spaces. This would considerably increase the complexity and cost of the release detection system.

2. If the primary steel liner courses are horizontal and the support angles or tees are arranged vertically, the new liner plates would span over several support angles and can be attached to the supports with intermittent plug welds.
3. Horizontal courses would be 6’-0” high based on the maximum plate width. This increases the number of horizontal joints in the barrel compared to 20-feet tall vertical courses.

We selected the vertical plate concept with vertical support angles for the following reasons:

1. Steel angles are less expensive than tees.
2. Vertical plates supported by vertical angles welded to the existing steel liner allow isolation of the barrel into vertical zones for improved leak detection and leak location. Six-feet wide liner plates with vertical angles spaced at 6’-0” on center, extending from the lower dome spring line to two feet below the expansion joint between the barrel and upper dome compartmentalizes the interstitial space of the barrel into 52 vertical spaces.
3. The width of the liner plates and spacing of the angles at 6’-0” on center is based on the maximum width of the new liner plate that can be through the existing isolation doors in the Upper Tunnel to Tanks 17, 18, 19, and 20. Slightly wider sheets could be used for Tanks 1 to 16; however, the sheets would still need to fit through the 8-feet diameter manhole of the tanks. We recommend 6’-0” wide x 20’-0” long plates for all tanks.

Interstitial Space

The interstitial space can be any width; however, increasing the width results in a greater reduction in storage capacity. We selected a 3-inch wide interstitial space. Our concern with a narrower width is the ability to place concrete or grout in the interstitial space, which must be done in 5-foot increments, for a 20-foot tall plate, before starting work on the next course.

To prevent buckling of the new steel liner from fluid pressure from tank contents, the interstitial space will be filled with self-leveling concrete or non-shrink grout. Self-leveling concrete or non-shrink grout was selected for ease in placement and consolidation in the 3-inch wide interstitial space. Filling the interstitial space with self-leveling concrete or non-shrink grout provides support of the new liner plates. Fluid pressure on the new liner from tank contents is transferred to the existing tank structure via the concrete or non-shrink grout fill. This allows the use of 1/4-inch thick steel liner plates, which is the same thickness as the existing steel liner. Thicker plates could be provided for additional corrosion allowance but at additional cost for thicker material and additional cost for welding thicker plates.

The concrete or grout must have compressive strength to resist fluid pressure on the primary steel liner from tank contents and chemical properties that will not promote corrosion. Additives can be introduced into the concrete or grout mix to inhibit corrosion and increase strength. A hydrophilic chemical grout was considered but dismissed. Hydrophilic grouts are a polyurethane grout that reacts with water and expands into a flexible foam seal and are typically used to seal leaks. Hydrophilic grouts; however, have little to no compressive strength and thus are not capable of supporting fluid pressure acting on the new steel liner.

If the interstitial space is not filled with concrete or grout, the new steel liner plates would need to be thicker, up to 1-1/8 inches thick at the bottom of the barrel and even thicker in the lower dome, to resist buckling from internal fluid pressure from tank contents. The spacing of the supports would need to be reduced and the thickness of the support angles would need be increased to resist crushing from internal fluid pressure from tank contents.

We recommend the interstitial space be filled with self-leveling concrete or non-shrink grout having a minimum compressive strength of 2,500 psi. To resist fluid pressure in the interstitial space from the concrete or grout without excessive bulging of the new liner plates, the self-leveling concrete or grout should be placed in lifts not exceeding in 5 feet and the liner plates need to be supported continuously at 3’-0” on center.

To meet the 3’-0” support spacing requirements, the edges of the new 6’-0” wide vertical liner plates on the barrel will be supported with a continuous vertical angle welded continuously on both sides to the existing steel liner. Additionally, two vertical angles arranged in the shape of a tube will be provided in the interstitial space at the center of the plate to support the plate and form a drainage path for leak detection. To prevent compartmentalizing the interstitial spaces into 3’-0” wide spaces the two support angles at the center of the liner plate which form a tube shape will be welded to the existing liner with intermittent fillet welds and will have drainage holes so that fuel that leaks into the interstitial space can drain into the “tube” space to the leak detection pipes.

The composite liner/interstitial space of the lower dome will be similar to the composite liner/interstitial space on barrel except the support angles will extend radially from the center of the bottom of the lower dome up to the dome spring line. Similar to original construction of the lower dome, the new liner plates will be flat plates custom cut to fit the shape of the dome and radial spacing of the support angles; the edges of the plates will be butt welded to each other and the support angles. The interstitial space will be filled with self-leveling concrete or non-shrink grout.

Geosynthetic Liner between Concrete and Steel Shell

In order to assure free drainage of any tank shell breach, to the collection ring (with two collection rings, the distance is 100 feet or less), we propose following the concept included in both the current US Cut and Cover Tank Standard Design, and NATO cut and cover tank standard.

To transfer internal pressure from tank contents acting on the primary steel liner to the concrete / grout/ precast concrete panels in the interstitial space and to the existing tank, the geosynthetic drainage mat must have a high compressive strength able of resisting the internal pressure of the tank contents without compressing. If the geosynthetic drainage mat compresses, membrane stress develops in the primary liner plates causing the plates to be over stressed. EEI has identified a geosynthetic material that is used in the mining industry for leachate ponds and below roads. [(6)] One of the products has a compressive strength of 60,000 psf which is greater than the 10,000 psf pressure at the bottom of the tank. Additionally, the geosynthetic drainage mat must be fuel resistant and not degrade when in contact with fuel.

Primary Steel Liner Plate and Liner Support Materials

ASTM A 36 carbon steel plates was selected as A36 plates are commonly used and readily available; high strength steels are not required as the liner plates are not a structural element as the primary steel liner relies on concrete or grout in the interstitial space to resist internal pressure from tank contents. Other carbon steel plates could be used if available. A36 angles were selected as A36 shapes are commonly used and readily available.

Hydrostatic Testing

A hydrotest is a test to demonstrate fitness for service and is primarily a test of the structural integrity of a tank. The new steel liner, however, is not a primary structural element as it relies on the concrete or grout in the interstitial space and on the existing tank to resist internal pressure from tank contents. A hydrotest, therefore, would not provide a test of the structural integrity of the new steel liner; nor is a structural integrity test of liner necessary. Non-destructive examination will be performed on the welds of the new liner.

A hydrotest also does not provide a reliable leak test as leak detection time is not immediate. It will take time for weeps and small leaks to migrate through the concrete or grout/steel liner interface in the interstitial spaces and collect in the leak detection pipes. It is possible that a hydrotest could be completed before a leak is detected in the leak detection pipes. A more reliable method of finding leaks in the new liner welds is to vacuum box test the welds as the results are immediately available, and can be repaired. The release detection system can also be used to provide a slight positive pressure and used to bubble test the liner welds.

For these reasons, a hydrotest is not warranted and is not included in Alternative 2A.

Interstitial Space Monitoring Piping System

The overall characteristics of the interstitial monitoring piping system includes the following:

- The piping must be of sufficient size to remain viable of the life of the tank, or at least until the next out of service inspection. For this Alternative, 1-1/2 inch diameter piping was selected. The experience with the original 3/4-inch tell-tale system installed in 1942 is that it easily was plugged (presumably by construction debris and or corrosion material).
- The material of the interstitial space monitoring piping must have sufficient corrosion allowance or be of non-corrosive material. For the purpose of this assessment we have used Schedule 80 carbon steel piping. However, consideration should be given for newer composite material pipe that is lighter in weight, and non-corrosive.
- The interstitial space monitoring system must be designed so it can be proof tested during construction, and then at every downstream tank out-of-service integrity inspection. This may take the form of flanged connections at the shell penetrations (at point of exit to lower access tunnel, and connection to collection header.
- The interstitial space pipes need to be configured such that they do not impede future integrity inspections, and shell scanning.

- The entire concept of a testing method for the in-place interstitial space and piping system may take many forms. For the purposes of this assessment we suggest at the top of the lower shell barrel leak detection zone, and top of the upper shell barrel leak detection zone, a horizontal header, similar to the headers at the bottom of the zone be used connected to piping/tubing extending to the upper dome and thru the access manhole into the gauging room, or through bulkhead connections through the tank manhole to the upper tunnel. Due to strict space concerns we suggest no more than 4 lines extend from the shell to the gauging room, plus two lines from the lower dome, for a total of 6 lines. These lines, being used for gas injection, conceivably could utilize 1/2-inch OD tubing, with no jointing except at each end.
- The 13 release detection pipes servicing the upper half of the barrel will be routed through a new 18-inch diameter penetration in the lower dome to the Lower Tunnel. This concept, of boring through the concrete plug and rock has been successfully completed on several tanks in the past. The 13 release detection pipes servicing the lower half of the barrel will be routed through second 18-inch diameter penetration in the lower dome to the Lower Tunnel. This could be a re-purposing of the present single wall 18-inch line that will no longer be used, or a new boring/casing.
- As previously noted, the system will have 56 penetrations through the shell, as compared to the original 500 in the barrel and lower dome.

The many practical details needed to implement the release detection system will be the responsibility of the overall engineer of record for the tank upgrade.

4.7 Preparatory Inspection and Repair of Existing Tank Liner

Prior to the construction of the new tank liner, the existing steel liner must undergo an inspection that will identify the integrity of the existing liner to serve as a secondary containment liner, and identify deficiencies needing repair. This also will serve to minimize the risk of a future breach.

The basic requirements for inspection and repair of the existing liner are based on Red Hill AOC SOW Section 2.2, Tank Inspection, Repair and Maintenance (TIRM) but with a greater remaining thickness criteria for repair of the existing steel liner. As the existing steel liner will be covered, and not accessible for repair, the thickness of the existing steel liner below which repair would be required would be thicker, based on corrosion rates, and an interval of 40 or more years compared to a repair threshold for 20-year interval until the next inspection as is the case for Alternatives 1A and 1B.

Inspection of the existing steel liner consists of visual inspection of the steel liner plates and welds for rejectable indications, scanning of the steel liner plates using Low Frequency Electromagnetic Technique (LFET) to identify areas of corrosion and pitting, and scanning the liner welds using Balanced Field Electromagnetic Technique (BFET) for surface and near surface indications.

4.8 Testing and Commissioning Procedures

Refer to discussions on attributes for discussion on testing and commissioning procedures.

4.9 Construction Logistics

Construction logistics for Alternative 2A are of significantly more complicated and important than concepts developed, followed, and refined for projects over the last 10 years that executed repairs similar to Alternative 1A. A more detailed discussion of logistics is presented in Part G of this document. The significant issue here is the ability to successfully move the plates through the tunnels into the tank, erect in place, and weld the plates under an industrial production line scale and covey concrete/grout into the tank.

4.10 TIRM

After startup and being placed into service, future integrity inspections, repairs, and maintenance will follow the requirements in Red Hill AOC SOW Section 2.2 TIRM Report and Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document.

The goal is for the tank to have a 20-year in-service period between outages for internal tank inspections and repairs. As the process of clean-inspect-repair can take 2-3 years, the development of an appropriate inspection protocol is required in order to meet a 20-year in-service goal

4.11 Attributes

The following discusses whether/how Alternative 2A meets the criteria for each attribute as defined in the attribute definition and EEI's rating of the Alternative for each attribute.

4.11.1 Constructible

Alternative 2A can be constructed in field at Red Hill using practicable construction means and methods. This alternative creates a double-wall tank with secondary containment and integral release detection. The lower dome and barrel will have a double wall. The upper dome will be inspected and repaired to prevent infiltration of groundwater. The greatest challenge for construction is logistics and restrictions working at Red Hill, inside the fuel storage facility and inside the tanks.

This tank upgrade project will follow standard industry tank and structural steel erection techniques. In addition, the newly constructed shell will receive a coating application to 100% of the tank interior surfaces, similar to Alternative 1B. The design consists of providing a 1/4-inch thick carbon steel liner inside the tank supported by structural steel angles welded to the existing steel liner. This new steel liner is the primary tank envelope and is separated from the existing steel liner by steel angles to create a 3-inch wide interstitial space for release detection. The interstitial space is filled with self-leveling concrete or non-shrink grout to resist fluid pressure from tank contents. The product side of the primary steel liner will be coated in accordance with UFGS 09 97 13.15 "Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks".

The existing steel liner will be inspected and repaired prior to being re-designated as secondary containment and will not be coated. Repairs to the existing steel liner is nearly identical to the efforts conducted to inspect and repair the Red Hill tanks over the last 13 years.[8] A total of 5 tanks (2, 6, 15, 16, 20) have gone through a cleaning, inspecting (including shell/weld scanning), repair, bottom dome recoating, and return to service.

The commonality and differences between Alternatives 1 and 2 are used to evaluate constructability as follows:

- Baseline integrity inspection of the interior surfaces of the existing tank, and repairs as may be required. Essentially the same as Alternative 1, except in the case of Alternative 2, the existing shell and lower dome are the outside "skin" of the interstitial secondary containment barrier, and is relied upon to support the new liner.
- Boring thru the lower dome, to the Lower Tunnel, so that new, double wall pipe nozzle(s) can be installed. The interstitial space created then can be monitored for leakage from the carrier pipe. This has been accomplished in Red Hill, for 3 tanks (5, 6, and 12), for installation of larger tell-tale systems[9].
- Construction of a new liner and concrete filled interstice, with leak detection piping to Lower Tunnel:
    - ➢ There are similarities to the current DoD Standard Design for Cut and Cover tanks, see Appendix B for additional discussion. However, the standard design generally is applied to tanks less than 40 feet tall, and the Red Hill barrels are 150 feet tall.
    - ➢ The Composite Tank approach to relining an older "mined" style steel lined concrete tank has been applied to the NAVSUP FLC Yokosuka Hakozaki terminal tanks in Japan. Tanks 101, 103, 104, 107, 108, 109, 112 and 113, constructed circa 1930s, were a nominal 120 ft. diameter, 100 ft. tall. The original riveted shell received a new steel liner, 0.177 inches thick, with a concrete infill. The created interstitial space has leak detection capability, convening to a sample point in the tunnel below the tank floor level. These tank repairs have performed well, have undergone Integrity Inspections over the last 10 years and have a long useful remaining life for DoD fuel storage. Refer to Appendix H for further discussion on the tank design, operation of the leak detection system, and other relevant information. Construction of the new liner in Red Hill is considered very similar to Hakozaki, with the exception of getting the plates into the tank through the access tunnels. Erecting the new shell on the 150 feet tall barrel is considered no more difficult than a 100 feet tall barrel at Hakozaki.
- Power for construction of this Alternative will be based upon contractor connection to the HECO power system. Refinement of power distribution, i.e., using cable/conduit in the tunnels, or direct boring from the top of the Red Hill ridge are considered construction and means refinements best left to the individual contractor's discretion. For alternative

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[8] See Final TIRM report dated OCT 2016, ¶1-3.9 to ¶1-3.14 for documentation on the recent efforts to inspect and repair tanks, with full shell surface and weld scanning. Prior efforts did not include full shell scanning.

[8] See Final TIRM report dated OCT 2016 for documentation on original tank construction

[9] See Appendix BF of the TIRM for documentation

2A, it is expected the electrical load may increase somewhat over 1B due to the number of welding machines employed. This would be the responsibility of the selected contractor.

- The movement, placement and welding of the liner support structure and actual liner present a considerable challenge. EEI believes the present contractor for the CIR of four tanks has established a viable method. For the tank inspection and repair, a monorail trolley beam is being erected within the tank just below the expansion joint. A minimum of two, and easily adapted to up to four or more suspended platforms are being installed for workers to have full access to the shell, making inspection and repair efficient. For the Alternative 2A project, EEI believes installation of two concentric monorails would simplify construction. The outermost ring would be used for material movement. Steel structural members of manageable prefabricated dimensions would be brought into the tank through the Upper Tunnel, and transferred to the material handling trolley. The steel members would then be moved and lowered into position for welding to the existing shell. The steel liner plates would similarly be moved into the tank and maneuvered into position for welding.
- Welding the steel support system would most likely use manual welding methods, although application of semi-automated welding equipment is considered feasible. The welding of the plates would most likely be with automated welding equipment commonly used on the erection of steel petroleum and water storage tanks.
- Filling the interstitial space with concrete or grout presents a considerable challenge in material conveyance. One method EEI believes to be practical is to bore an access from the top of the Red Hill ridge into the upper dome (approximately 100-150 feet to the top of the tank). Other methods under consideration include concrete pumping systems, which has been used before for tunnel repairs.

Based on the items identified above as generally being conventional construction, and more specifically that DoD has completed similar projects in the past, EEI has determined that Alternative 2A can be assigned a “Somewhat Meets Criteria” rating. The most significant item that is somewhat unconventional is the need to possibly bore down into the upper dome to enable efficient concrete infill of the interstitial space.

Rating: Somewhat Meets Criteria

4.11.2 Testable

To determine if an Alternative can be shown to meet hydraulic and structural integrity standards prior to being placed into service, this attribute defines the basic litmus test for acceptability during construction prior to filling and during startup/commissioning when filling. This macro approach to testability focuses on the industry standard practices for testing the material, joints, welds, etc. used in repair/construction of steel tanks. This attribute also examines the ability of whether an alternative can be tested for integrity during construction prior to being filled. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 13 – Commissioning and Testing Procedures was developed to demonstrate the degree of rigor required for the testing and commissioning procedures necessary to place the tank repair/upgrade in service and includes the details of that process in the criteria established for that attribute.

In that Alternative 2A results in a double wall UST, all applicable construction practices can be tested as dictated by applicable industry standards. In addition to the Navy's protocol for inventory monitoring and trend analysis required by their tank commissioning procedures, the interstitial space between the exterior and interior shell and bottom can be monitored visually by checking the leak detection chamber, and with an automated alarm liquid sensor in the leak detection chamber to ensure hydraulic integrity.

Alternative 2A meets the criteria for testable during construction and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

4.11.3 Inspectable

To determine if an Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service, this attribute defines criteria as to whether a tank upgrade is inspectable. This attribute focuses on the industry standard practices for inspection during construction. Attribute 14 - TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade) and Attribute 15 - TIRM Requirements for Future Integrity Inspections were developed to demonstrate the degree of rigor required to develop a TIRM using industry standard inspection techniques for the inspection procedures necessary to place the tank repair/upgrade in service and includes the details of those criterion as established for the respective attributes.

For Alternative 2A, the interior of the primary shell (hydraulic boundary) can be inspected and rejectable indications repaired, resulting in the issue of a Suitability for Service testament as determined by the tank's ability to meet structural and hydraulic integrity standards.

Alternative 2A meet the criteria of this attribute and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

4.11.4 Repairable

While most bulk tank systems are repairable to some degree, various levels of effort can be undertaken to effect similar repairs. These levels of effort are factored into the rating of the ability to effect repairs for each alternative considered. The basis for this attribute centers around the aspects of capabilities for on-site repairs using standard/traditional construction/repair means and methods.

Using the status quo efforts as a gauge, removal or modification of the Red Hill infrastructure is not required to gain access to the tank liner, all interior surfaces of the primary tank liner, tank nozzles, and internal components are accessible for repair, and all repairs can be performed from inside the tank without having to remove part of the primary tank or internal component to access an area for repair.

While the mechanisms for effecting any repairs in these Red Hill tanks are quite unique and complex, they have been used for many years and innovations/improvements are being incorporated into the standards with each successive repair effort. All actions are well within the norm of repair method considerations, are feasible to execute, and require no special equipment that render these options unreasonable.

Repair of the existing steel liner after new primary steel liner plates are installed is possible but would require removing the primary steel liner and concrete/grout fill in the interstitial space, locating the breach in the existing steel liner, repairing the existing steel liner, and re-stalling the primary steel liner at the repair area and filling the interstitial space with concrete or grout.

For the primary shell of the Alternative 2A concept, the level of effort is representative of the status quo plus the elements of repair associated with the coating systems. Since only interior surfaces of the primary tank and internal components are accessible for repair and can only be performed from inside the primary tank and repairs to the secondary containment would require removal of part of the primary tank or component to access an area for repair to portions of the tank system, Alternative 2A has been assigned a “Somewhat Meets Criteria” rating.

Rating: Somewhat Meets Criteria

4.11.5 Practicable

This attribute rates the degree to which an alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters. Given the complexities and interactive dependencies of multiple attributes and their associated importance among stakeholders, this attribute is used to combine several factors to provide a cost/benefit basis for the decision makers.

The three major determinable factors are:

- The extent of the impact/modification to the Red Hill infrastructure or physical arrangement as determined in Attribute 1,
- The cost per depicted in the cost analysis associated with Attribute 17 as compared to the current CIR estimates of $7.5M per tank, and
- The ability to complete the upgrades by the mandated timeframe set by the Red Hill AOC SOW as derived from the duration modeling for Attribute 18.

Alternative 2A can be constructed within the confines of Red Hill, but it will have “extensive” impact/modification to the Red Hill infrastructure or physical arrangement. Fabricating a second shell within the original shell to form a double wall tank with an interstitial space for monitoring is a formidable undertaking. In addition, the design element of this alternative and volume reduction aspects that necessitate the need for 20 tanks vice the current 18, is expressively more impactful to timing and overall program cost than any of the single wall alternatives.

The construction cost of this alternative is estimated to be [redacted] per tank and falls within the 1000% to 2000% range. The duration modeling data indicates that all tank work is not expected to be completed within the compliance timeframe set by the Red Hill AOC SOW, but by using a four-tank upgrade cycle execution strategy, all in-service tanks will have been upgraded by the compliance deadline.

Due to the level of infrastructure impact, measurable cost increase and necessity for a greater than three-tank execution strategy, Alternative 2A has been assigned a “Mostly Does Not Meet Criteria” rating.

Rating: Mostly Does Not Meet Criteria

4.11.6 Corrosion Damage Mechanism

Alternative 2A has a coating applied to the lower dome, barrel, and upper dome, which is an enhancement over the current practice for all Red Hill tank repairs. These coatings provide protection from corrosion in the most susceptible areas where water (including salt water) may be present (Lower Dome), and additional protection in the barrel and Upper Dome. This alternative has new tank nozzle piping as well.

There is, however, an element of risk associated with the welding of the new steel liner support angles to the old steel liner. Refer to additional discussion in Red Hill AOC Section 2.2 TIRM Report, Chapter 17, for expansion on the new to old steel welding concerns.

Alternative 2A has been assigned a “Mostly Meets Criteria” rating, as although the tank is 100% coated, the difficulty in assuring a corrosion free environment on the interstitial space at the new to old steel welding results in a reduction of the rating.

Rating: Mostly Meets Criteria

4.11.7 Successful Implementation Elsewhere

Composite tanks (double wall), where an original concrete cut and cover or mined tanks with single wall carbon steel liners has been modified for secondary containment with new carbon steel primary liners with interstitial spaces, are currently in operation at other large fuel depots such as Hakozaki in Japan. When constructed and maintained properly they have been very successful in preventing and detecting leaks. The addition of secondary containment coupled with physical leak detection/capture features specifically allows this design to detect leaks without the use of internal, electronic sensing mechanisms. Specific examples for reference are the upgraded tanks in Hakozaki, Japan as discussed in Appendix H.

Since the Alternative 2A concept has been used at other large fuels depots and would be just as successful in preventing leaks at Red Hill, this alternative has been assigned a “Meets Criteria” rating.

Rating: Meets Criteria

4.11.8 Reliability

For all TUAs being evaluated, reliability is defined as the measure of a tank's ability to perform its required function under stated conditions for a specified period (i.e. level of confidence). The rudimentary functional requirement of most any storage tank is to maintain hydraulic integrity and prevent the contained product from unintentionally exiting the vessel. The stated conditions are the manner and environment in which the storage tank is operated and maintained. The specified period is the designated interval of uninterrupted operations, i.e. the next out-of-service internal inspection.

Each alternative relies on a steel shell as its primary hydraulic boundary. In all cases, the integrity of the primary shell is designed to meet the definition of reliability as stated above. While a certain amount of variability may be introduced in the type of steel used, coatings applied and construction techniques, these elements drive the different concepts into various levels of confidence above and beyond the qualifications of basic reliability.

With regards to system reliability, considering alternatives with enhancements that include secondary containment extends beyond the discussion of reliability of the primary tank shell and move towards the reliability of the tank system to minimize the extent of the effects stemming from a failure in the primary shell. Those added enhancements are addressed in other attributes within this document and the merits of the different systems are detailed with multiple factors beyond the limits of this attribute, which specifically targets the reliability of the primary shell to perform as designed.

In that Alternative 2A would is inspected and repaired in accordance to proven industry standards for double wall steel tanks encased in concrete, it can be relied upon to perform its required function under the stated conditions until, at a minimum, the next inspection interval and thus has been assigned a “Meets Criteria” rating.

Rating: Meets Criteria

4.11.9 Impact on Storage Volume

Alternative 2A provides for fuel storage in the lower dome and tank barrel up to 2 feet below the expansion joint at the top of the barrel (elevation of 188 ft. - 5 in.). Alternative 2A does not provide for fuel storage in the barrel extension (Tank 5-20) or upper dome; thus, there is a reduction in storage volume compared to the existing tanks. The reduction in storage volumes are different between Tanks 2-4 and Tanks 5-18 and 20 due to a 12-feet tall barrel extension in Tanks 5-18 and 20 that is currently used for storage. The container volume is limited to the height of the double wall portion of the shell. The 3-inch wide interstitial space in the barrel and lower dome also results in storage volume reduction. However, with the existing shell being re-designated as secondary containment, the out of service tanks (1 and 19) can be inspected, repaired and upgraded for return to service and added to the overall system volume calculations to mitigate the net volume change.

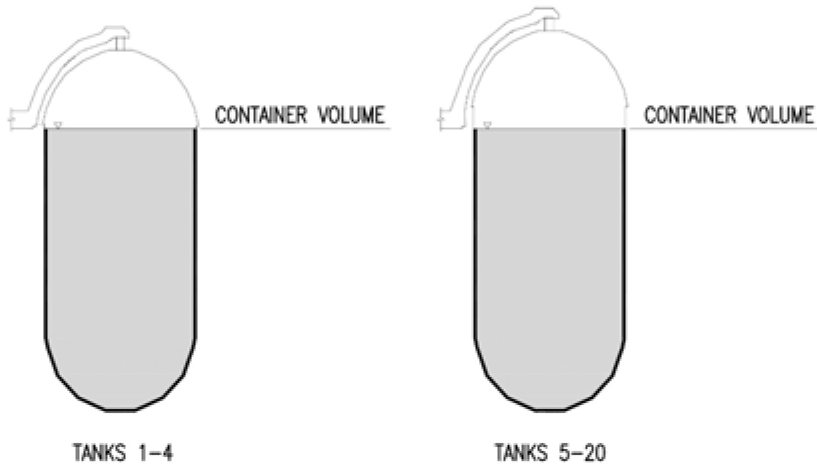

Figure E-4.0-9 TUA 2A Composite Tank 2A Container Volume

Shaded area indicates volume of product in tank

The reduction in container volume compared to the existing tanks are as follows:

- Existing container volume (see Alt 1A graphic):
  - Tanks 2 to 4: 285,148 Bbls (238'-6" tall)
  - Tanks 5 to 18 and 20: 301,934 Bbls (250'-6" tall)
  - Tanks 1 and 19: Out of Service
  - System (Tanks 2-18 and 20): 5,384,454 Bbls
- Container volume after Alternative 2A upgrade:
  - Individual container: 236,263 Bbls
  - System (Tanks 1-20): 4,725,260 Bbls
- Change in container volume after Alternative 2A upgrade:
  - Tanks 2 to 4: 48,885 Bbl reduction per tank (17.1% reduction)
  - Tanks 5 to 18 and 20: 65,671 Bbl reduction per tank (21.8% reduction)
  - Tank 1 and 19: 236,263 Bbl increase per tank (currently out of service)
  - System (Tanks 1-20) 659,194 Bbl net reduction (12.2% net reduction)

Note that the container volume represents maximum volume. Working storage volumes are less to accommodate safety, liquid expansion from temperature change, regulatory limitations, etc. Tanks 1 and 19 have been formally "taken out of service" under Hawaii DOH rules. Restoration of the tanks for return to service will require an unknown environmental/permitting effort.

Conclusion: Alternative 2A (with Tanks 1 and 19 included) still results in a reduction of facility storage volume compared to existing tanks. The overall system volume results in a 12.2% reduction.

Rating: Not Rated

4.11.10 Provides Secondary Containment

Alternative 2A provides a double wall interstitial space on the barrel and lower dome effectively making this alternative a double wall tank. The existing steel liner on the barrel and lower dome provides secondary containment. This alternative consists of providing a new 1/4-inch thick carbon steel liner on the lower dome and barrel of the existing tank. The new steel liner is separated from the existing steel liner by steel angles or tees welded to the existing steel liner to create an interstitial space filled with grout or concrete. Secondary containment is provided by the existing steel liner. The interstitial space provides a means for leak detection.

As this alternative relies on the integrity of the existing steel liner for secondary containment, the steel liner and welds of the barrel and lower dome of the existing tank need to be 100% scanned for thinning due to corrosion and rejectable indications in welds and repaired.

Alternative 2A complies with secondary containment as promulgated by 40 CFR 280, thus an alternative means of regulatory compliance is not required. Secondary containment concepts include inherent release detection barrier and release detection capability outside of the primary barrier (tank shell). This alternative also includes an integral release detection system that is part of the tank upgrade construction. Release detection provided by secondary containment interstice zoned by shell area and piped by gravity to a sensor chamber in the Lower Tunnel. Release detection sensors provide direct measurement/indication of a release. This provides dynamic full-time release detection with sensors transmitting an alarm to the central location.

This alternative includes replacing existing concrete encased piping from the tank to the first valve outside tank with double wall construction tank nozzles. The interstitial space will be a zone of the leak detection system.

Upper dome would not receive a composite liner and thus will not be used for fuel storage; this results in a reduction in storage capacity.

Given the above information, the concept of Alternative 2A to provide secondary containment meets current EPA requirements specified by 40 CFR 280 criteria being an inner and outer barrier with an interstitial space that is monitored for leaks, a “Meets Criteria” rating has been assigned.

Rating: Meets Criteria

4.11.11 Dependency on Existing Tank Steel Liner Integrity

The original construction of the existing tanks was accomplished by excavating the lava rock formation of Red Hill to create a chamber for each tank which was then lined with reinforced concrete and a 1/4-inch thick carbon steel liner. Where corrosion of the steel liner may have occurred, it is detected and remedied during the tank inspection and repair process, restoring the liner to acceptable thickness. Nevertheless, when considering alternatives for the best available practicable technologies, a determination of the dependency on the existing tank liner (as repaired) integrity is prudent.

This attribute was designed to determine the level to which each alternative being analyzed depends on the original steel liner for hydraulic integrity to contain product (primary tank) or provide a barrier between a breach of the primary tank liner and the environment (i.e. interstitial space boundary, or dike wall/floor secondary containment boundary). For evaluation purposes, the rating system used is oriented towards a higher rating for the least amount of dependency on the existing liner.

Alternative 2A constructs a new primary carbon steel liner and uses the existing steel liner as secondary containment creating an interstitial space on the barrel and the bottom. In addition, the alternative includes the DoD standard thick film polysulfide modified epoxy novolac coating system to the barrel and Upper Dome for enhanced hydraulic integrity. Therefore, while it does not rely on the hydraulic integrity of the existing repaired tank liner to contain product, it does depend on the existing tank liner to serve as the outer barrier of an interstitial space or as secondary containment.

Because the existing liner cannot be inspected, it is suggested that the criteria for corrosion assessment be changed to a longer duration, as discussed in the TIRM attribute. However, there is a possibility that some corrosion on the existing liner, within the interstitial space, may occur under certain conditions, such as moisture introduction through the interstitial monitoring system. As such, Alternative 2A has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

4.11.12 Release Detection Integral to Tank Construction

This attribute defines whether an Alternative has release detection capability that is integral to (i.e. is part of) the upgrade construction such as an interstitial space with monitoring.

Alternative 2A has a release detection system that is integral to the tank that includes a secondary containment with an interstitial monitoring system. As Alternative 2A has monitoring of the interstitial space, other methods of release detection identified in 40 CFR 280 are not required. Special technology is not required for release detection other than sensors in the release detection chamber in the Lower Tunnel. This alternative has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

4.11.13 Testing and Commissioning Procedures

This attribute is aimed at determining the level of rigor necessary for testing and commissioning procedures required to return the tank to service after repair/upgrade. These procedures are based on the final verifications prior to filling, and considerers the different methods available to monitor the tank for hydraulic or structural failure during and/or immediately after filling.

"Returning the tank to service" includes actions necessary to prepare the tank for the first filling with fuel, performing commissioning steps, determining the tank repair was successful, and determining the tank to be liquid tight and suitable for returning the tank to service.

In accordance with the NAVFAC Naval Engineering Training and Operating Procedures and Standards (NETOPS) 34 and the NAVSUP GLS Instruction 10345.1 (3), coordination and proper review of the following elements is mandatory prior to a transfer of custody of the tank back to the operator:

- A statement signed by an appropriately certified API 653 tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service. The statement shall include due dates for the next applicable formal inspections (internal, external) and any repairs required prior to those next inspections. Next inspection due dates shall be the maximum allowable by API 653 code. The normal interval under API 653 for a new tank is 10 years, based on the corrosion rates are not yet known. However, API 653, ¶6.4.2.1.1 permits a longer period by meeting certain characteristics in Table 6.1. One such characteristic permits increasing the next inspection interval by 5 years if the tank has a fiberglass liner per API RP 652. We consider the thick film coating system consisting of the polysulfide modified epoxy novolac to be a superior system to fiberglass, and thus qualifies. The API table also permits an additional 10 years before the first inspection if there is a release detection barrier. The interstitial space with monitoring system qualifies under this provision. Thus, the next inspection interval for Alternative 2A tanks can be as long as 25 years from the time the tank shell/liner is installed. NAVSUP guidance is no more than 20 years, and being less than allowable API requirements, is acceptable. EEI believes this approach is consistent with Chapter 19 in the Red Hill SOW Section 2.2 TIRM Report.
- The Statement shall also note that as a final test, the tank shall be given a 3rd party certified leak test upon reaching its first full height liquid fill, is required by NAVSUP policy.
- A completed inspection report including all required calculations and analysis. Preliminary or field reports cannot be substituted for this requirement.
- A list of repairs identified during inspection, including completed repairs and repairs that are still pending. All pending repairs shall be annotated with a due date.
- Third-party certified calibration (“strapping”) charts when a tank is first placed in service when certified calibration charts did not previously exist, or when repairs were made that would be reasonably expected to change the tank’s calibration.
- A statement signed by agents of the Execution/Construction Agent and repair contractor that custody of the tank is returned to the activity and that the above items have been provided to the operator.

Once the tank has been declared suitable to receive product, the filling protocols must be authorized by the commanding officer. These protocols, required by NAVSUP mandate, are drafted specifically for the type of tank being filled and verified by SMEs at the NAVSUP Energy Office. The operators will then develop a tank specific operations order in accordance with the above stated protocol and mandate. This specific operations order, reviewed and approved by the commanding officer, will consider the unique requirements associated with the tank being filled. Mandatory elements include:

- Tank filling procedures with appropriately defined incremental fill levels and hold times;
- Physical inspection, gauging, and trend analysis as appropriate upon reaching each incremental fill level; and
- Emergency drain-down plan in the event the tank needs to be emptied, including specific triggers as to when the drain-down plan should be activated.

The development and implementation of this operations order is predicated on the parameters presented by the specifics of the tank being filled. Other factors taken into considerations include:

- Ability to continuously visually monitor the shell and/or floor surfaces for a breach of hydraulic integrity or evidence of structural failure;
- Ability of the shell and/or floor that cannot be directly visually monitored, to be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping);
- Ability of the installed tank inventory control system to reasonably determine unacceptable variances during tank filling when performed using the requisite number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity when the tank does not have a shell or floor secondary containment system with release detection pining that can be continuously monitored for hydraulic integrity; and/or
- Ability to conduct a final hydraulic integrity test to meet the approved tank tightness testing requirements prior to placing the tank in routine operations.

Alternative 2A includes a shell and bottom interstitial space with release detection piping, that can be continuously monitored for hydraulic integrity. Therefore, tank filling would include physical inspection (visual monitoring of these release detection systems) in addition to using the applicably determined number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using the tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.1 may be required prior to turning the tank over to the operator for routine operations. Therefore, Alternative 2A has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

4.11.14 TIRM Requirements for Inspection of Existing Tank prior to application of Tank Upgrade

Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document specifies the level of inspection and repair necessary for the current tanks in service at Red Hill, by cross referencing to the Red Hill AOC SOW Section 2.2 TIRM Report. Each of the alternatives require varying degrees of inspection and repair criteria as compared to the TIRM specifications (for existing tank inspections) published in Red Hill AOC SOW Section 2.2 TIRM Report, Appendix BE, UFGS Specification SECTION 33 56 17.00 20 INSPECTION OF FUEL STORAGE TANKS and Appendix BD, SECTION 33 56 18.00 20 REPAIR OF FUEL STORAGE TANKS.

Centering on the level of dependency each TUA has on the integrity of existing shell/dome, considerations are given to the level and type of inspection and repair of the existing tank structure, liner and nozzles. If there is no dependency on the existing shell or dome, a visual inspection of the existing tank structure (such as embedded angles that support the steel liner) is the primary requirement to meet criteria. With limited dependence on the integrity of the existing shell/dome, inspection of the existing tank steel liner and tank nozzles following industry standards would be required, consisting of visual inspection and ultrasonic examination at spot locations with repair of rejectable indications identified being limited to the repair of existing welds and isolated areas of the steel liner.

As the reliance on the integrity of the existing steel liner increases, the ability to access the original liner for inspection and repair becomes paramount to meeting criteria. The ideal situation would include unfettered access for inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of all rejectable indications identified. However, if an alternative relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, it would result in a less favorable scoring in meeting the requirements of this criteria.

If an alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report or Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document, it would fully meet the criteria of this attribute as the rating system used is oriented towards a higher rating meeting the TIRM Report, and a lower rating for larger departures from the TIRM Report.

While Alternative 2A adds a new carbon steel liner with a coating system with each requiring specific inspection and repair efforts respectively, it would also require inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) plus pressure testing of tank nozzles and repair of rejectable indications identified prior to installation of the new liner.

In that Alternative 2A relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, the level of repairs would have to be such that they would be effective to the greatest length of time possible vice just to the next inspection interval. Given these stated conditions, Alternative 2A has been assigned a “Mostly Meets Criteria” rating.

Rating: Mostly Meets Criteria

4.11.15 TIRM Requirements for Future Integrity Inspections

Red Hill AOC SOW Section 2.0 states that the purpose of the TIRM report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/Hawaii DOH in the Red Hill AOC SOW for future integrity inspections at Red Hill. It is important that the processes of the future inspection, repair, and maintenance of the Red Hill tanks are well defined to ensure that the goal of keeping the tanks permanently leak-free going forward can be met going forward. The report examines the pros and cons of past, current, and emerging means and methods for work on the tanks to provide the basis for decisions on a strategy that can best achieve the goal of leak-free tanks.

To meet the conditions of Red Hill AOC Section 2.0, each alternative has been rated to determine the level of rigor necessary to conduct future integrity inspections and/or the access provisions required to complete the mandatory inspections and properly maintain the system. The basis for determination of ratings for each alternative examine the ability to competently inspect visually all shell and roof (dome) surfaces and welds from inside or outside the tank, and floor welds and steel liner from inside the tank and with conventional floor scanning equipment, all following traditional integrity investigation protocol outlined in API 653.

As alternative designs prove to be less accessible or require special procedures for access to all surfaces and welds be competently inspected visually or require departure from standard methods for traditional integrity investigation protocols outlined in API 653, the rating declines. Rating continues to decline for primary shells, including upper dome, barrel and lower dome welds and liner, that require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces. An alternative that is incapable of undergoing integrity inspections of any kind will fail to meet this criterion.

For Alternative 2A, the existing steel liner in the upper dome and the new tank shell and lower dome welds and interior surfaces must be inspected from inside the tank visually and with modified conventional equipment and procedures that follow traditional integrity investigation protocols outlined in API 653. For this composite (double wall) tank design, access to all surfaces would require special procedures. Therefore, Alternative 2A has been assigned a "Somewhat Meets Criteria" rating.

Rating: Somewhat Meets Criteria

4.11.16 Impact on Operating and Maintenance Requirements and Procedures

Alternative 2A represents an enhanced design for physical leak detection (interstitial space with release detection piping system) and secondary containment with minimal impact to current operations as compared to the status quo. The upgrade results in minor impacts to the current operating and maintenance requirements and procedures. This alternative includes the present day operational efforts conducted to operate and maintain the Red Hill facility with additional requirements for the built-in release detection system. A total of 18 tanks have been included in the routine operational procedures and basic operator level maintenance for more than a decade, but this alternative would require two additional tanks (utilization of current out of service Tanks 1 and 19) to make up the much of the volume loss by creating the interstitial spaces and the loss of the storage volume use of the upper dome. Therefore, the oversight of the facility is operationally affected and may require a minimal increase in manning and materials for proper operations and maintenance.

Operating and maintaining a UST facility is significantly less intensive than an AST facility. For Red Hill specifically, the manning for operations and maintenance is minimal due to the high level of automation associated with the facility's systems and the inherent design of the structures. The operator level maintenance of the physical tanks is centered around the skin valves, ventilation systems and bottom water draw off. There are currently no requirements for fire protection systems on USTs. The unique design of these new composite USTs maintains the present-day conditions that negates the need for Cathodic Protection systems.

Standard Operating Procedures currently written for the Red Hill tanks would largely remain in place and require specific updates on operations and maintenance of the newly installed release detection system. Each tank leak detection zones will have individual conveying piping to the single detection chamber in the Lower Tunnel. This chamber will have a conventional sensor (pressure, liquid sensing, or float) that would detect fluids. The operation and maintenance of such sensors is very minimal, requiring periodic proof of operability testing and rare replacement if not functioning. The signaling of a leak detection alarm most likely will piggy back on the present fiber optics system used for inventory. A specific protocol with tailored response procedures would be developed to detail the necessary steps to be taken should the presence of any fluid be detected in the RDS as per the requirements stipulated in the AOC.

Overall requirements include physical patrols and/or automated means/systems of monitoring the interstitial spaces and reporting systems as well as specific tailored response procedures if a fluid is detected.

We suggest that the significant elimination of annual tightness testing, outsource expense and local labor support requirements will offset any minor increase in routine maintenance to manage/monitor the secondary containment interstitial leak detection system and additional operational tanks, thus assigning the attribute a "Meets Criteria" rating.

In the event the results of the Red Hill AOC SOW Section 4.0, Release Detection/ Tank Tightness Testing, results in an increase in requirements or procedures, this rating may need to be revisited.

Rating: Meets Criteria

4.11.17 Tank Upgrade Construction Cost Estimate (Planning Level)

This attribute provides stakeholders with pertinent information on overall construction execution cost, for the number of total tanks in a given upgrade alternative. These estimates are derived by compiling the projected cost for one tank constructed as a part of multiple tank repair contracts. The single tank cost is then used to develop the cost of each group of tanks, escalated to the midpoint of construction of each group of tanks. Government costs, design costs, construction contingencies, and Title II costs are not included. These estimates are for the physical tank upgrade portion of the overall project and do not include any electronic, volumetric / mass measurement type release detection system or fiber optic communication system.

Details of the explicit cost derivation for each TUA presented in PART I - Cost Estimates. The cost of Alternative 2A is estimated to be [redacted] per tank NPV. Note that with Alternative 2A, a total of 20 tanks are required to meet storage needs, as compared to 18 tanks with the Alternative 1A, 1B, and 1D.

This attribute is for informational purposes, no ratings are applied.

Rating: Not Rated

4.11.18 Tank Upgrade Duration

Upgrade duration is determined as an estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). For rating purposes, the Navy designated the baseline for each upgrade cycle as **three** tanks undergoing upgrade at a time utilizing two 10-hour shifts per day for six days a week.

Any TUA that cannot meet the Red Hill AOC SOW deadline for compliance without changing any of these parameters will receive a rating commensurate with the level of change. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one parameter as the determining rating factor for any TUA not meeting compliance with the above stated parameters. However, with the overarching mandate to maintain at least 15 tanks in service at all times during upgrade execution, the tanks per cycle variant is capped at five tanks per cycle and other parameters would require adjustment accordingly.

PART G - Construction Execution Considerations, provides the details by which the project execution duration conclusions were estimated.

The specific tank and cycle times for Alternative 2A upgrades, inclusive of all contingency factors, are estimated at 1.1 years per tank or 3.2 effective years per **four**-tank cycle. Taking all contingency factors into consideration, the estimated compliance date for all in-service tanks to be upgraded via the Alternative 2A concept is 2034.4. The project duration is approximately 21.6 years with a project completion date of 2040.1.

Rating: Mostly Meets Criteria

5.0 ALTERNATIVE 2B - COMPOSITE TANK (DOUBLE WALL) DUPLEX STAINLESS STEEL

5.1 General Description

Alternative 2B is same as Alternative 2A except uses 3/16-inch thick duplex stainless steel as the primary tank liner instead of a 1/4-inch thick carbon steel liner and eliminates the need to coat the primary steel liner. Refer to more detailed discussion and graphics under the Alternative 2A section for details.

The concept results in a double wall tank with interstitial shell and floor, with an interstitial space leak detection system with piping to the lower access tunnel. All piping to the tank will be double wall through the concrete plug below the tank.

5.2 Attributes

The following discusses whether/how Alternative 2B meets the criteria for each attribute as defined in the attribute definition and EEI's rating of the Alternative for each attribute.

5.2.1 Constructible

Alternative 2B can be constructed in field at Red Hill using practicable construction means and methods. Alternative 2B creates a double wall tank with secondary containment and integral release detection. The lower dome and barrel will have a double wall. The upper dome will be inspected and repaired to prevent infiltration of groundwater. The greatest challenge for construction is logistics and restrictions working at Red Hill, inside the fuel storage facility and inside the tanks.

Alternative 2B will follow standard industry tank and structural steel inspection and erection techniques, similar to Alternative 2A. The design consists of providing a 3/16-inch thick duplex stainless-steel liner inside the tank supported by structural steel angles welded to the existing steel liner. This new steel liner is the primary tank envelope and is separated from the existing steel liner by steel angles to create a 3-inch wide interstitial space for release detection. The interstitial space is filled with self-leveling concrete or non-shrink grout to resist fluid pressure from tank contents. As stainless-steel is corrosion resistant, the product side of the primary steel liner will not be coated as required for Alternative 2A.

The existing steel liner will be inspected and repaired prior to being re-designated as secondary containment and will not be coated. Repairs to existing steel liner is nearly identical to the efforts conducted to inspect and repair the Red Hill tanks over the last 13 years.[10] A total of 6

[10] See Final TIRM report dated OCT 2016, ¶1-3.9 to ¶1-3.14 for documentation on the recent efforts to inspect and repair tanks, with full shell surface and weld scanning. Prior efforts did not include full shell scanning.
[10] See Final TIRM report dated OCT 2016 for documentation on original tank construction

tanks (2, 5, 6, 15, 16, 20) have gone through a cleaning, inspecting (including shell/weld scanning), repair, bottom dome recoating, and return to service.

The commonality and differences between Alternatives 1 and 2, are used to evaluate constructability as follows:

- Baseline integrity inspection of the interior surfaces of the existing tank, and repairs as may be required. Essentially the same as Alternative 1, except in the case of Alternative 2, the existing shell and lower dome are the outside "skin" of the interstitial secondary containment barrier, and is relied upon to support the new liner.
- Boring thru the lower dome, to the Lower Tunnel, so that new, double wall pipe nozzle(s) can be installed so that the primary pipe, is surrounded by a secondary containment casing. The interstitial space created then can be monitored for leakage from the carrier pipe. This has been accomplished in Red Hill, for 3 tanks (5, 6, and 12), for installation of larger tell-tale systems.[11] In the case of Alternative 2B, the carrier pipe would be stainless steel, to match the tank liner.
- Construction of a new liner and concrete filled interstice, with leak detection piping to Lower Tunnel:
  - ➢ There are similarities to the current DoD Standard Design for Cut and Cover tanks, see Appendix H for additional discussion. However, the standard design generally is applied to tanks less than 40 feet tall, and the Red Hill barrels are 150 feet tall.
  - ➢ The Composite approach to relining an older "mined" style steel lined concrete tank has been applied to the NAVSUP FLC Yokosuka Hakozaki terminal tanks in Japan. Tanks 101, 103, 104, 107, 108, 109, 112 and 113, constructed circa 1930s, were a nominal 120 feet diameter, 100 feet tall. The original riveted shell received a new carbon steel liner, 0.177 inches thick, with a concrete infill. The created interstitial space has leak detection capability, terminating at a sample point in the tunnel below the tank floor level. These tank repairs have performed well, have undergone Integrity Inspections over the last 10 years, and have a long useful remaining life for DoD fuel storage. Refer to Appendix H for further discussion on the tank design, operation of the leak detection system, and other relevant information.
  - ➢ The difference between the carbon steel liner in Alternative 2A, and duplex stainless-steel liner in 2B is primarily center around the welding process for liner installation. However, we do not feel that is a significant factor as duplex stainless-steel tankage with welded fabrication is a common industrial requirement. The contractor will need to provide specialized welding procedures for the stainless to carbon welding that minimizes corrosion potentials. This again, however, is a common industrial practice.

[11] See Appendix BF of the TIRM for documentation.

- Power for construction of this Alternative will be based upon the direct contractor connection to the HECO power system. Refinement of power distribution, i.e., using cable/conduit in the tunnels, or direct boring from the top of the Red Hill ridge are considered construction and means refinements best left to the individual contractor's discretion.
- The movement, placement and welding of the liner support structure and actual liner present a considerable challenge. EEI believes the present contractor for the CIR of 5 tanks has established a viable method. For the tank inspection and repair, a monorail trolley beam has been erected within the tank just below the expansion joint. A minimum of two, and easily adapted to up to four or more suspended platforms are being installed for workers to have full access to the shell, making inspection and repair efficient. For Alternative 2B, EEI believes installation of two concentric monorails would simplify construction. The outermost ring would be used for material movement. Steel structural members of manageable prefabricated dimensions would be brought into the tank through the Upper Tunnel, and transferred to the material handling trolley. The steel members would then be moved and lowered into position for welding to the existing shell. The steel liner plates would similarly be moved into the tank and maneuvered into position for welding.
- Welding of the steel support system would most likely use manual welding methods, although application of semi-automated welding equipment is considered feasible. The welding of the plates would most likely be with automated welding equipment commonly used on the erection of industrial process storage tanks.
- Filling the interstitial space with concrete of non-shrink grout presents a challenge in material movement. One method EEI believes to be practical is to bore an access from the top of the Red Hill ridge into the upper dome (approximately 100-150 ft. to the top of the tank). Other methods under consideration include concrete pumping systems, which has been used before for tunnel repairs.

As to the infrastructure of Red Hill, the lack of sufficient power was eliminated by contractors starting the project with temporary generators while they construct a power service entrance directly connected to Hawaii Electric Company (HECO). Other features such as overall tunnel ventilation has not presented any difficulties.

Although the majority of items addressed above would indicate that this alternative is fairly conventional, the lack of a demonstrable successful use of a stainless-steel liner welded to a carbon steel frame results in EEI determining that Alternative 2B should be assigned a "Mostly Does Not Meet Criteria" rating. The most significant item is welding and corrosion potential concerns with stainless steel in contact with the carbon steel structure.

Rating: Mostly Does Not Meet Criteria

5.2.2 Testable

To determine if an Alternative can be shown to meet hydraulic and structural integrity standards prior to being place into service, this attribute defines the basic litmus test for acceptability during construction prior to filling and during startup/commissioning when filling. This macro approach to testability focuses on the industry standard practices for testing the material, joints, welds, etc. used in repair/construction of steel tanks. This attribute also examines the ability of whether an alternative can be tested for integrity during construction prior to being filled. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 13 – Commissioning and Testing Procedures was developed to demonstrate the degree of rigor required for the testing and commissioning procedures necessary to place the tank repair/upgrade in service and includes the details of that process in the criteria established for that attribute.

In that Alternative 2B results in a double wall UST, all applicable construction practices for USTs can be tested as dictated by applicable industry standards. In addition to the Navy's protocol for inventory monitoring and trend analysis required by their tank commissioning procedures, the interstitial space between the exterior and interior shells and bottom can be monitored visually by checking the leak detection chamber, and with an automated alarm liquid sensor in the leak detection chamber, to ensure hydraulic integrity.

Alternative 2B meets the criteria for testable during construction and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

5.2.3 Inspectable

To determine if an Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service, this attribute defines criteria as to whether a tank upgrade is inspectable. This attribute focuses on the industry standard practices for inspection during construction. Attribute 14 (TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade) and Attribute 15 (TIRM Requirements for Future Integrity Inspections) were developed to demonstrate the degree of rigor required to develop a TIRM using industry standard inspection techniques for the inspection procedures necessary to place the tank repair/upgrade in service and includes the details of those criterion as established for the respective attributes.

For Alternative 2B, the interior of the primary shell (hydraulic boundary) can be inspected and rejectable indications repaired, resulting in the issue of a Suitability for Service testament as determined by the tank's ability to meet structural and hydraulic integrity standards.

Alternative 2B meets the criteria of this attribute and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

5.2.4 Repairable

While most bulk tank systems are repairable to some degree, various levels of effort can be undertaken to effect similar repairs. These levels of effort are factored into the rating of the ability to effect repairs for each alternative considered. The basis for this attribute centers around the aspects of capabilities for on-site repairs using standard/traditional construction/repair means and methods.

Using the status quo efforts as a gauge, removal or modification of the Red Hill infrastructure is not required to gain access to the tank liner, all interior surfaces of the primary tank liner, tank nozzles, and internal components are accessible for repair, and all repairs can be performed from inside the tank without having to remove part of the primary tank or internal component to access an area for repair.

While the mechanisms for effecting any repairs in these Red Hill tanks are quite unique and complex, they have been used for many years and innovations/improvements are being incorporated into the standards with each successive repair effort. All actions are well within the norm of repair method considerations, are feasible to execute, and require no special equipment that render these options unreasonable.

Repair of the existing steel liner after new primary steel liner plates are installed is possible but would require removing the primary steel liner and concrete/grout fill in the interstitial space, locating the breach in the existing steel liner, repairing the existing steel liner, and re-installing the primary steel liner at the repair area and filling the interstitial space with concrete or grout.

For the primary shell of the Alternative 2B concept, the level of effort is representative of the status quo plus the elements of repair associated with the stainless-steel material. Since only interior surfaces of the primary tank and internal components are accessible for repair and can only be performed from inside the primary tank and repairs to the secondary containment would require removal of part of the primary tank or component to access an area for repair to portions of the tank system, Alternative 2B has been assigned a “Somewhat Meets Criteria” rating.

Rating: Somewhat Meets Criteria

5.2.5 Practicable

This attribute rates the degree to which an alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters. Given the complexities and interactive dependencies of multiple attributes and their associated importance among stakeholders, this attribute is used to combine several factors to provide a cost/benefit basis for the decision makers.

The three major determinable factors are:

- The extent of the impact/modification to the Red Hill infrastructure or physical arrangement as determined in Attribute 1,
- The cost per tank depicted in the cost analysis associated with Attribute 17 as compared to the current CIR estimates of $7.5M per tank, and
- The ability to complete the upgrades by the mandated timeframe set by the Red Hill AOC SOW as derived from the duration modeling for Attribute 18.

As with Alternative 2A, Alternative 2B can be constructed within the confines of Red Hill, but it will have "extensive" impact/modification to the Red Hill infrastructure or physical arrangement. Fabricating a second shell within the original shell to form a double wall tank with interstitial space for monitoring is a formidable undertaking. Using stainless-steel in lieu of carbon steel for this new primary shell will have cost and potentially schedule impacts due to the specialty nature of working with this material on such a large scale. In addition, the design element of this alternative and volume reduction aspects that necessitate the need for 20 tanks vice the current 18, is expressively more impactful to timing and overall program cost than any of the single wall alternatives.

The construction cost of this alternative is estimated to be [redacted] per tank and falls within the 1000% to 2000% range. The duration modeling data indicates that all tank work is expected to be completed within the compliance timeframe set by the Red Hill AOC SOW using a four-tank upgrade cycle execution strategy.

Due to the level of infrastructure impact, measurable cost increase and necessity for a greater than three-tank execution strategy, Alternative 2B has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

5.2.6 Corrosion Damage Mechanism

Alternative 2B has a stainless steel liner on the lower dome and barrel, and has a coating applied to the upper dome, both of which are an enhancement over the current practice for all Red Hill tank repairs. This alternative has new tank nozzle piping as well.

There is, however, an element of risk associated with welding the new steel liner support angles to the existing carbon steel liner, and a risk of welding the stainless steel liner to the carbon steel structure. Refer to additional discussion in Red Hill AOC Section 2.2 TIRM Report, Chapter 17, for expansion on the new to old steel welding concerns.

Alternative 2B has been assigned a "Somewhat Meets Criteria" rating, as although the tank is stainless steel, the difficulty in assuring a corrosion free environment on the interstitial space at the new to old steel welding and stainless steel to carbon steel welding results in a reduction of the rating.

Rating: Somewhat Meets Criteria

5.2.7 Successful Implementation Elsewhere

Composite tanks (double wall), where an original concrete cut and cover tanks with single wall carbon steel liners has been modified for secondary containment with new carbon steel primary liners with interstitial spaces, are currently in operation at other large fuel depots such as Hakozaki in Japan. When constructed and maintained properly they have been very successful in preventing and detecting leaks. The addition of secondary containment coupled with physical leak detection/capture devices specifically allows this design to detect leaks without the use of internal, electronic sensing mechanisms. However, all these tanks use a carbon steel liner. EEI is not aware of any composite style tank retrofit with stainless steel liner elsewhere. A stainless steel cut and cover tank was erected inside of a concrete cut and cover tank at Guantanamo Bay, Cuba. This tank, however, was freestanding, and did not use the original concrete tank for anything more than secondary containment.

The differences in use of a stainless steel liner versus a carbon steel liner are few, and are centered around welding technology, and corrosion, as discussed in Attribute 6.

Since the Alternative 2B concept has not been used at other large fuels depots, this alternative has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Does Not Meet Criteria

5.2.8 Reliability

For all TUAs being analyzed, reliability is defined as the measure of a tank's ability to perform its required function under stated conditions for a specified period (i.e. level of confidence). The rudimentary functional requirement of most any storage tank is to maintain hydraulic integrity and prevent the contained product from unintentionally exiting the vessel. The stated conditions are the manner and environment in which the storage tank is operated and maintained. The specified period is the designated interval of uninterrupted operations, i.e. the next out-of-service internal inspection.

Each alternative relies on a steel shell as its primary hydraulic boundary. In all cases, the integrity of the primary shell is designed to meet the definition of reliability as stated above. While a certain amount of variability may be introduced in the type of steel used, coatings applied, and construction techniques, these elements drive the different concepts into various levels of confidence above and beyond the qualifications of basic reliability.

With regards to system reliability, considering alternatives with enhancements that include secondary containment extends beyond the discussion of reliability of the primary tank shell and move towards the reliability of the tank system to minimize the extent of the effects stemming from a failure in the primary shell. Those added enhancements are addressed in other attributes within this document and the merits of the different systems are detailed with multiple factors beyond the limits of this attribute, which specifically targets the reliability of the primary shell to perform as designed.

In that Alternative 2B would be constructed in accordance to proven industry standards for double wall steel tanks encased in concrete, it can be relied upon to perform its required function under the stated conditions until, at a minimum, the next inspection interval and thus has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

5.2.9 Impact on Storage Volume

Alternative 2B provides for fuel storage in the lower dome and tank barrel up to 2 feet below the expansion joint at the top of the barrel (elevation of 188 ft. - 5 in.). Alternative 2B does not provide for fuel storage in the barrel extension (Tank 5-20) or upper dome; thus, there is a reduction in storage volume compared to the existing tanks. The reduction in storage volumes are different between Tanks 2-4 and Tanks 5-18 and 20 due to a 12-feet tall barrel extension in Tanks 5-18 and 20 that is currently used for storage. The container volume is limited to the height of the double wall portion of the shell. The 3-inch wide interstitial space in the barrel and lower dome also results in storage volume reduction. However, the out of service tanks (1 and 19) can be inspected, repaired and upgraded for return to service and added to the overall system volume to mitigate the net volume change.

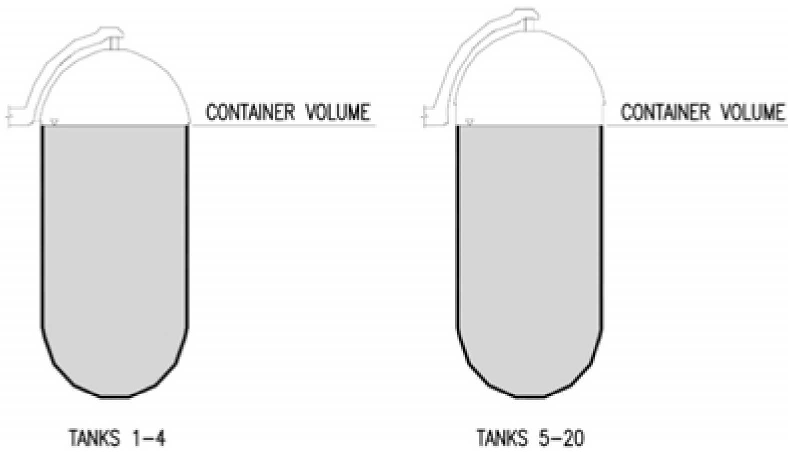

Figure E-5.0-1 TUA 2B Composite Tank Container Volume

Shaded area indicates volume of product in tank

The reduction in container volume compared to the existing tanks are as follows:

- Existing container volume (see Alt 1A graphic):
  - Tanks 2 to 4: 285,148 Bbls (238'-6" tall)
  - Tanks 5 to 18 and 20: 301,934 Bbls (250'-6" tall)
  - Tanks 1 and 19: Out of Service
  - System (Tanks 2-18 and 20): 5,384,454 Bbls
- Container volume after Alternative 2B upgrade:
  - Individual container: 236,263 Bbls
  - System (Tanks 1-20): 4,725,260 Bbls
- Change in container volume after Alternative 2B upgrade:
  - Tanks 2 to 4: 48,885 Bbl reduction per tank (17.1% reduction)
  - Tanks 5 to 18 and 20: 65,671 Bbl reduction per tank (21.8% reduction)

- Tank 1 and 19: 236,263 Bbl increase per tank (currently out of service)
- System (Tanks 1-20) 659,194 Bbl net reduction (12.2% net reduction)

Note that the container volume represents maximum volume. Working storage volumes are less to accommodate safety, liquid expansion from temperature change, regulatory limitations, etc. Tanks 1 and 19 have been formally "taken out of service" under Hawaii DOH rules. Restoration of the tanks for return to service will require an unknown environmental/permitting effort.

Conclusion: Alternative 2B results in a reduction of storage volume compared to existing tanks. The overall system volume results in a 12.2% reduction.

Rating: Not Rated

5.2.10 Provides Secondary Containment

Alternative 2B provides a double wall interstitial space on the barrel and lower dome effectively making this alternative a double wall tank. The existing steel liner on the barrel and lower dome provides secondary containment. This alternative consists of providing a new 3/16-inch thick stainless steel liner on the lower dome and barrel of the existing tank. The new steel liner is separated from the existing steel liner by steel angles or tees welded to the existing steel liner to create an interstitial space filled with concrete or mom-shrink grout. The interstitial space provides a means for leak detection.

As this alternative relies on the integrity of the existing steel liner for secondary containment, the steel liner and welds of the barrel and lower dome of the existing tank need to be 100% scanned for thinning due to corrosion and rejectable indications in welds and repaired.

Alternative 2B complies with secondary containment as promulgated by 40 CFR 280, thus an alternative means of regulatory compliance is not required. Secondary containment concepts include inherent release detection barrier and release detection capability outside of the primary barrier (tank shell). This alternative also includes an integral release detection system that is part of the tank upgrade construction. Release detection is provided by secondary containment interstitial space zoned by shell area and piped by gravity to a sensor chamber in the lower tunnel. Release detection sensors in the sensor chamber provide direct measurement/indication of a release. This provides dynamic full-time release detection with sensors transmitting an alarm to the central location.

This alternative includes replacing existing concrete encased piping from the tank to the first valve outside tank with double wall construction tank nozzles. The interstitial space will be a zone of the leak detection system.

Upper dome would not receive a composite liner and thus will not be used for fuel storage; this results in a reduction in storage capacity.

Given the above information, the concept of Alternative 2B to provide secondary containment meets current EPA requirements specified by 40 CFR 280 criteria being an inner and outer barrier with an interstitial space that is monitored for leaks, a "Meets Criteria" rating has been assigned.

Rating: Meets Criteria

5.2.11 Dependency on Existing Tank Steel Liner Integrity

The original construction of the existing tanks was accomplished by excavating the lava rock formation of Red Hill to create a chamber for each tank which was then lined with reinforced concrete and a 1/4-inch thick carbon steel liner. Where corrosion of the steel liner may have occurred, it is detected and remedied during the tank inspection and repair process, restoring the liner to acceptable thickness. Nevertheless, when considering alternatives for the best available practicable technologies, a determination of the dependency on the existing tank liner (as repaired) integrity is prudent.

This attribute was developed to determine the level to which each alternative being evaluated depends on the original steel liner for hydraulic integrity to contain product (primary tank) or provide a barrier between a breach of the primary tank liner and the environment (i.e. interstitial space boundary, or dike wall/floor secondary containment boundary). For evaluation purposes, the rating system used is oriented towards a higher rating for the least amount of dependency on the existing liner.

Alternative 2B constructs a new primary stainless-steel liner and uses the existing carbon steel liner as secondary containment creating an interstitial space on the barrel and the bottom. Therefore, while it does not rely on the hydraulic integrity of the existing repaired tank liner to contain product, it does depend on the existing tank liner to serve as the outer barrier of an interstitial space or as secondary containment.

Because the existing liner cannot be inspected, it is suggested that the criteria for corrosion assessment be changed to a longer duration, as discussed in the TIRM attribute. However, there is a possibility that some corrosion on the existing liner, within the interstitial space, may occur under certain conditions, such as moisture introduction through the interstitial monitoring system. As such, Alternative 2B has been assigned a "Mostly Meets Criteria" rating

Rating: Mostly Meets Criteria

5.2.12 Release Detection Integral to Tank Construction

This attribute defines whether an Alternative has release detection capability that is integral to (i.e. is part of) the upgrade construction such as an interstitial space with monitoring.

Alternative 2B has a release detection system that is integral to the tank that includes a secondary containment with an interstitial monitoring system. As Alternative 2B has monitoring of the interstitial space, other methods of release detection identified in 40 CFR 280 are not required. Special technology is not required for release detection other than sensors in the release detection chamber in the Lower Tunnel. This alternative has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

5.2.13 Testing and Commissioning Procedures

This attribute is aimed at determining the level of rigor necessary for testing and commissioning procedures required to return the tank to service after repair/upgrade. These procedures are based on the final verifications prior to filling, and considerers the different methods available to monitor the tank for hydraulic or structural failure during and/or immediately after filling.

"Returning the tank to service" includes actions necessary to prepare the tank for the first filling with fuel, performing commissioning steps, determining the tank repair was successful, and determining the tank to be liquid tight and suitable for returning the tank to service.

In accordance with the NAVFAC Naval Engineering Training and Operating Procedures and Standards (NETOPS) 34 and the NAVSUP GLS Instruction 10345.1 (3), coordination and proper review of the following elements is mandatory prior to a transfer of custody of the tank back to the operator:

- A statement signed by an appropriately certified API 653 tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service. The statement shall include due dates for the next applicable formal inspections (internal, external, and leak test) and any repairs required prior to those next inspections. Next inspection due dates shall be the maximum allowable by API 653 code. The normal interval under API 653 for a new tank is 10 years, based on the corrosion rates are not yet known. However, API 653, ¶6.4.2.1.1 permits a longer period by meeting certain characteristics in Table 6.1. The API table permits an additional 10 years before the first inspection if there is a release detection barrier. The lower dome and barrel interstitial space with monitoring system qualifies under this provision. Thus, the next inspection interval for Alternative 2B tanks can be as long as 20 years from the time the tank shell/liner is installed. NAVSUP guidance is no more than 20 years. EEI believes this approach is consistent with Chapter 19 in the Red Hill SOW Section 2.2 TIRM Report.
- The Statement shall also note that as a final test, the tank shall be given a 3rd party certified leak test upon reaching its first full height liquid fill, is required by NAVSUP policy.
- A completed inspection report including all required calculations and analysis. Preliminary or field reports cannot be substituted for this requirement.
- A list of repairs identified during inspection, including completed repairs and repairs that are still pending. All pending repairs shall be annotated with a due date.
- Third-party certified calibration ("strapping") charts when a tank is first placed in service when certified calibration charts did not previously exist, or when repairs were made that would be reasonably expected to change the tank's calibration.
- A statement signed by agents of the Execution/Construction Agent and repair contractor that custody of the tank is returned to the activity and that the above items have been provided to the operator.

Once the tank has been declared suitable to receive product, the filling protocols must be authorized by the commanding officer. These protocols, required by NAVSUP mandate, are drafted specifically for the type of tank being filled and verified by SMEs at the NAVSUP Energy Office. The operators will then develop a tank specific operations order in accordance with the above stated protocol and mandate. This specific operations order, reviewed and approved by the commanding officer, will consider the unique requirements associated with the tank being filled. Mandatory elements include:

- Tank filling procedures with appropriately defined incremental fill levels and hold times;
- Physical inspection, gauging, and trend analysis as appropriate upon reaching each incremental fill level; and
- Emergency drain-down plan in the event the tank needs to be emptied, including specific triggers as to when the drain-down plan should be activated.

The development and implementation of this operations order is predicated on the parameters presented by the specifics of the tank being filled. Other factors taken into considerations include:

- Ability to continuously visually monitor the shell and/or floor surfaces for a breach of hydraulic integrity or evidence of structural failure;
- Ability of the shell and/or floor that cannot be directly visually monitored, to be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping);
- Ability of the installed tank inventory control system to reasonably determine unacceptable variances during tank filling when performed using the requisite number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity when the tank does not have a shell or floor secondary containment system with release detection piping that can be continuously monitored for hydraulic integrity; and/or
- Ability to conduct a final hydraulic integrity test to meet the approved tank tightness testing requirements prior to placing the tank in routine operations.

Alternative 2B includes a shell and bottom interstitial space with release detection piping, that can be continuously monitored for hydraulic integrity. Therefore, tank filling would include physical inspection (visual monitoring of these release detection systems) in addition to using the applicably determined number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using the tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.5 may be required prior to turning the tank over to the operator for routine operations. Therefore, Alternative 2B has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

5.2.14 TIRM Requirements for Inspection of Existing Tank prior to application of Tank Upgrade

Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document specifies the level of inspection and repair necessary for the current tanks in service at Red Hill, by cross referencing to the Red Hill AOC SOW Section 2.2 TIRM Report. Each of the alternatives require varying degrees of inspection and repair criteria as compared to the TIRM specifications (for existing tank inspections) published in Red Hill AOC SOW Section 2.2 TIRM Report, Appendix BE, UFGS Specification SECTION 33 56 17.00 20 INSPECTION OF FUEL STORAGE TANKS and Appendix BD, SECTION 33 56 18.00 20 REPAIR OF FUEL STORAGE TANKS.

Centering on the level of dependency each TUA has on the integrity of existing shell/dome, considerations are given to the level and type of inspection and repair of the existing tank structure, liner and nozzles. If there is no dependency on the existing shell or dome, a visual inspection of the existing tank structure (such as embedded angles that support the steel liner) is the primary requirement to meet criteria. With limited dependence on the integrity of the existing shell/dome, inspection of the existing tank steel liner and tank nozzles following industry standards would be required, consisting of visual inspection and ultrasonic examination at spot locations with repair of rejectable indications identified being limited to the repair of existing welds and isolated areas of the steel liner.

As the reliance on the integrity of the existing shell increases, the ability to access the original liner for inspection and repair becomes paramount to meeting criteria. The ideal situation would include unfettered access for inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of all rejectable indications identified. However, if an alternative relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, it would result in a less favorable scoring in meeting the requirements of this criteria.

If an alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report or Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document, it would fully meet the criteria of this attribute as the rating system used is oriented towards a higher rating meeting the TIRM Report, and a lower rating for larger departures from the TIRM Report.

While Alternative 2B adds a new liner made of stainless-steel which requires specific inspection and repair efforts, it would still require inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) plus pressure testing of tank nozzles and repair of rejectable indications identified prior to installation of the new liner.

In that Alternative 2B relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, the level of repairs would have to be such that they would be effective to the greatest length of time possible vice just to the next inspection interval. Given these stated conditions, Alternative 2B has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

5.2.15 TIRM Requirements for Future Integrity Inspections

Red Hill AOC SOW Section 2.0 states that the purpose of the TIRM report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/Hawaii DOH in the Red Hill AOC SOW for future integrity inspections at Red Hill. It is important that the processes of the future inspection, repair, and maintenance of the Red Hill tanks are well defined to ensure that the goal of keeping the tanks permanently leak-free going forward can be met going forward. The report examines the pros and cons of past, current, and emerging means and methods for work on the tanks to provide the basis for decisions on a strategy that can best achieve the goal of leak-free tanks.

To meet the conditions of Red Hill AOC Section 2.0, each alternative has been rated to determine the level of rigor necessary to conduct future integrity inspections and/or the access provisions required to complete the mandatory inspections and properly maintain the system. The basis for determination of ratings for each alternative examine the ability to competently inspect visually all shell and roof (dome) surfaces and welds from inside or outside the tank, and floor welds and steel liner from inside the tank and with conventional floor scanning equipment, all following traditional integrity investigation protocol outlined in API 653.

As alternative designs prove to be less accessible or require special procedures for access to all surfaces and welds be competently inspected visually or require departure from standard methods for traditional integrity investigation protocols outlined in API 653, the rating declines. Rating continues to decline for primary shells, including upper dome, barrel and lower dome welds and liner, that require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces. An alternative that is incapable of undergoing integrity inspections of any kind will fail to meet this criterion.

Alternative 2B adds a new stainless-steel composite liner over the original steel liner. In this configuration, the existing steel liner in the upper dome and the new tank shell and lower dome welds and interior surfaces must be inspected from inside the tank visually and with modified conventional equipment and procedures that follow traditional integrity investigation protocols outlined in API 653. For this composite (double wall) tank design, access to all surfaces would require special procedures. Therefore, Alternative 2B has been assigned a "Somewhat Meets Criteria" rating.

Rating: Somewhat Meets Criteria

5.2.16 Impact on Operating and Maintenance Requirements and Procedures

Alternative 2B represents an enhanced design for physical leak detection (interstitial space with release detection piping) and secondary containment with minimal impact to current operations as compared to the status quo. The upgrade results in minor impacts to the current operating and maintenance requirements and procedures. This alternative includes the present day operational efforts conducted to operate and maintain the Red Hill facility with additional requirements for the built in tell-tale system. A total of 18 tanks have been included in the routine operational procedures and basic operator level maintenance for more than a decade, but this alternative would require two additional tanks (utilization of current out of service Tanks 1 and 19) to make up the volume loss by creating the interstitial spaces and the loss of the storage volume use of the upper dome. Therefore, the oversight of the facility is operationally affected and may require a minimal increase in manning and materials for proper operations and maintenance.

Operating and maintaining a UST facility is significantly less intensive than an AST facility. For Red Hill specifically, the manning for operations and maintenance is minimal due to the high level of automation associated with the facility's systems and the inherent design of the structures. The operator level maintenance of the physical tanks is centered around the skin valves, ventilation systems and bottom water draw off. There are currently no requirements for fire protection systems on USTs. The unique design of these new composite USTs maintains the present-day conditions that negates the need for Cathodic Protection systems.

In accordance with current federal regulations, annual tank tightness testing would not be required due to the installation of secondary containment as provided with this alternative. Therefore, facility operations would see a positive impact in the form of cost avoidance over the status quo options by saving several weeks of set up and testing each year. Additionally, this alternative would not require an upgraded inventory / leak detection system which would also save time and effort associated with these additional operational and maintenance requirements.

Standard Operating Procedures currently written for the Red Hill systems would largely remain in place and require specific updates on operations and maintenance of the newly installed release detection system. Each tank leak detection zones will have individual conveying piping to the single leak detection chamber in the Lower Tunnel. This chamber will have a conventional sensor (pressure, liquid sensing, or float) that would detect fluids. The operation and maintenance of such sensors is very minimal, requiring periodic proof of operability testing and rare replacement if not functioning. The signaling of a leak detection most likely will piggy back on the present fiber optics system used for inventory. A specific protocol with tailored response procedures would be developed to detail the necessary steps to be taken should the presence of any fluid be detected in the RDS as per the requirements stipulated in the AOC.

Overall requirements include physical patrols and/or automated means/systems of monitoring the interstitial spaces and reporting systems as well as specific tailored response procedures if a fluid is detected.

We suggest that the significant elimination of annual tightness testing, outsource expense and local labor support requirements will offset any minor increase in routine maintenance to manage/monitor the secondary containment interstitial leak detection system and additional operational tanks, thus assigning the attribute a "Meets Criteria" rating.

In the event the results of the Red Hill AOC SOW Section 4, Release Detection/ Tank Tightness Testing, results in an increase in requirements or procedures, this Rating may need to be revisited.

Rating: Meets Criteria

5.2.17 Tank Upgrade Construction Cost Estimate (Planning Level)

This attribute provides stakeholders with pertinent information on overall project execution cost, for the number of total tanks in a given upgrade alternative. These estimates are derived by compiling the projected cost for one tank constructed as a part of multiple tank repair contracts. The single tank cost is then used to develop the cost of each group of tanks, escalated to the midpoint of construction of each group of tanks. Government costs, design costs, construction contingencies, and Title II costs are not included. These estimates are for the physical tank upgrade portion of the overall project and do not include any electronic, volumetric / mass measurement type release detection system or fiber optic communication system.

Details of the cost derivation for each TUA is presented in PART I - Cost Estimates. The cost of Alternative 2B is estimated to be [redacted] per tank NPV. Note that with Alternative 2B, a total of 20 tanks are required to meet storage needs, as compared to 18 tanks with the Alternative 1A, 1B, and 1D.

This attribute is for informational purposes, no ratings are applied.

Rating: Not Rated

5.2.18 Tank Upgrade Duration

Upgrade duration is determined as an estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). For rating purposes, the Navy designated the baseline for each upgrade cycle as **three** tanks undergoing upgrade at a time utilizing two 10-hour shifts per day for six days a week.

Any TUA that cannot meet the Red Hill AOC SOW deadline for compliance without changing any of these parameters will receive a rating commensurate with the level of change. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one parameter as the determining rating factor for any TUA not meeting compliance with the above stated parameters. However, with the overarching mandate to maintain at least 15 tanks in service at all times during upgrade execution, the tanks per cycle variant is capped at five tanks per cycle and other parameters would require adjustment accordingly.

PART G - Construction Execution Considerations, provides the details by which the project execution duration conclusions were estimated.

The specific tank and cycle times for Alternative 2B upgrades, inclusive of all contingency factors, are estimated at 0.8 years per tank or 2.5 effective years per **four**-tank cycle. Taking all contingency factors into consideration, the estimated compliance date for all in-service tanks to be upgraded via the Alternative 2B concept is 2034.2. The project duration is approximately 18.3 years with a project completion date of 2036.8.

Rating: Mostly Meets Criteria

6.0 ALTERNATIVE 3A - TANK WITHIN A TANK (CARBON STEEL)

6.1 General Description

Alternative 3A involves constructing a 90’-0” diameter, carbon steel tank within the existing tanks. The new tank inside Tanks 1 to 4 will have a 150’-0’ shell height above the lower dome. As existing tanks 5 to 20 are 12 feet taller than Tanks 1 to 4, the new Tank inside Tanks 5 to 20 will have a 162’-0” shell height. The smaller diameter of the new tank compared to the existing tank provides a 5’-0” wide annular space around the tank that allows normal observation and periodic inspection of the exterior of the new tank shell and the existing steel liner on the barrel and upper dome of the present tank. The new tank will be designed in accordance with the applicable sections of API 650. The tank will be anchored and braced laterally with horizontal struts to the existing tank to resist rocking from seismic ground motion. The existing steel liner on the tank barrel and lower dome is inspected and repaired and becomes secondary containment barrier.

The interior of tank the will be coated with polysulfide modified epoxy novolac in accordance with UFGS 09 97 13.15 “Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks”. The exterior of the tank and the steel liner of the existing tank will be coated with a zinc-rich epoxy/epoxy coating in accordance with UFGS 09 97 13.27 “Exterior Coating of Steel Structures”.

Alternative 3A includes taking out of service the existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank and providing new nozzle piping within pipe sleeves (i.e. double wall construction), as they are considered an extension of the tank. Most likely they will require boring from inside the tank, to the lower access tunnel, a distance of approximately 45 feet.

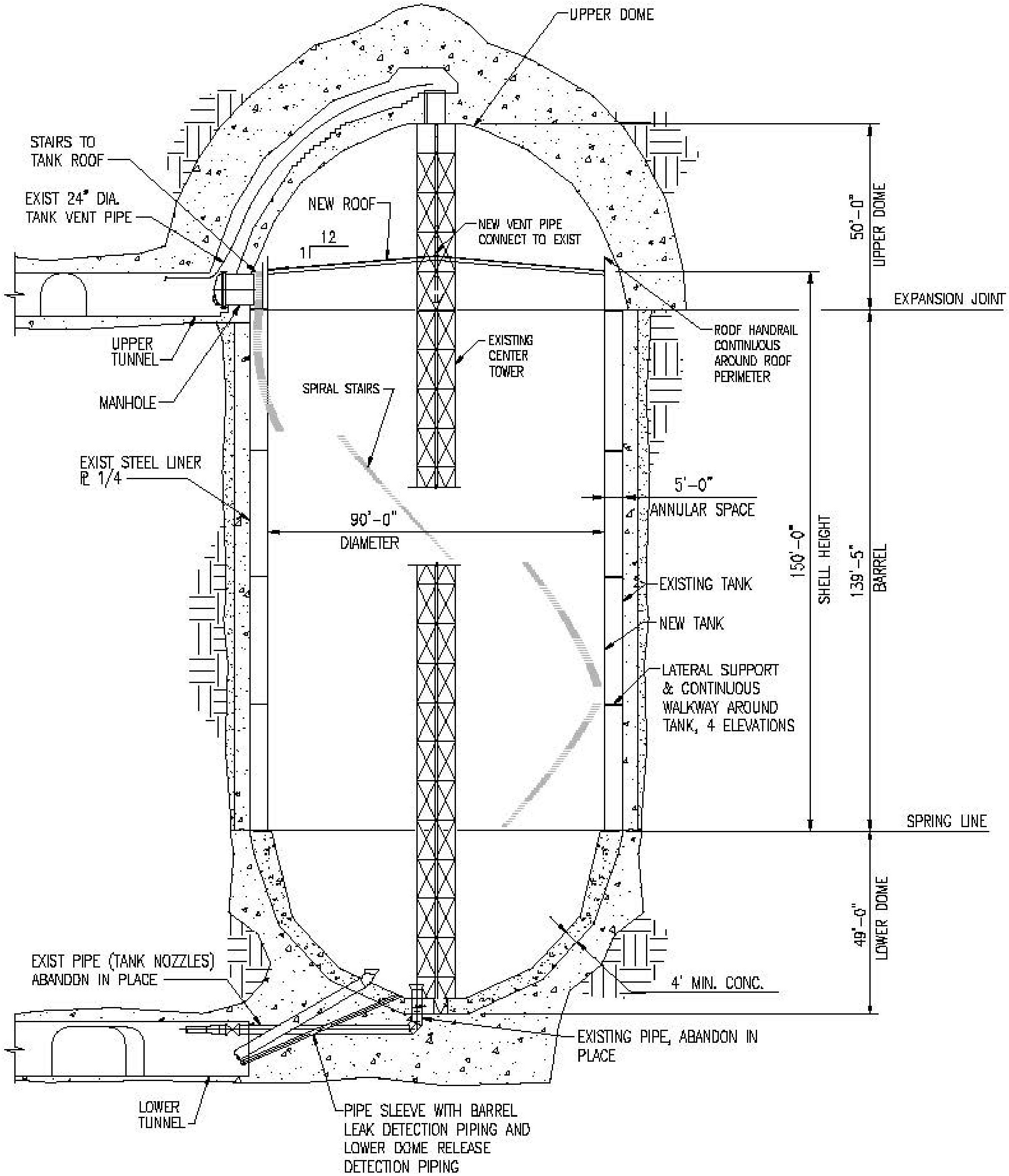

Figure E-6.0-1 TUA 3A Tank within a Tank - Tanks 1 - 4 Elevation

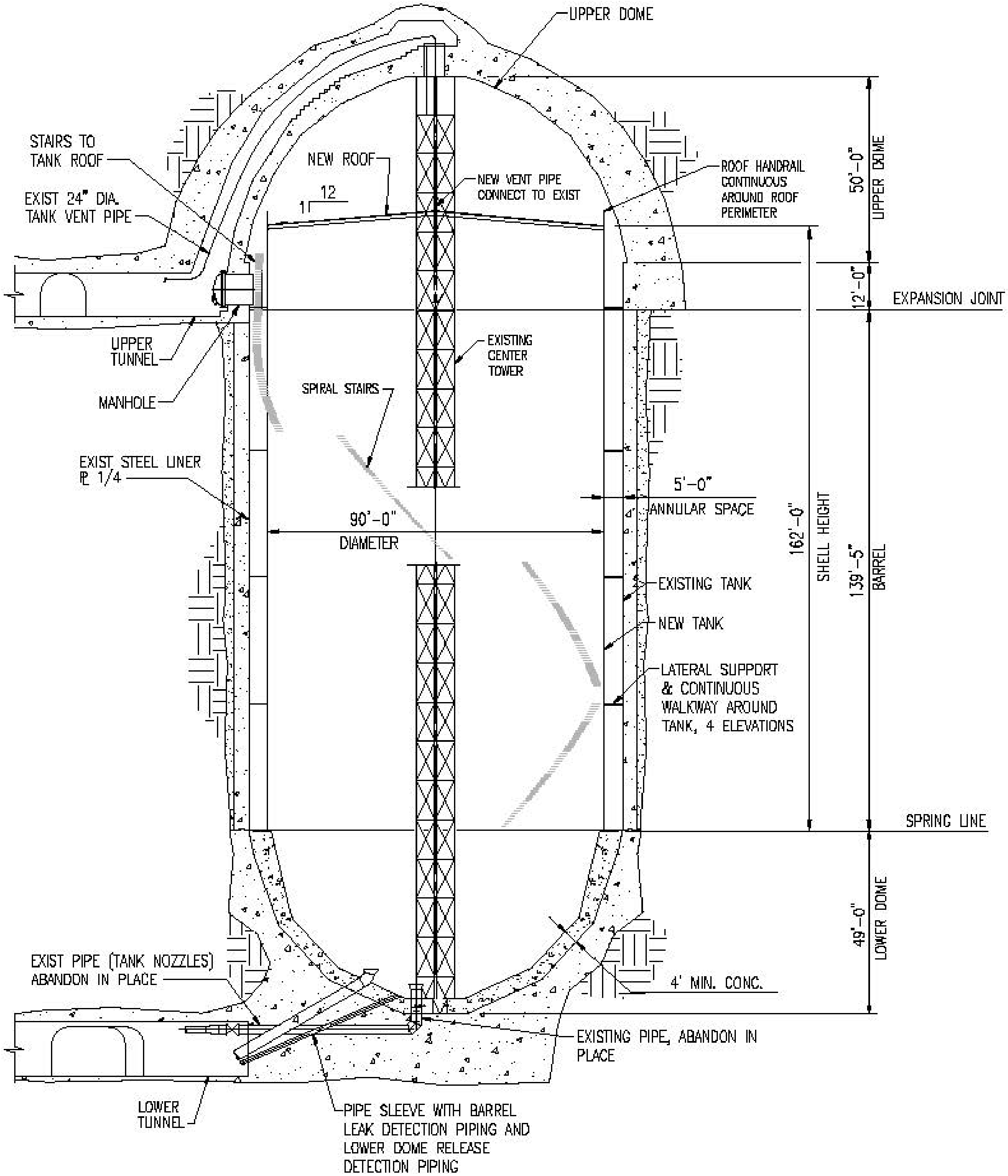

Figure E-6.0-2 TUA 3A Tank within a Tank - Tanks 5 - 20 Elevation

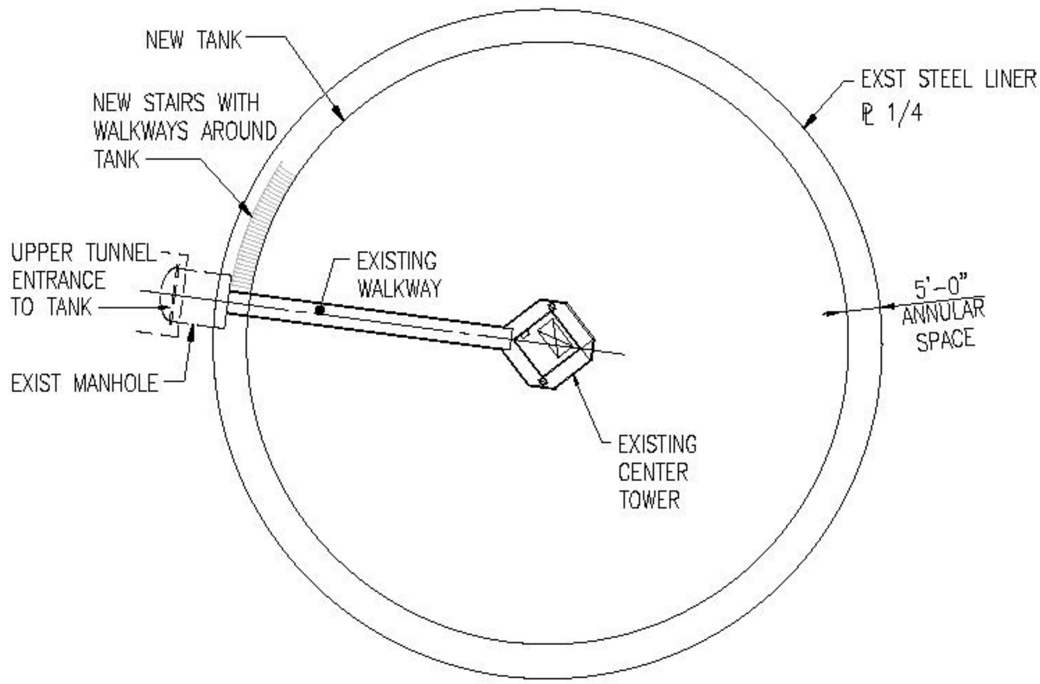

Figure E-6.0-3 TUA 3A Tank within a Tank Plan

6.2 Features of Alternative

This section summarizes the overall features of the specific alternative. See the following expanded sections with engineering discussions that support the descriptions and recommendations presented herein. Specific features of alternative 3A are summarized as:

- Inspection of the existing steel liner following requirements in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document. This document in turn, refers to materials developed under the Red Hill AOC SOW Section 2.2 TIRM Report. In the case of Alternative 3A, the procedures and repair thresholds will be adjusted to reflect the fact that the existing barrel will be used for secondary containment for the new tank and thus will be visible/accessible in the future during tank integrity inspections.
- 5-feet wide annular space between the tank and existing tank.
- Tank anchored to resist overturning from seismic ground motion and braced against lateral movement and overturning from seismic ground motion with horizontal struts.
- Self-supported fixed cone roof with a vent pipe connected to the existing tank vent pipe at the top of the upper dome.

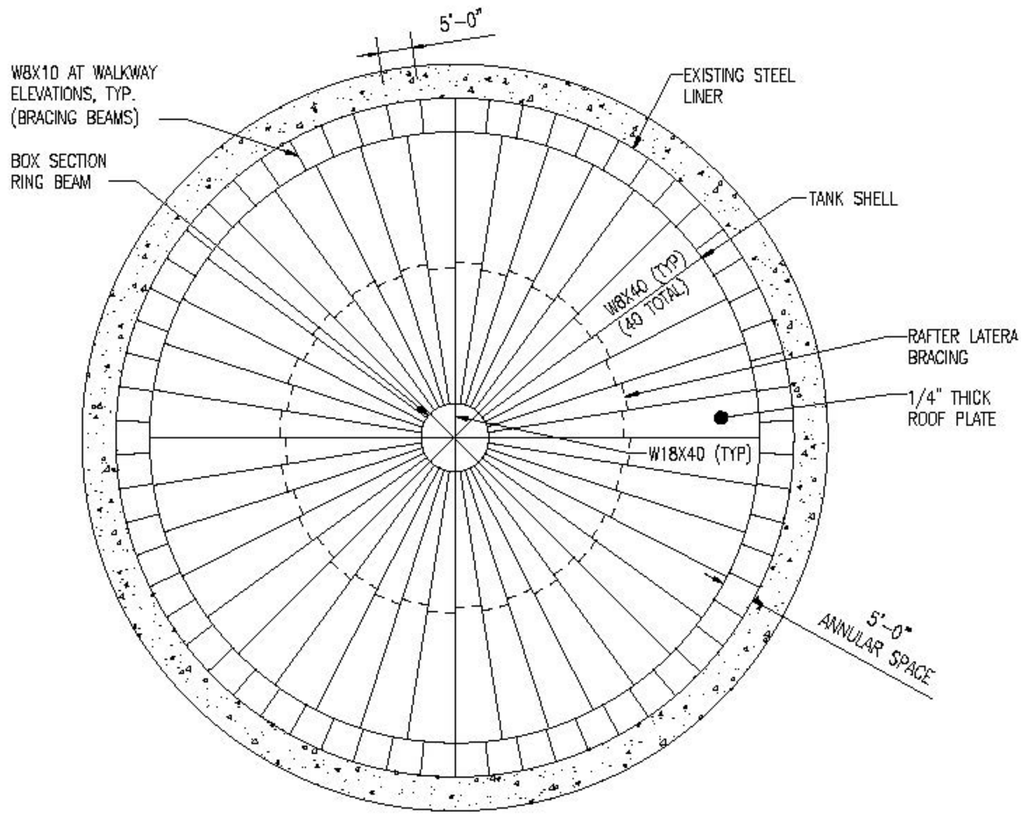

Figure E-6.0-4 TUA 3A Tank within a Tank Roof Framing Plan

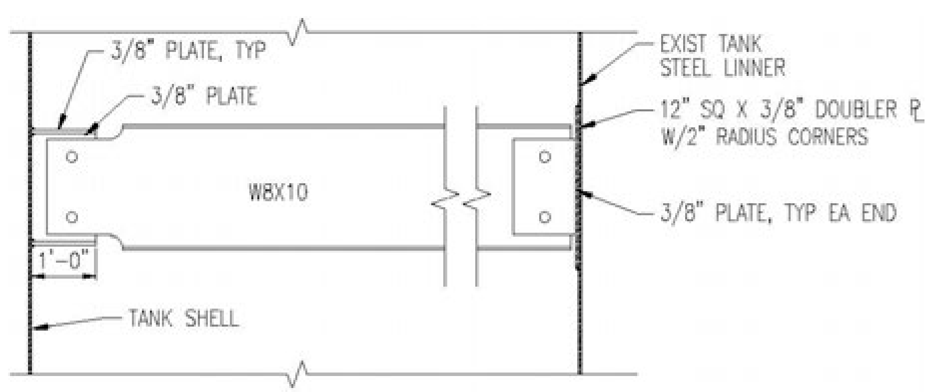

Figure E-6.0-5 TUA 3A Tank within a Tank Bracing Beam

- Double wall dome bottom with interstitial space filled with concrete. The dome bottom consists of 5/16-inch thick steel plates supported on reinforced concrete fill on top of the existing steel liner in the lower dome that will extend up to the lower dome/barrel joint and under the shell of the new tank to support the tank. Shear studs will be provided to anchor the concrete fill to the existing steel liner. It is estimated that the concrete fill will be 4'-0" thick below the floor of the new dome bottom and increase in thickness up the sides of the lower dome to 6'-0" thick at the top of the lower dome. The floor of dome bottom will be flat and constructed of 1/2-inch thick plates for additional strength and corrosion allowance. A dome bottom concept relies on the reinforced concrete fill acting as an inverted dome in compression to support the entire weight of the new tank.

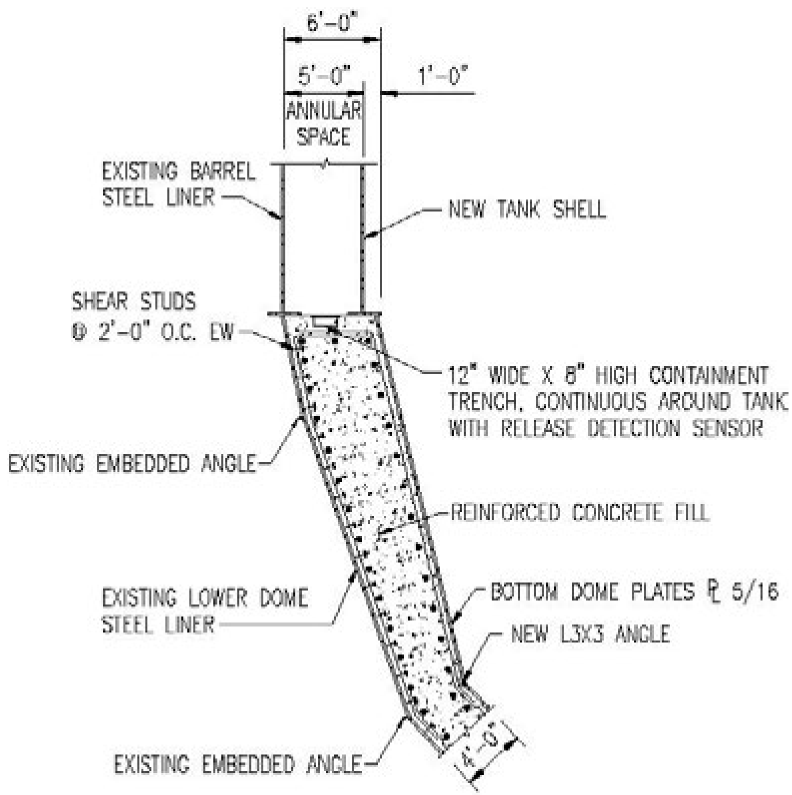

Figure E-6.0-6 TUA 3A Tank within a Tank Section at Lower Dome

- Drainage channels in the concrete fill in the interstitial space of the dome bottom with release detection piping into the Lower Tunnel.
- Spiral stair on the exterior of the tank to access the annular space.

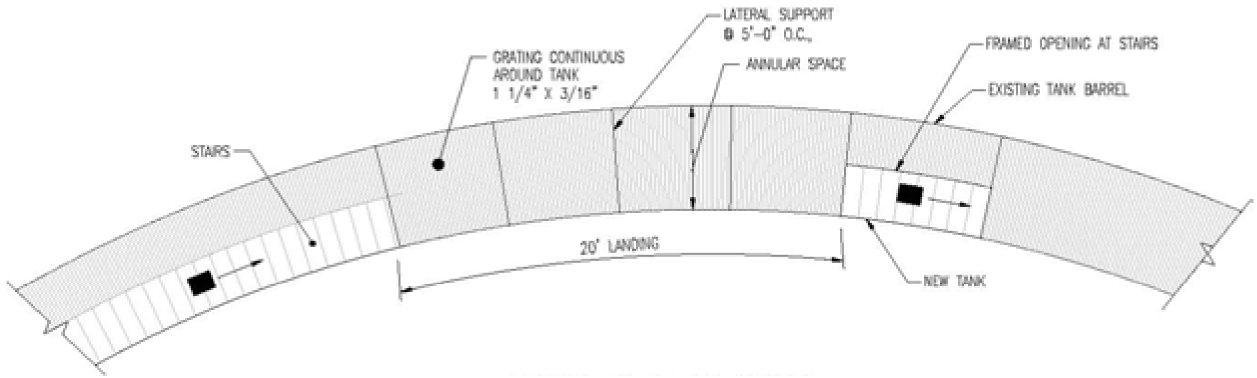

Figure E-6.0-7 TUA 3A Tank within a Tank Section Partial Plan at Stairs

- A walkway around the entire tank at four elevations at approximately 35 feet vertical spacing to provide access to the exterior of the tank for inspection and repair.
- The existing steel liner on the tank barrel and lower dome provides secondary containment.

6.3 Release Detection

As the exterior of the new tank is visible, leaks in the shell can be readily located and repaired. Additionally, the floor of the annular space between the tank and existing barrel will have a trench to collect and contain leaks. The trench will be continuous around the tank and drain to four equally spaced sumps. The sumps could be equipped with a level float and alarm equipment when liquid collects in the sumps. Alternatively, the sumps could be connected to 1-1.5-inch or 2-inch pipe(s) that penetrate the lower dome concrete into the Lower Tunnel (inside a secondary containment casing, and exit into a chamber with alarm float, similar to the concept of Alternative 2A).

The concrete filled interstitial space of the lower dome serves as release detection for the entire dome bottom. The entire interstitial space of the lower dome will drain via drainage channels in the concrete to a sump in the interstitial space below the center of the lower dome floor. The interstitial space of the dome bottom will have two leak detection pipes for redundancy. 1-1/2 inch diameter, extra strong pipe was selected for release detection piping to reduce the possibility of pipe blockage and to increase service life. All leak detection piping will be fully welded. No threaded fittings will be permitted. The leak detection piping will be routed from a new sump below the center of the new tank floor to the Lower Tunnel; thus, the entire interstitial space of the dome bottom will be one zone for release detection purposes. Drilling or coring of the concrete between the existing lower dome and the Lower Tunnel will be required to provide a path for the leak detection piping.

6.4 Tank Nozzles

Alternative 3A includes taking out of service the existing single wall concrete encased piping (i.e. tank nozzles) from the tank to the first valve outside tank and providing new nozzle piping within pipe sleeves (i.e. double wall construction). The existing 32-inch nozzle could be considered for reuse for the drain line, as a casing.

The tank nozzles (i.e. fill/issue piping) will be routed through the dome bottom and into the Lower Tunnel and tie into the existing piping the Lower Tunnel. Drilling or coring of the concrete between the existing lower dome and the Lower Tunnel will be required to provide a pipe sleeve for the new tank nozzles.

Additional piping considerations include:

- Sample lines routed through an existing line no longer needed, and repurposed as a secondary casing.
- The annular space around the tank must be drained to the Lower Tunnel drainage system. Most likely this would involve a drain line from the top of the lower dome (at the floor level of the gallery) running through the tank, and exiting the lower dome through a cased line to the Lower Tunnel. This could be a new bored line, or repurposed older line.

6.5 Engineering Considerations

Tank Roof

The tank can be either open-top or have a fixed roof. An open top tank allows booms to be mounted on the center tower for construction and for future inspection and maintenance of the tank. An open top tank, however, prevents ventilating the annular space for personnel access. The tank would need to have a fixed roof and be vented to the existing tank vent pipe at the top of the upper dome or the annular space would need a roof and ventilation. We recommend a fixed roof tank with a vent pipe connected to the existing tank vent pipe at the top of the upper dome. The roof will also have a hatch for entry into the tank. Several options for a fixed roof were considered.

- Rafter-Supported Cone Roof supported from the Center Tower: In this option roof plates would be supported on structural steel rafters spanning 45 feet from the tank shell to the center tower. Roof plates would be 3/16-inch thick minimum (1/4-inch plates are recommended). The center tower will need to be evaluated to support additional load and most likely strengthened to support of the weight of the fixed roof.
- Truss-Supported Cone Roof: In this option the roof would not be supported from the center tower. Roof plates would be supported on long trusses supported from shell. This option, however, presents challenges in fabricating the trusses in short lengths so that they can be brought through the Upper Tunnel, into the tank, and temporarily supported in place until field splices are completed.
- Self-Supported Dome Roof: This option consists of butt welded formed plates and possibly internal or external stiffeners.
- Self-Supported Cone Roof: This concept consists of 40-feet long steel framing rafters supported from the new tank shell and framing into a 10-feet diameter compression ring around the existing tower, no roof loads would be supported from the center tower.

We selected the self-supported cone roof concept (for cost estimating) for the following reasons:

1. A self-supported cone roof does not increase load on the center tower. Loads for the fixed roof are supported by the tank shell.
2. A self-supported cone roof is easier to construct than a dome roof in that flat plates with lapped fillet welded joints are used; whereas a dome roof would require rolled plates and butt-welded joints.
3. Rolled shape rafters are readily available; whereas trusses require additional fabrication and are difficult to coat.

An additional consideration is to include a monorail around the perimeter of the tank, supported by the roof trusses, or from the shell, such that a trolley can be used in the construction of the tank for tank internal lining application, and in the future for shell inspection.

Tank Bottom

Two options were considered for the tank bottom:

- Dome Bottom
- Cone-Down "Flat" Bottom

Dome Bottom: A dome bottom would consist of 5/16-inch thick steel plates supported on reinforced concrete fill on top of the existing steel liner in the lower dome. The existing steel liner will be inspected, repaired, and coated with a urethane lining to provide secondary containment. Reinforced concrete fill will be placed on top of the existing steel liner to support the new dome bottom plates. Shear studs wedded to the existing steel liner of the lower dome will be provided to anchor the concrete fill to the existing steel liner. The concrete fill will be 4'-0" thick below the floor of the new dome bottom. The concrete fill will increase in thickness up the sides of the lower dome to 6'-0" thick at the top of the lower dome and extend under the shell of the new tank to support the new tank. The floor of new dome bottom will be flat and constructed of 1/2-inch thick plates for additional strength and corrosion allowance. A dome bottom concept relies on the reinforced concrete fill acting as an inverted dome in compression to support the entire weight of the tank.

Cone Down Bottom: A cone down bottom consists of 5/16-inch thick steel plates, a sand cushion layer below the steel plates, and a flexible membrane liner below the sand cushion. The floor would have a 5% slope to a sump at the center of the tank. The entire lower dome of the existing tank would be filled with structural fill or lean concrete to create a flat surface for the new floor. A flexible membrane liner would be placed on top of the structural fill or lean concrete, followed by the sand cushion and floor plates. This option does not rely on the existing steel liner or a urethane lining for secondary containment because the flexible membrane liner provides secondary containment. Another benefit of this option is that an impressed current cathodic protection system can be provided in the sand cushion filled interstitial space between the tank floor and membrane liner. Filling the lower dome of the existing tank to construct a cone bottom, however, results in a significant reduction in storage capacity.

As the cone down bottom concept results in a significant reduction in storage capacity, it is not as viable as the new tank with a dome bottom, and thus was ruled out.

Hydrostatic Testing

API 650 requires a new tank be hydrotested with water, if available. When water is not available API 650 allows testing of the shell by a penetrating oil test of all shell welds for leakage or by vacuum box testing or by a combination of a penetrating oil test and vacuum box testing.

Water is available at Red Hill; however, the logistics of obtaining the water, filling the tank, and disposing of the test water are complex. The only pipeline that could be used to fill a tank is a 6-inch slop line and would several weeks to fill a tank. Note that Red Hill AOC SOW Section 2.2 TIRM Report paragraph 17-8.2.b states that the existing 6-inch water lines in the Upper and Lower Tunnels are believed to be original construction and should not be used to transport the high volume of water needed to fill the tank. Thus, new or temporary water lines would need to be installed in the adits and tunnels. Drain pipes would need to be installed in the Lower Tunnel and connect to the slop line.

There is also no place to dispose of the test water other than to temporarily store it in Tank 1 as suggested by Red Hill AOC SOW Section 2.2 TIRM Report. Trucking the water offsite is not feasible. A temporary lagoon could be excavated to allow the water to filter into the ground. This, however, is also probably not feasible as an environmental discharge permit would be extremely difficult if not impossible to obtain as the area is over an aquifer.

Given the unique conditions of hydrotesting the new tanks at Red Hill, EEI has assessed the risks of not hydrotesting the tank and what measures could be done if a hydrotest is not performed. Our assessment is as follows:

- The risk that the tank could fail catastrophically is low. The new tank will be designed, fabricated, and constructed in accordance with API 650. Careful detailing and construction of the tank following the requirements of API 650 and quality control, inspection, and testing during construction will be required.
- As ambient air temperature inside the Red Hill complex is generally constant and not expected to fall below 60 degrees F the risk of brittle fracture failure is considered to be low.
- Should a tank leak or fail, it will be contained by the existing tank.

Based on our assessment of the above risk factors, it is our assessment that the new tanks could be constructed without performing a hydrotest with water.

If a hydrotest is **not** performed, the following is recommended as an engineering standard of care, or required by referenced criteria documents:

- Perform radiography of shell welds in accordance with API 650.
- Perform a penetrating oil or vacuum box test of 100% of the shell welds.
- Perform Balanced Field Electromagnetic Technique (BFET), or ultrasonic shear wave inspection of 100% of the shell welds. Inspect for cracks, lack of fusion, lack of penetration, porosity, and other rejectable indications. Repair all rejectable indications. This additional inspection is recommended as API 650 does not require 100% of shells

welds be radiographed. Additionally, BFET and ultrasonic shear wave can potentially detect rejectable indications in welds that are not readily detectable by radiography.

- Initially fill the tank (to the rim angle) with fuel and hold for 24 hours.
- Operate the tank at a reduced fill height below the rim angle and roof framing (this ensures that tank operates at a lower stress level than initial filling).
- Should the new tank leak or fail during initial filling with fuel, the fuel will be contained within the existing tank.

Repairing tanks in groups of three tanks and performing an initial fill test with fuel will require using the fuel from a fourth tank to perform the initial fill test of the new tanks. It is expected obtaining test fuel at Red Hill will not be a problem.

6.6 Preparatory Inspection and Repair of Existing Tank Liner

For Alternative 3A, the inspection of the existing tank barrel will be at the lowest level of any of the alternatives. The existing shell will become the secondary containment hydraulic barrier, and will be fully visible and inspectable for the life of the tank. We recommend the existing shell be given a thorough visual examination for corrosion or other conditions, and near 100% scanning for backside corrosion.

The upper dome area will be given the same degree of inspection as Alternative 2A, as under Alternative 3A it is not a hydraulic barrier or containment feature.

Alternative 3A relies on the integrity of the existing steel liner of the lower dome for secondary containment. As the existing steel liner of lower dome will be covered with concrete and a new steel liner, the existing steel cannot be inspected at future integrity inspections, the existing steel of the lower dome requires a higher level of repair than Red Hill AOC SOW Section 2.2 TIRM Report.

6.7 Testing and Commissioning Procedures

Refer to discussions on attributes for discussion on testing and commissioning procedures.

6.8 Construction Logistics

Construction logistics for Alternative 3A are of significantly more complicated and important than concepts developed, followed, and refined for projects over the last 10 years that executed repairs similar to Alternative 1A. A more detailed discussion of logistics is presented in Part G of this document. The significant issue here is the ability to successfully form and pour the new lower dome concrete foundation, move plates into the tank, erect in place, and weld the plates under an industrial production line scale.

6.9 TIRM

After startup and placed into service, future integrity inspections, repairs, and maintenance will follow the TIRM requirements in Red Hill AOC SOW Section 2.2 TIRM Report in part.

Inspection, evaluation, and repair of the tank will also follow the requirements of API 653 Tank Inspection, Repair, Alteration, and Reconstruction as the tank predominately meets the requirements of API 650.

The goal is for the tank to have a 20-year in-service period between outages for internal tank inspections and repairs. As the process of clean-inspect-repair can take 2-3 years, the development of an appropriate inspection protocol is required in order to meet a 20-year in-service goal.

6.10 Attributes

The following discusses whether/how Alternative 3A meets the criteria for each attribute as defined in the attribute definition and EEI's rating of the Alternative for each attribute.

6.10.1 Constructible

Alternative 3A can be constructed in the field at Red Hill using practicable construction means and methods. Construction will follow standard industry standards for aboveground storage tanks, followed by coating application. The greatest challenge for construction is logistics and restrictions working at Red Hill, inside the fuel storage facility and inside the tanks.

Power for construction of this Alternative will be based upon the direct contractor connection to the HECO power system. Other features such as overall tunnel ventilation has not presented any difficulties. The power requirements are expected to be similar to Alternative 2.

Preparation of the existing tank for Alternative 3A is similar to Alternatives 1 and 2. The commonality and differences between the Alternatives are used to determine constructability as follows:

- Baseline integrity inspection of the interior surfaces of the tank and repairs as may be required. Essentially the same as Alternative 1A, except in the case of Alternative 3A, the existing shell and lower dome are the secondary containment barrier. As the existing barrel shell will easily be inspectable in the future and not in contact with product (above lower dome level), some inspection and repair criteria can be relaxed.
- Boring thru the lower dome to the Lower Tunnel so that new double wall pipe nozzles can be installed results in the primary pipe being surrounded by a testable secondary containment casing. This has been accomplished in Red Hill for 3 tanks (5, 6, and 12), for installation of larger tell-tale systems.[12]

[12] See Appendix BF of the TIRM for documentation

The overall concept for this alternative is erecting an API 650 tank inside the present tank cavity. The new tank will also have features identified in the DoD Standard Aboveground Storage Tank standard where applicable. To support the weight of the new tank, the reinforced concrete in the lower dome will be approximatively 4-feet thick and 6-feet thick at the transition to barrel.

The floor will have structural members to permit sequential construction of the new dome with many similar aspects of the original dome. The design includes drainage channels and release detection piping such that the concrete filled interstitial space qualifies as a double bottom floor.

As described for Alternate 2, steel members and sheets must be sized so that they can be conveyed through the Upper Tunnel to the tank.

The actual erection of the tank will follow conventional tank construction techniques, consisting of horizontal plates set in place, tack welded and then fully welded by automatic welding machines. A conventional cone up roof will be erected. Depending on final design options, the center tower may or may not be used for roof support.

The coating the tank interior and exterior surfaces will utilize conventional means and methods employed for aboveground bulk fuel storage tanks.

Although much of the tank construction is quite conventional, factors such as the floor being an inverted dome, a tank inside of a Red Hill tank has not yet been done, and major infrastructure will be needed, EEI has determined that Alternative 3A be assigned a "somewhat meets criteria" rating.

Rating: Somewhat Meets Criteria

6.10.2 Testable

To determine if an Alternative can be shown to meet hydraulic and structural integrity standards prior to being place into service, this attribute defines the basic litmus test for acceptability during construction prior to filling and during startup/commissioning when filling. This macro approach to testability focuses on the industry standard practices for testing the material, joints, welds, etc. used in repair/construction of steel tanks. This attribute also examines the ability of whether an alternative can be tested for integrity during construction prior to being filled. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 13 – Commissioning and Testing Procedures was developed to demonstrate the degree of rigor required for the testing and commissioning procedures necessary to place the tank repair/upgrade in service and includes the details of that process in the criteria established for that attribute.

In that Alternative 3A results in an API 650 tank with a double bottom constructed inside the present tank, all applicable construction practices for ASTs can be tested as dictated by applicable industry standards. In addition to the Navy's protocol for inventory monitoring and trend analysis required by their tank commissioning procedures, the exterior of the shell, the interior of the secondary containment and the interstitial space under the bottom can be monitored via a visual leak test to ensure hydraulic integrity.

Alternative 3A meets the criteria for testable during construction and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.3 Inspectable

To determine if an Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service, this attribute defines the basic litmus test as to whether a TIRM can be developed using industry standard inspection techniques. This approach to inspections focuses on the industry standard practices for required inspection criteria and intervals based on a qualified inspector's determination of suitability for service applicable to the periodic maintenance and repair of steel tanks. However, since these core elements represent absolute values in a pass/fail scenario, Attribute 14 - TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade and Attribute 15 - TIRM Requirements for Future Integrity Inspections were developed to demonstrate the degree of rigor required to develop a TIRM using industry standard inspection techniques for the inspection procedures necessary to place the tank repair/upgrade in service and includes the details of those criterion as established for the respective attributes.

In that Alternative 3A results in an API 650 tank with a double bottom constructed inside the present tank, all appropriate inspection practices for ASTs can be performed as dictated by applicable industry standards. For Alternative 3A, the interior and exterior of the primary shell and the interior of the secondary containment can be inspected resulting in the issue of a Suitability for Service testament as determined by the tank's ability to meet structural and hydraulic integrity standards..

Alternative 3A meets criteria of this attribute and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.4 Repairable

While most bulk tank systems are repairable to some degree, various levels of effort can be undertaken to effect similar repairs. These levels of effort are factored into the rating of the ability to effect repairs for each alternative considered. The basis for this rating centers around the aspects of capabilities for on-site repairs using standard/traditional construction/repair means and methods.

Using the status quo efforts as a gauge, removal or modification of the Red Hill infrastructure is not required to gain access to the tank liner, all interior and exterior surfaces of the primary tank liner, tank nozzles, internal components, and secondary containment are accessible for repair, and all repairs can be performed from inside the tank or annular space without having to remove part of the primary tank or internal component to access an area for repair.

While the mechanisms for effecting any repairs in these Red Hill tanks are quite unique and complex, they have been used for many years and innovations/improvements are being incorporated into the standards with each successive repair effort. All actions are well within the norm of repair method considerations, are feasible to execute, and require no special equipment that render these options unreasonable.

For the primary shell of the Alternative 3A, the level of effort is representative of the status quo plus the elements of repair associated with the coating systems as with options for Alternative 1B. Since interior and exterior surfaces of the primary tank, internal components, and secondary containment are accessible for repair from inside the tank or secondary containment, Alternative 3A has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

6.10.5 Practicable

This attribute rates the degree to which an alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters. Given the complexities and interactive dependencies of multiple attributes and their associated importance among stakeholders, this attribute is used to combine several factors to provide a cost/benefit basis for the decision makers.

The three major determinable factors are:

- The extent of the impact/modification to the Red Hill infrastructure or physical arrangement as determined in Attribute 1,
- The cost per tank depicted in the cost analysis associated with Attribute 17 as compared to the current CIR estimates of $7.5M per tank, and
- The ability to complete the upgrades by the mandated timeframe set by the Red Hill AOC SOW as derived from the duration modeling for Attribute 18.

Alternative 3A can be constructed within the confines of Red Hill, but it will have "extensive" impact/modification to the Red Hill infrastructure or physical arrangement. Fabricating a tank within the original tank to form a tank within a tank with a double bottom and interstitial space for monitoring is a rare and formidable undertaking. In addition, the design element of this alternative and volume reduction aspects that necessitate the need for 20 tanks vice the current 18, is expressively more impactful to timing and overall program cost than any of the single wall alternatives.

The construction cost of this alternative is estimated to be [redacted] per tank and falls within the 1000% to 2000% range. The duration modeling data indicates that all tank work is not expected to be completed within the compliance timeframe set by the Red Hill AOC SOW, but by using a five-tank upgrade cycle execution strategy, all in-service tanks will have been upgraded by the compliance deadline.

Due to the level of infrastructure impact, measurable cost increase and necessity for a greater than three-tank execution strategy, Alternative 3A has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

6.10.6 Corrosion Damage Mechanism

Alternative 3A tank has a coating applied to the interior of the lower dome, barrel, underside of the roof, and tank exterior, which is an enhancement over the current practice for all Red Hill tank repairs. These coatings provide protection from corrosion in the most susceptible areas where water (including salt water) may be present (Lower Dome), and additional protection elsewhere. Additionally, the tank nozzles are all new piping.

Alternative 3A has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.7 Successful Implementation Elsewhere

A tank-within a tank concept has successfully been constructed inside a concrete cut and cover tank at NS Guantanamo Bay, Cuba but has not been used on tank of the size and scale of Red Hill tanks. The referenced tank was relatively small, and easily accessible compared to Red Hill.

Within DoD, at the FLC Yokosuka, Sasebo Detachment Iorizaki and Yokose Terminals have very large cut and cover tanks in use today. The original concrete tanks with no steel liners were used as the secondary containment for new free standing concrete shell/steel lined tanks. An accessible gallery is between the new concrete tank barrel and original concrete tank. The floors have leak detection channels leading to sumps in the gallery. While the facility has multiple tanks ranging from 200,000 Bbl to 435,000 Bbl, the tanks have large footprints, but much shorter shell heights than Red Hill. The facility does demonstrate however that when constructed and maintained properly they have been very successful in preventing and detecting leaks. The addition of secondary containment coupled with physical leak detection/capture devices specifically allows this design to detect leaks without the use of internal, electronic sensing mechanisms. Specific examples for reference are the upgraded tanks in Yokose, Japan as discussed in Appendix H.

Since the Alternative 3A concept has been used at other large fuels depots and would be just as successful in preventing leaks at Red Hill, this alternative has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.8 Reliability

For all TUAs being analyzed, reliability is defined as the measure of a tank's ability to perform its required function under stated conditions for a specified period (i.e. level of confidence). The rudimentary functional requirement of most any storage tank is to maintain hydraulic integrity and prevent the contained product from unintentionally exiting the vessel. The stated conditions are the manner and environment in which the storage tank is operated and maintained. The specified period is the designated interval of uninterrupted operations, i.e. the next out-of-service internal inspection.

Each alternative relies on a steel shell as its primary hydraulic boundary. In all cases, the integrity of the primary shell is designed to meet the definition of reliability as stated above. While a certain amount of variability may be introduced in the type of steel used, coatings applied and construction techniques, these elements drive the different concepts into various levels of confidence above and beyond the qualifications of basic reliability.

With regards to system reliability, considering alternatives with enhancements that include secondary containment extends beyond the discussion of reliability of the primary tank shell and move towards the reliability of the tank system to minimize the extent of the effects stemming from a failure in the primary shell. Those added enhancements are addressed in other attributes within this document and the merits of the different systems are detailed with multiple factors beyond the limits of this attribute, which specifically targets the reliability of the primary shell to perform as designed.

In that Alternative 3A is constructed in accordance to proven industry standards (API 650) for a single wall, steel tank, it can be relied upon to perform its required function under the stated conditions until, at a minimum, the next inspection interval and has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.9 Impact on Storage Volume

Alternative 3A provides for fuel storage in the new tank up to the elevation underside of the roof framing at the rim angle. Alternative 3A results in a reduction in storage volume compared to the existing tanks. The 5-foot wide annular space between the existing barrel and new tank shell and the interstitial space between the new tank floor and the existing lower dome results in reductions to storage volume. The reduction in storage volumes for Tanks 1 to 4 is different than Tanks 5-18 in that the new tank in Tanks 5 to 20 is 12 feet taller. Tanks 1 and 19 (currently not in service) can be inspected, repaired, upgraded for return to service and added to the overall system storage volume.

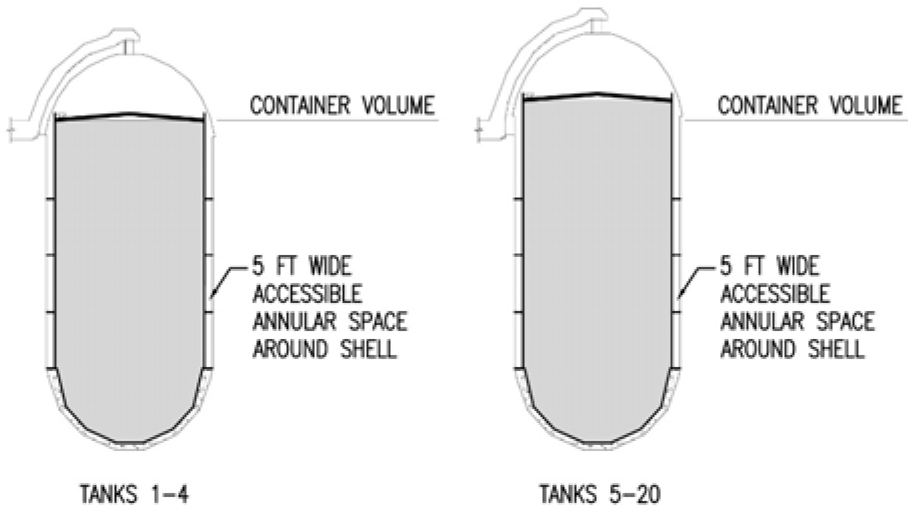

Figure E-6.0-8 TUA 3A Tank within a Tank Container Volume

Shaded area indicates volume of product in tank

The reduction in container volume compared to the existing tanks are as follows:

- Existing system volume (see Alt 1A graphic):
  - ➢ Tanks 2 to 4 (238'-6" tall): 285,148 Bbls per tank
  - ➢ Tank 5 to 18 and 20 (250'-6" tall): 301,934 Bbls per tank
  - ➢ Tanks 1 and 19: Out of Service
  - ➢ System (Tanks 2-18 and 20): 5,384,454 Bbls
- Container volume after Alternative 3A upgrade:
  - ➢ Tanks 1 to 4: 204,587 Bbls per tank (filled to underside of roof framing)
  - ➢ Tank 5 to 20: 218,184 Bbls per tank (filled to underside of roof framing)
  - ➢ System (Tanks 1-20): 4,309,292 Bbls
- Reduction in Volume after Alternative 3A upgrade:
  - ➢ Tanks 2 to 4: 80,561 Bbl reduction per tank (28.2% reduction per tank)
  - ➢ Tanks 5 to 18 and 20: 83,750 Bbl reduction per tank (27.7% reduction per tank)
- Increase in Volume after Alternative 3A upgrade:
  - ➢ Tank 1 (currently out of service): 204,587 Bbl increase after upgrade
  - ➢ Tank 19 (currently out of service): 218,184 Bbl increase after upgrade
- Net Change in Volume after Alternative 3A upgrade:
  - ➢ System (Tanks 1-20) 1,075,162 Bbl net reduction (19.97% net reduction)

Conclusion: Alternative 3A results in a significant reduction of facility storage volume compared to existing tanks. The resulting overall system volume is a 20% reduction.

Rating: Not Rated

6.10.10 Provides Secondary Containment

Alternative 3A involves constructing a new tank inside the existing tank. The new tank would be 90'-0" diameter and have an inverted dome bottom and a fixed cone roof with a vent pipe connected to the existing tank vent system. The smaller diameter of the new tank creates a 5'-0" wide annular space around the tank that allows for the integrity inspection of the exterior of the tank. The annular space also allows inspection of the steel liner of the existing tank. Containment of leaks is provided by secondary containment provided by the steel liner of the existing tank. The annular space around the barrel and the interstitial space below the bottom provides a means for leak detection.

As this alternative relies on the integrity of the existing steel liner for secondary containment, the steel liner and welds of the barrel and lower dome of the existing tank need to be 100% scanned for thinning due to corrosion and rejectable indications in welds and repaired. If a tank was inspected within the past 5 years that included scanning of the steel liner and welds and repair of thin areas and rejectable indications in welds, the existing steel liner does not need to be re-inspected. This is justified that in Alternative 3A, the original steel liner is a secondary barrier that in and of itself can be inspected at any time for integrity. If the steel liner has never been scanned, 100% scanning of the steel liner and welds of the barrel and lower dome of the existing tank is included in execution of this alternative.

Secondary containment concepts include inherent release detection barrier and release detection capability outside of the primary barrier (tank shell). Release detection sensors provide direct measurement/indication of a release. As the exterior of the new tank is visible, leaks in the shell can be readily located and repaired. It is envisioned the annular space floor will have a channel and sump for a liquid sensor (float or similar) so an alarm can be sounded at the operations center. We also recommend the sump have an outlet, and piping connection to the lower access tunnel, where it could be connected to a chamber with liquid level sensor and alarm features.

The interstitial space of the dome bottom will have channels and leak detection pipes. The leak detection piping will be routed from a new sump below the center of the new tank floor to a leak detection chamber in the Lower Tunnel, similar to that described for Alternatives 2A and 2B; the entire interstitial space of the dome bottom will be one zone for leak detection purposes with two pipes recommended for redundancy.

This alternative includes replacing existing concrete encased piping from the tank to the first valve outside tank in the lower tunnel with double wall construction.

The accessible annular space, the overall reduction in tank height and the installation of a double bottom results in a significant reduction in storage capacity.

Given the above information, the concept of Alternative 3A to provide secondary containment meets current EPA requirements specified by 40 CFR 280 UST criteria being an inner and outer barrier with an interstitial space that is monitored for leaks as well as 40 CFR 112 AST criteria for secondary containment with a sufficiently impermeable barrier and contains the full volume of the container plus precipitation. As both criteria are satisfied, the alternative has been assigned a 'Meets Criteria' rating.

Rating: Meets Criteria

6.10.11 Dependency on Existing Tank Steel Liner Integrity

This attribute was developed to determine the level to which each alternative being evaluated depends on the original steel liner for hydraulic integrity to contain product (primary tank) or provide a barrier between a breach of the primary tank liner and the environment (i.e. interstitial space boundary, or dike wall/floor secondary containment boundary). For evaluation purposes, the rating system used is oriented towards a higher rating for the least amount of dependency on the existing liner.

Alternative 3A constructs a new primary carbon steel, tank and uses the existing steel liner as secondary containment and an interstitial space on the bottom. In addition, this alternative includes a full coating system of all internal surfaces of the new primary tank for enhanced hydraulic integrity as well as a coating system on the external surface of the new tank and the internal surface of the existing tank shell liner where exposed, including the barrel and upper dome. Therefore, while Alternative 3A does not rely on the hydraulic integrity of the existing tank liner to contain product, it does depend on the existing tank liner to serve as the outer barrier of an interstitial space or as secondary containment. As such, Alternative 3A has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

6.10.12 Release Detection Integral to Tank Construction

This attribute defines whether an Alternative has release detection capability that is integral to (i.e. is part of) the upgrade construction such as an interstitial space with monitoring.

Alternative 3A has a release detection system that is integral to the tank dome bottom. The shell is accessible from the annular space and can be inspected for leaks. The floor of the annular space between the tank and existing barrel has a trench to collect and contain leaks. The trench will be continuous around the tank and drain to four equally spaced sumps. The sumps could be equipped with a level float and alarm equipment when liquid collects in the sumps, connected with piping to a leak detection chamber in the lower tunnel.

As Alternative 3A has monitoring of the interstitial space, other methods of release detection identified in 40 CFR 280 are not required, if 40 CFR 280 even applies, as the tank configuration is that of an AST. Special technology is not required for release detection other than sensors in the release detection chamber in the Lower Tunnel. This alternative has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.13 Testing and Commissioning Procedures

This attribute is aimed at determining the level of rigor necessary for testing and commissioning procedures required to return the tank repair/upgrade to service. These procedures are based on the final verifications prior to filling, and considerers the different methods available to monitor the tank for hydraulic or structural failure during and/or immediately after filling.

In accordance with the NAVFAC Naval Engineering Training and Operating Procedures and Standards (NETOPS) 34 and the NAVSUP GLS Instruction 10345.1, (3) coordination and proper review of the following elements is mandatory prior to a transfer of custody of the tank back to the operator:

- A statement signed by an appropriately certified API 653 tank inspector indicating the tank is suitable for return to service including any caveats, clarifications, or limitations that would affect tank operations after return to service. The statement shall include due dates for the next applicable formal inspections (internal, external, and leak test) and any repairs required prior to those next inspections. Next inspection due dates shall be the maximum allowable by API 653 code. The normal interval under API 653 for a new tank is 10 years, based on the corrosion rates are not yet known. However, API 653, ¶6.4.2.1.1 permits a longer period by meeting certain characteristics in Table 6.1. One such characteristic permits increasing the next inspection interval by 5 years if the tank has a fiberglass liner per API RP 652. We consider the thick film coating system consisting of the polysulfide modified epoxy novolac to be a superior system to fiberglass, and thus qualifies. The API table also permits an additional 10 years before the first inspection if there is a release detection barrier. The lower dome interstitial space with monitoring system qualifies under this provision. Thus, the next inspection interval for Alternative 3A tanks can be as long as 25 years from the time the tank is erected. NAVSUP guidance is no more than 20 years, and being less than allowable API requirements, is acceptable. EEI believes this approach is consistent with Chapter 19 in the Red Hill SOW Section 2.2 TIRM Report.
- The Statement shall also note that as a final test, the tank shall be given a 3rd party certified leak test upon reaching its first full height liquid fill, is required by NAVSUP policy. EEI recommends this step, even though the Alternative 3A tank is essentially an API 650 tank, as the interstitial space in the lower dome is subjected to its highest pressure during this fill.
- A completed inspection report including all required calculations and analysis. Preliminary or field reports cannot be substituted for this requirement.
- A list of repairs identified during inspection, including completed repairs and repairs that are still pending. All pending repairs shall be annotated with a due date.
- Third-party certified calibration (“strapping”) charts when a tank is first placed in service when certified calibration charts did not previously exist, or when repairs were made that would be reasonably expected to change the tank’s calibration.

- A statement signed by agents of the Execution/Construction Agent and repair contractor that custody of the tank is returned to the activity and that the above items have been provided to the operator.

Once the tank has been certified suitable to receive product, the filling protocols must be authorized by the commanding officer. These protocols, required by NAVSUP mandate, are drafted specifically for the type of tank being filled and verified by SMEs at the NAVSUP Energy Office. The operators will then develop a tank specific operations order in accordance with the above stated protocol and mandate. This specific operations order, reviewed and approved by the commanding officer, will consider the unique requirements associated with the tank being filled. Mandatory elements include:

- Tank filling procedures with appropriately defined incremental fill levels and hold times;
- Physical inspection, gauging, and trend analysis as appropriate upon reaching each incremental fill level; and
- Emergency drain-down plan in the event the tank needs to be emptied, including specific triggers as to when the drain-down plan should be activated.

The development and implementation of this operations order is predicated on the parameters presented by the specifics of the tank being filled. Other factors taken into considerations include:

- Ability to continuously visually monitor the shell and/or floor surfaces for a breach of hydraulic integrity or evidence of structural failure;
- Ability of the shell and/or floor that cannot be directly visually monitored, to be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping);
- Ability of the installed tank inventory control system to reasonably determine unacceptable variances during tank filling when performed using the requisite number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity when the tank does not have a shell or floor secondary containment system with release detection piping that can be continuously monitored for hydraulic integrity; and/or
- Ability to conduct a final hydraulic integrity test to meet the approved tank tightness testing requirements prior to placing the tank in routine operations.

Alternative 3A represents a concept where the tank can be filled while continuously visually monitoring the shell surfaces for a breach of hydraulic integrity or evidence of structural failure, and a floor that, while cannot be directly visually monitored, can be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping). Therefore, tank filling would include physical inspection (visual monitoring of the external shell and release detection piping system for the bottom) in addition to using at least the minimum number of "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using the tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.5 may be required if a decision is made to operate these tanks by the UST regulations prior to turning the tank over to the operator for routine operations. However, as these tanks would essentially be ASTs in underground vaults, AST regulations may apply which would possibly negate the need for tank tightness testing. However, EEI recommends completing such a test to assure the lower dome interstitial space is liquid tight. Given the above information, Alternative 3A has been assigned a "Meets Criteria" rating.

Rating: Meets Criteria

6.10.14 TIRM Requirements for Inspection of Existing Tank prior to application of Tank Upgrade

Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document specifies the level of inspection and repair necessary for the current tanks in service at Red Hill, by cross referencing to the Red Hill AOC SOW Section 2.2 TIRM Report. Each of the alternatives require varying degrees of inspection and repair criteria as compared to the TIRM specifications (for existing tank inspections) published in Red Hill AOC SOW Section 2.2 TIRM Report, Appendix BE, UFGS Specification SECTION 33 56 17.00 20 INSPECTION OF FUEL STORAGE TANKS and Appendix BD, SECTION 33 56 18.00 20 REPAIR OF FUEL STORAGE TANKS.

Depending on the level of dependency each TUA has on the integrity of existing shell/dome, considerations are given to the level and type of inspection and repair of the existing tank structure, liner and nozzles. If there is no dependency on the existing shell or dome, a visual inspection of the existing tank structure (such as embedded angles that support the steel liner) is the primary requirement to meet criteria. With limited dependence on the integrity of the existing shell/dome, inspection of the existing tank steel liner and tank nozzles following industry standards required, resulting in the least requirements and thus not meeting the established criteria.

As the reliance on the integrity of the existing steel liner increases, the ability to access the original liner for inspection and repair becomes paramount to meeting criteria. The ideal situation would include unfettered access for inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of all rejectable indications identified. However, if an alternative relies considerably on the integrity of the existing shell and the existing shell cannot be re-inspected at future integrity inspections, it would result in a less favorable scoring in meeting the requirements of this criteria.

If an alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report or Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document, it would fully meet the criteria of this attribute as the rating system used is oriented towards a higher rating meeting the TIRM Report, and a lower rating for larger departures from the TIRM Report.

While Alternative 3A adds a new carbon steel tank with a coating system, each requiring specific inspection and repair efforts respectively, it would also require inspection of the existing tank steel liner and tank nozzles following industry standards using visual inspection and ultrasonic examination at spot locations with repair of rejectable indications limited to existing welds and isolated areas of the steel liner. In that Alternative 3A has limited dependence on the integrity of the existing shell and the existing shell can be re-inspected at future integrity inspections, Alternative 3A has been assigned a "Mostly Does Not Meet Criteria" rating.

Rating: Mostly Does Not Meet Criteria

6.10.15 TIRM Requirements for Future Integrity Inspections

Red Hill AOC SOW Section 2.0 (TIRM) states that the purpose of the TIRM report is to review and expand upon the issues that have been agreed to by Navy/DLA and EPA/Hawaii DOH in the Red Hill AOC SOW for future integrity inspections at Red Hill. It is important that the processes of the future inspection, repair, and maintenance of the Red Hill tanks are well defined to ensure that the goal of keeping the tanks permanently leak-free going forward can be met.

To meet the conditions of Red Hill AOC Section 2.0, each alternative has been rated to determine the level of rigor necessary to conduct future integrity inspections and/or the access provisions required to complete the mandatory inspections and properly maintain the system. The basis for determination of ratings for each alternative examine the ability to competently inspect visually all shell and roof (dome) surfaces and welds from inside or outside the tank, and floor welds and steel liner from inside the tank and with conventional floor scanning equipment, all following traditional integrity investigation protocol outlined in API 653.

As alternative designs prove to be less accessible or require special procedures for access to all surfaces and welds be competently inspected visually or require departure from standard methods for traditional integrity investigation protocols outlined in API 653, the rating declines. Rating continues to decline for primary shells, including upper dome, barrel and lower dome welds and liner, that require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces. An alternative that is incapable of undergoing integrity inspections of any kind will fail to meet this criterion.

Alternative 3A constructs a new steel, with internal and external coatings, and a coating system on the original steel liner. This design creates an annular space between the existing shell and the new tank. While the coatings will have their own specific inspection and repair considerations, this tank system allows the shell and roof to be competently inspected visually, from outside the tank, and floor welds and steel liner to be inspected from inside the tank visually and with modified conventional equipment and procedures, all following traditional integrity investigation protocol outlined in API 653. Given these stated conditions, Alternative 3A has been assigned a "Mostly Meets Criteria" rating.

Rating: Mostly Meets Criteria

6.10.16 Impact on Operating and Maintenance Requirements and Procedures

Alternative 3A represents a complete redesign of the facility which provides leak detection and secondary containment, but results in significant changes to current operating and maintenance requirements and procedures as compared to the status quo. This alternative includes the present daily operational efforts conducted to operate and maintain the Red Hill facility with additional requirements for the upkeep and monitoring of the annular and interstitial spaces. A total of 18 tanks have been included in the routine operational procedures and basic operator level maintenance for more than a decade, but this alternative would require the two additional available tanks (utilization of current out of service Tanks 1 and 19), but additional storage to make up the significant volume loss. In that this additional storage is not available in Red Hill, alternate storage would be required elsewhere resulting in inventory management of external resources and scheduling to provide the current level of volume and throughput capability currently available in the existing Red Hill complex.

Operating and maintaining a UST facility is significantly less intensive than an AST facility. For the current Red Hill facility specifically, the manning for operations and maintenance is minimal due to the high level of automation associated with the facility's systems and the inherent design of the structures. Alternative 3A can best be considered as an AST facility in an underground chamber or vault. The oversite and requirements would change drastically and encompass a plethora of additional resources not currently employed with the status quo. For USTs, the operator level maintenance of the physical tanks is centered around the skin valves, ventilation systems and bottom water draw off, whereas the operator level maintenance for ASTs also includes constant monitoring and preservation of the external skin of the tank and secondary containment as well as all appurtenances associated with the design of ASTs.

In the same fashion as berms and berm liners for AST facilities require vigilance and maintenance, the existing steel liner that serves as secondary containment would require significant upkeep efforts. The five-feet wide annular space between the new tank and the existing tank provides minimal space for facility personnel to inspect and maintain the secondary containment and would require adherence to strict confined space entry procedures.

While there are currently no requirements for fire protection systems on USTs, a unique design for a fire suppression system would be required for this one of a kind facility. This system would add higher level of complexity, effort and resources to the operations and maintenance of the facility. The unique design of the Red Hill tanks negates the need for Cathodic Protection systems and since the lower domes of the current tanks would be reutilized with this upgrade, thus a Cathodic Protection system would not be required for Alternative 3A.

In accordance with current federal regulations, annual tank tightness testing would not be required due to the secondary containment provided with this alternative. Therefore, facility operations would see a positive impact in the form of cost avoidance over the status quo options by saving several weeks of set up and testing each year. However, with the external shell being inspectable, introduction of the mandatory 5-year in-service inspections would need to be implemented above current requirements. On the other hand, the 20-year out-of-service inspections would be much less rigorous than the same 20-year inspections on any of the Alternate 1 and 2 options, as the tank shell is fully visible and accessible; the inspection of the lower dome would be similar. As with Alternatives 2A and 2B, this alternative would not require an upgraded inventory / leak detection system which would also save time and effort associated with these additional operational and maintenance requirements.

Given the radical change in operations and maintenance requirements and procedures driven by the considerations stated above, the oversight of the facility would be operationally impacted beyond a reasonable degree and may require more than a 10 percent increase in manning, material and funding for proper operations and maintenance. The long-term cost associated with the sustainment of such a facility would result in an unfavorable Net Present Value as compared to other alternatives when producing a Business Case Analysis, which is irrespective of the clean inspect and repair costs covered under the TIRM section.

Standard Operating Procedures currently written for the Red Hill tanks would require a complete overhaul due to the wholesale changes in the operations and maintenance requirements and procedures of the complete redesign of this tank system. This would include physical patrols and/or automated means/systems of monitoring the interstitial spaces and reporting systems as well as specific tailored response procedures (as required by the AOC) if a fluid is detected and significant resource requirements for routine maintenance of the outer shell of the tank and the current steel liner of the existing tanks for secondary containment. As the projected increase in cost exceeds 10%, this Alternative 3A has earned a “Mostly Does Not Meet Criteria” rating.

Rating: Mostly Does Not Meet Criteria

6.10.17 Tank Upgrade Construction Cost Estimate (Planning Level)

This attribute provides stakeholders with pertinent information on overall project execution cost, for the number of total tanks in a given upgrade alternative. These estimates are derived by compiling the projected cost for one tank constructed as a part of multiple tank repair contracts. The single tank cost is then used to develop the cost of each grouping of tanks, escalated to the midpoint of construction of each grouping. Government costs, design costs, construction contingencies, and Title II costs are not included. These estimates are for the physical tank upgrade portion of the overall project and do not include any electronic, volumetric / mass measurement type release detection system or fiber optic communication system.

Details of the explicit cost derivation for each TUA is presented in PART I - Cost Estimates. The cost of Alternative 3A is estimated to be [redacted] per tank NPV.

This attribute is for informational purposes, no ratings are applied to Attribute 17.

Rating: Not Rated

6.10.18 Tank Upgrade Duration

Upgrade duration is determined as an estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). For rating purposes, the Navy designated the baseline for each upgrade cycle as **three** tanks undergoing upgrade at a time utilizing two 10-hour shifts per day for six days a week.

Any TUA that cannot meet the Red Hill AOC SOW deadline for compliance without changing any of these parameters will receive a rating commensurate with the level of change. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one parameter as the determining rating factor for any TUA not meeting compliance with the above stated parameters. However, with the overarching mandate to maintain at least 15 tanks in service at all times during upgrade execution, the tanks per cycle variant is capped at five tanks per cycle and other parameters would require adjustment accordingly.

PART G - Construction Execution Considerations, provides the details by which the project execution duration conclusions were estimated.

The specific tank and cycle times for Alternative 3A upgrades, inclusive of all contingency factors, are estimated at 1.0 years per tank or 3.2 effective years per **five**-tank cycle. Taking all contingency factors into consideration, the estimated compliance date for all in-service tanks to be upgraded via the Alternative 3A concept is 2034.9. The project duration is approximately 19.6 years with a project completion date of 2038.1.

Rating: Somewhat Meets Criteria

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PART F - BAPT TANK UPGRADE MATRIX

TABLE F-1
BAPT TANK UPGRADE MATRIX

Attribute	Attribute Definition (Criteria for Evaluation of Alternative)	Rating System	TUA Rating					
			1A	1B	1D	2A	2B	3A
Category: General								
1. Constructible	Alternative can be constructed in field at Red Hill using practicable construction means and methods. Practicable must recognize the difficulty in bringing construction materials into the tanks through the limited access Upper Tunnel, or other methods as may be developed for individual alternatives, as well as the degree of difficulty in accessing the tank surfaces for the inspection and repair process.	• **Meets Criteria:** Has been done before at Red Hill, can be constructed within the confines of Red Hill with no impact/modification to the Red Hill infrastructure or physical arrangement.	X	X				
		• **Mostly Meets Criteria:** Has been done elsewhere but not at Red Hill, requires some impact/modification to the interior of Red Hill tanks and/or infrastructure such removal or installation of steel liner plates, or as boring through the Lower Dome to install new tank nozzles.						
		• **Somewhat Meets Criteria:** Has been done elsewhere but not at Red Hill, requires extensive modification to Red Hill infrastructure such as drilling shaft down to the top of the tank to bring power/concrete into tank, new access to tunnel system, new access to tanks.				X		X
		• **Mostly does Not Meet Criteria:** Has not been done before elsewhere, plus requires same major infrastructure or physical modification as defined above.			X		X	
		• **Does not Meet Criteria:** Rating not applicable.						
2. Testable	Alternative can be tested and shown acceptable during construction prior to filling and during startup/commissioning when filling. **Note**: "Testable" further refined by Attribute 13.	• **Meets Criteria:** Alternative can be shown to meet hydraulic and structural integrity standards prior to being place into service.	X	X	X	X	X	X
		• **Does not Meet Criteria:** Alternative cannot be shown to meet hydraulic and structural integrity standards prior to being place into service.						
3. Inspectable	Alternative can be inspected to determine integrity on a periodic basis while tank is in service or out of service. **Note**: Inspection requirements for each TUA further refined in the TIRM and Attributes 14 & 15.	• **Meets Criteria:** TIRM can be developed using industry standard inspection techniques.	X	X	X	X	X	X
		• **Does not Meet Criteria:** Inspection techniques not readily available.						

TABLE F-1 BAPT TANK UPGRADE MATRIX								
Attribute	**Attribute Definition (Criteria for Evaluation of Alternative)**	**Rating System**	**TUA Rating**					
			1A	**1B**	**1D**	**2A**	**2B**	**3A**
4. Repairable	Alternative can be repaired in field at Red Hill using standard, traditional construction/repair means and methods.	• **Meets Criteria:** Removal or modification of the Red Hill infrastructure is not required to gain access to the tank. All interior surfaces of the primary tank, tank nozzles, internal components, and secondary containment are accessible for repair. Repairs can be performed from inside the tank or secondary containment without having to remove part of the primary tank or internal component to access an area for repair.	X	X	X			
		• **Mostly Meets Criteria:** Removal or modification of the Red Hill infrastructure is not required to gain access to the tank. Interior and exterior surfaces of the primary tank, internal components, and secondary containment are accessible for repair. Repairs can be performed from inside the tank or secondary containment. Requires removal of part of the primary tank or component to access an area for repair.						X
		• **Somewhat Meets Criteria:** Removal or modification of the Red Hill infrastructure is required to gain access to the tank. Only interior surfaces of the primary tank and internal components are accessible for repair. Repairs can only be performed from inside the primary tank or component to access an area for repair.				X	X	
		• **Mostly does Not Meet Criteria:** Removal or modification of the Red Hill infrastructure is required to gain access to the tank. Only select areas of the tank can be repaired						
		• **Does not Meet Criteria:** No area of the tank is accessible for repair.						
5. Practicable	Alternative can be done or put into practice successfully in the time frame required by the Red Hill AOC SOW given the confines and associated infrastructure of the facility with reasonable expectations that meet stakeholder cost/benefit analysis parameters.	• **Meets Criteria:** Alternative can be constructed within the confines of Red Hill with no impact/modification to the Red Hill infrastructure or physical arrangement at a cost within **250%** of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.	X					
		• **Mostly Meets Criteria:** Alternative can be constructed within the confines of Red Hill with minimal impact/modification to the Red Hill infrastructure or physical arrangement at a cost between **250% and 500%** of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.		X				
		• **Somewhat Meets Criteria:** Alternative can be constructed within the confines of Red Hill with moderate impact/modification to the Red Hill infrastructure or physical arrangement at a cost between **500% and 1,000%** of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.						
		• **Mostly does Not Meet Criteria:** Alternative can be constructed within the confines of Red Hill with significant impact/modification to the Red Hill infrastructure or physical arrangement at a cost between **1,000 and 2,000%** of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.			X	X	X	X
		• **Does not Meet Criteria:** Alternative cannot be constructed within the confines of Red Hill without detrimental impact/modification to the Red Hill infrastructure or physical arrangement at a cost that **exceeds 2,000%** of status quo CIR estimates and in the time frame set by the Red Hill AOC SOW.						

TABLE F-1 BAPT TANK UPGRADE MATRIX								
Attribute	**Attribute Definition (Criteria for Evaluation of Alternative)**	**Rating System**	**TUA Rating**					
			1A	**1B**	**1D**	**2A**	**2B**	**3A**
6. Corrosion Damage Mechanism	Alternate has a coating system that provides corrosion protection or is constructed of a corrosion resistant material.	• **Meets Criteria:** – 100% of the interior (product side) of the tank is coated or is constructed of corrosion resistant material. – Interior of existing nozzles is 100% coated or is constructed of new piping designed for a 70+ year life.		**X**				**X**
		• **Mostly Meets Criteria:** – 100% of the interior (product side) of the tank is coated or is constructed of corrosion resistant material. – Interior of existing nozzles is not coated or is not constructed of new piping designed for a 70+ year life.			**X**	**X**		
		• **Somewhat Meets Criteria:** – The lower dome (product side) of the tank is coated or is constructed of corrosion resistant material. – Interior of existing nozzles is 100% coated or is constructed of new piping designed for a 70+ year life. – The barrel and upper dome are not coated or constructed of corrosion resistant material	**X**				**X**	
		• **Mostly does Not Meet Criteria:** – The lower dome (product side) of the tank is coated or is constructed of corrosion resistant material. – Interior of existing nozzles is not coated or is not constructed of new piping designed for a 70+ year life. • The barrel and upper dome are not coated or constructed of corrosion resistant material						
		• **Does not Meet Criteria:** – The lower dome, barrel, upper dome are not coated and are not corrosion resistant material – Interior of existing nozzles is not coated or is not constructed of new piping designed for a 70+ year life.						

TABLE F-1
BAPT TANK UPGRADE MATRIX

Attribute	Attribute Definition (Criteria for Evaluation of Alternative)	Rating System	TUA Rating					
			1A	1B	1D	2A	2B	3A
7. **Successful Implementation Elsewhere**	Alternative has been put into place at other large fuel depots and is successful in preventing leaks to the environment and/or detecting leaks.	• **Meets Criteria:** Alternative used at other large fuels depots, would be successful in preventing leaks and would be successful in detecting leaks at Red Hill.				X		X
		• **Mostly Meets Criteria:** Alternative used at other large fuels depots and would be successful in preventing leaks at Red Hill.	X	X				
		• **Somewhat Meets Criteria:** Alternative used at other large fuels depots and would be successful in detecting leaks at Red Hill.						
		• **Mostly does Not Meet Criteria:** Alternative not used at other large fuels depots, but would be successful in preventing leaks and/or detecting leaks.			X		X	
		• **Does not Meet Criteria:** Alternative not used at other large fuels depots and would not be successful in preventing leaks and/or detecting leaks.						
8. **Reliability**	Ability of Alternative to perform its required function (hold product) under stated conditions for a specified minimum period, which is defined as the next out-of-service internal inspection interval.	• **Meets Criteria**: Can be relied upon to perform its function until the next inspection at a minimum.	X	X	X	X	X	X
		• **Does not Meet Criteria**: Cannot be relied upon to perform its function until the next inspection.						
9. **Impact on Storage Volume**	If the Alternative results in a reduction in volume, the reduction is presented as a percent reduction in volume compared to the existing overall facility volume and the reduction in volume is presented. The impact on any volume reduction is not rated.	• **Alt 2A** – Reduction in Volume after Alternative 2A upgrade: Tanks 2 to 4: 48,885 Bbl reduction per tank (17.1% reduction) Tanks 5 to 18 and 20: 65,671 Bbl reduction per tank (21.8% reduction) – Increase in Volume after Alternative 2A upgrade: Tank 1 and 19: 236,263 Bbl increase per tank (currently out of service) – Net Change in Volume after Alternative 2A upgrade: System (Tanks 1-20) 659,194 Bbl net reduction (12.2% net reduction) • **Alt 2B** – Same reduction in volume as Alt 2A • **Alt 3A** – Reduction in Volume after Alternative 3A upgrade: Tanks 2 to 4: 80,561 Bbl reduction per tank (28.2% reduction per tank) Tanks 5 to 18 and 20: 83,750 Bbl reduction per tank (27.7% reduction per tank) – Increase in Volume after Alternative 3A upgrade: Tank 1 (currently out of service): 204,587 Bbl increase after upgrade Tank 19 (currently out of service): 218,184 Bbl increase after upgrade – Net Change in Volume after Alternative 3A upgrade: System (Tanks 1-20) 1,075,162 Bbl net reduction (19.97% net reduction)	**0.0%**	**0.0%**	**0.0%**	**12.2%**	**12.2%**	**20.0%**

TABLE F-1 BAPT TANK UPGRADE MATRIX								
Attribute	**Attribute Definition (Criteria for Evaluation of Alternative)**	**Rating System**	**TUA Rating**					
			1A	**1B**	**1D**	**2A**	**2B**	**3A**
Category: Environmental Considerations								
10. Provides Secondary Containment	Alternative provides secondary containment of a release from the primary tank. The primary tank is the wall of the tank that provides primary containment, e.g. the wall of a single wall tank or the inner wall of a double wall tank. **Note**: Under 2015 EPA 40 CFR 280 final rule, secondary containment is not required for field-erected tanks larger than 50,000 gallons. **Note:** For the purpose of evaluation, a tank that is configured such that the exterior surface of the shell/roof if visibly inspectable, is considered an aboveground tank.	• **Meets Criteria:** – UST: Meets 40 CFR 280 criteria for secondary containment (i.e. has an inner and outer barrier with an interstitial space that is monitored for leaks). – AST: Meets 40 CFR 112 requirements for secondary containment (i.e. sufficiently impermeable barrier and contains the full volume of the container plus precipitation).				X	X	X
		• **Does not Meet Criteria:** Does not meet either of the above criteria.	X	X	X			
11. Dependency on Existing Tank Steel Liner Integrity	Alternative is not dependent on the hydraulic integrity of the existing tank liner to contain product (primary tank) or provide a barrier between a breach of the primary tank, and the environment (i.e. interstitial space boundary, or dike wall/floor secondary containment boundary.	• **Meets Criteria:** Alternative does not rely on the hydraulic integrity of the existing tank liner to contain product.			X			
		• **Mostly Meets Criteria:** Alternative does not rely on the hydraulic integrity of the existing tank liner to contain product, but relies on existing tank liner to serve as the outer barrier of an interstitial space or as secondary containment.				X	X	X
		• **Somewhat Meets Criteria:** Alternative relies on both the hydraulic integrity of the existing tank liner and the hydraulic integrity of the tank upgrade.						
		• **Mostly does Not Meet Criteria:** Alternative relies on the hydraulic integrity of the existing tank liner to contain product, but includes an upgrade such as an internal lining to enhance the hydraulic integrity of tank to contain product.		X				
		• **Does not Meet Criteria:** Alternative is solely dependent on the hydraulic integrity of the existing tank to contain product.	X					

TABLE F-1 BAPT TANK UPGRADE MATRIX								
Attribute	**Attribute Definition (Criteria for Evaluation of Alternative)**	**Rating System**	**TUA Rating**					
			1A	**1B**	**1D**	**2A**	**2B**	**3A**
Category: Release Detection								
12. Release Detection Integral to Construction	Alternative has release detection capability that is integral to (i.e. is physically part of) the upgrade construction such as an interstitial space with monitoring, or visible / inspectable space such as a dike surrounding the tank. The complexity and ability to confirm integrity of the system are factored into the rating of the alternative **Note**: This attribute does not address the use of tank internal (volume and/or mass based technology) leak detection systems.	• **Meets Criteria:** The tank surfaces are nearly 100% visually inspectable for integrity and operability.						
		• **Mostly Meets Criteria:** A leak from the shell is visibly observable. A release detection system from the tank floor / lower dome is present, and can be tested by leak simulation.						X
		• **Somewhat Meets Criteria:** A release detection system (interstitial space) for the shell and floor is present, but cannot be directly observed for integrity. A means is present to simulate a leak or otherwise test the integrity of the release detection system operability.				X	X	
		• **Mostly does not meet criteria:** A release detection system (interstitial space) for the shell and floor is present, and it cannot be directly observed for integrity, and cannot be integrity tested using a leak simulation method.						
		• **Does Not Meet Criteria:** No release detection system is a part of the tank construction thereby triggering the necessity for alternative leak detection methods as mandated by 40 CFR 280.43.	X	X	X			

TABLE F-1 BAPT TANK UPGRADE MATRIX								
Attribute	**Attribute Definition (Criteria for Evaluation of Alternative)**	**Rating System**	**TUA Rating**					
			1A	**1B**	**1D**	**2A**	**2B**	**3A**
Category: Testing and Commissioning								
13. Testing and Commissioning Procedures	Alternative does not require rigorous level of testing and commissioning procedures to return the tank repair/upgrade to service. In this case, "placing the tank in service" are actions necessary for the first filling with fuel, performing commissioning steps, and determining the tank repair process was successful, declared liquid tight, and suitable for turning over to the Red Hill operator for use. The Release Detection System must be included in the testing process.	• **Meets Criteria:** The tank can be filled while continuously visually monitoring the shell surfaces for a breach of hydraulic integrity or evidence of structural failure, and the floor that cannot be directly visually monitored, can be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping).						X
		• **Mostly Meets Criteria:** The tank can be filled while floor and shell that cannot be directly visually monitored, can be monitored for a hydraulic integrity breach through a passive leak detection system (i.e. interstitial space with release detection piping).				X	X	
		• **Somewhat Meets Criteria:** The tank does not have a shell or floor secondary containment system with release detection piping, that can be continuously monitored for hydraulic integrity. Tank filling must be performed with numerous "hold points" with a duration sufficient to perform trend analysis for hydraulic integrity using tank inventory system. At the successful conclusion of the filling, a final hydraulic integrity test meeting the requirements established under Red Hill AOC SOW Section 4.5 is required prior to turning the tank over to the operator.	X	X	X			
		• **Mostly does Not Meet Criteria:** No means/procedures are possible to evaluate hydraulic integrity as a part of the filling process using the installed inventory system. A separate hydraulic integrity test meeting the requirements of Red Hill AOC SOW Section 4.1 is required at multiple filling "hold points" to determine hydraulic integrity during filling and prior to turning the tank over to the operator.						
		• **Does not Meet Criteria:** The tank cannot be monitored for hydraulic or structural failure during, or immediately after filling.						

TABLE F-1
BAPT TANK UPGRADE MATRIX

Attribute	Attribute Definition (Criteria for Evaluation of Alternative)	Rating System	TUA Rating					
			1A	1B	1D	2A	2B	3A
Category: Tank Inspection, Repair and Maintenance (TIRM) Requirements								
14. TIRM Requirements for Inspection and Repair of Existing Tank prior to application of Tank Upgrade	Alternative requires a level of inspection and repair of existing tank as specified in Red Hill AOC SOW Section 2.2 TIRM Procedures Report Appendix BD: UFGS 33 56 17.00 20 Inspection of Fuel Storage Tanks and Appendix BE UFGS 33 56 18.00 20 Repair of Red Hill Fuel Storage Tanks.	• **Meets Criteria:** Alternative requires same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report.	X	X				
		• **Mostly Meets Criteria:** Alternative relies on the integrity of the existing steel liner. As the existing steel liner cannot be inspected at future integrity inspections, Alternative requires a higher level of repair than Red Hill AOC SOW Section 2.2 TIRM Report.				X	X	
		• **Somewhat Meets Criteria:** Alternative relies considerably on the integrity of the existing shell, which can be re-evaluated on a periodic (20 year) re-inspection cycle. Alternative requires inspection of the existing tank steel liner and tank nozzles following industry standards and using conventional NDE methods (plate scanning for corrosion, and vacuum box testing in addition to visual inspection, ultrasonic examination) and repair of rejectable indications identified.						
		• **Mostly does Not Meet Criteria:** Alternative does not require same level of inspection and repair as described in Red Hill AOC SOW Section 2.2 TIRM Report. Alternative has limited dependence on integrity of existing steel liner. Alternative involves inspection of the existing steel liner following industry standards using only visual inspection and ultrasonic examination at spot locations. Repair of rejectable indications identified limited to repair of existing welds and isolated areas of the steel liner.						X
		• **Does not Meet Criteria:** Alternative does not rely on the integrity of the steel liner			X			

TABLE F-1 BAPT TANK UPGRADE MATRIX								
Attribute	**Attribute Definition (Criteria for Evaluation of Alternative)**	**Rating System**	**TUA Rating**					
			1A	**1B**	**1D**	**2A**	**2B**	**3A**
15. TIRM Requirements for Future Integrity Inspections	Alternative does not require rigorous level of inspection, and/or access provisions to complete integrity inspections and maintain the system.	• **Meets Criteria:** Tank welds, shell and roof can be competently inspected visually, from outside the tank, and floor welds and steel liner can be inspected from inside the tank visually and with conventional floor scanning equipment, all following traditional integrity investigation protocol outlined in API 653.						
		• **Mostly Meets Criteria:** Tank Shell and roof can be competently inspected visually, from outside the tank, and floor welds and steel liner can be inspected from inside the tank visually and with modified conventional equipment and procedures, all following traditional integrity investigation protocol outlined in API 653.						X
		• **Somewhat Meets Criteria:** Tank shell, upper dome and lower dome welds and liner must be inspected from inside the tank visually and with modified conventional equipment and procedures, all following traditional integrity investigation protocol outlined in API 653. Access to all surfaces requires special procedures.			X	X	X	
		• **Mostly does Not Meet Criteria:** Tank primary shell including upper dome, barrel and lower dome welds and liner require much more rigorous visual and scanning inspection protocol using special equipment and procedures to access the surfaces.	X	X				
		• **Does not Meet Criteria:** Inspection to determine integrity is not possible.						
Category: Operation and Maintenance								
16. Impact on Operating and Maintenance Requirements and Procedures	Current means of filling, emptying, or management of a static tank condition, or tank periodic testing is not impacted by the Alternative upgrade. If the Alternative results in an impact to operational requirements, the increase is presented as a percent growth in required resources compared to the existing overall facility sustainment requirements. The impact on any operational parameter is rated in accordance with the resource requirement estimates as provided during interviews with NAVSUP. **Note**: This attribute is not intended to address long term "non-routine" maintenance that is evaluated under the TIRM approach.	• **Meets Criteria:** Has **little to no** impact to the current means of filling, emptying, or management of a static tank condition, operational requirements for periodic tank testing or expenses towards labor or material for operations and/or maintenance.	X	X	X	X	X	
		• **Mostly Meets Criteria:** Requires **<5% increase** in operational requirements (i.e. filling, emptying or management of a static tank condition) such as additional expenses for labor and materials for operations and/or maintenance.						
		• **Somewhat Meets Criteria:** Requires **5-10% increase** in operational requirements (i.e. filling, emptying or management of a static tank condition) such as additional expenses for labor and materials for operations and/or maintenance.						
		• **Mostly does Not Meet Criteria:** Requires **>10% increase** in operational requirements (i.e. filling, emptying or management of a static tank condition) such as additional expenses for labor and materials for operations and/or maintenance.						X
		• **Does not Meet Criteria:** Tank cannot be operated or maintained.						

TABLE F-1
BAPT TANK UPGRADE MATRIX

Attribute	Attribute Definition (Criteria for Evaluation of Alternative)	Rating System	TUA Rating					
			1A	1B	1D	2A	2B	3A
Category: Construction								
17. **Tank Upgrade Construction Cost Estimate (Planning Level)**	An execution cost estimate of one tank constructed as a part of a multiple tank repair contract. Government costs, design costs, construction contingencies, Title II, and release detection system costs are not included.	• **No rating applied:** Cost is reported for decision makers to evaluate.	*Not Rated*					
		Cost per Tank (FY18) (Million dollars)	[redacted]					
		Life Cycle Cost (50-years) (Million dollars)						
18. Tank Upgrade Duration	An estimate of execution time for one tank upgrade, and combinations of tank upgrades inclusive of typical government contracting time requirements as compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). **Note**: Baseline estimation parameters designate each upgrade cycle to be considered as three tanks undergoing upgrade at a time with two 10-hour shifts per day at six days a week. Actual cycle times will be determined by specific TUA requirements and may overlap if/when feasible.	• **Meets Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame utilizing a **three** tanks per cycle phasing with two 10-hour shifts per day at six days a week.	X	X				
		• **Mostly Meets Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame utilizing a **four** tanks per cycle phasing with two 10-hour shifts per day at six days a week.			X	X	X	
		• **Somewhat Meets Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame utilizing a **five** tanks per cycle phasing with two 10-hour shifts per day at six days a week.						X
		• **Mostly does Not Meet Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame requiring **more than a five** tanks per cycle phasing with two 10-hour shifts per day at six days a week.						
		• **Does not Meet Criteria:** Tank upgrade duration for all the required number of tanks is projected to meet the Red Hill AOC SOW mandated time frame requiring **more than a five** tanks per cycle phasing and additional parameter alterations.						

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PART G - CONSTRUCTION EXECUTION CONSIDERATIONS

1.0 SITE ACCESS

1.1 Delivery of Construction Materials

Access to Red Hill is currently available at the manned guard shack next to Halawa prison and through the privatized Army housing area. There are two roads; the guard house entrance is connected to the lower access road and the privatized housing area gate connects to upper access road with direct access to Adit 4. Mobilizing personnel and material through existing guard shack will be acceptable for Alternatives 1A and 1B. It would be safer and easier to move the long, heavy steel plates required for Alternatives 1D, 2A, 2B, and 3A through the housing area to Adit 4. Moving heavy large trucks up the extremely narrow and steep road from lower access road to upper access road is not ideal and contractor would probably want to avoid it. The lower access road has direct access to Adits 3 and 6, but neither of these locations would facilitate getting the plates to the upper tunnel where the tank access manways are located.

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[redacted]

Figure G-1.0-1 Red Hill Topography Map of Roads, Adits, and Access Points

1.2 Contractor Yard and Laydown

Existing contractor yard and laydown area outside Adit 4 is sufficient for Alternatives 1A and 1B but will not be large enough to stage steel plate and/or concrete batch plant required for Alternatives 1D, 2A, 2B, and 3A. The hill directly behind Adit 4 is quite steep so expanding this area will be difficult and costly. There is an area that is relatively flat just inside the gate at military housing. This area could be used as laydown area but arrangements would have to be made to open or man the gate as required. It would be prudent to include removal of building 349, clearing and providing new pavement, guard rail barriers, and overall civil site improvements outside Adit 4 for any TUA project chosen to expedite work and increase contractor safety.

1.3 Tunnel Access, Staging, and Material Handling

Historically, the largest challenge Red Hill tank contractors have faced is the difficulty moving personnel, material, and equipment into the tunnel and into the tanks. Multiple contractors have sufficient experience with personnel and material handling necessary for Alternatives 1A and 1B. However, no contractor has worked through the logistics of moving, locating and welding large steel angles, I-beams or plates inside the tanks. The largest single repair to date was approximately 15 feet high x 6 feet wide. This is equivalent in size to one of approximately 600 plates that would be required for Alternatives 1D, 2A, 2B, and 3A.

All Material must pass through this door

Adit 4 laydown area, Building 349 is abandoned

For Alternatives 1D, 2A, 2B, and 3A, the contractor would have to design and install a conveyance system to move steel from Adit 4 to the tank manholes. Options considered include installing an overhead monorail system for steel plate handling, purchasing rail car locomotive to utilize the existing rail system in the Upper Tunnel and an electrical vehicle conveyance system. Naturally, there are issues with designing, installing and operating any of these conveyance methods. There are existing train tracks that run up the middle of the tunnel but these tracks do not split off toward the tanks and have not been used in over 20 years. An overhead monorail system would probably have to relocate existing ceiling mounted utilities such as electrical trays and fire sprinkler lines. A mechanized means to safely move plates on the monorail would be required. Tunnel width would limit the number of electric vehicles that can traverse back and forth in the tunnel. Both electric vehicles and rail car methods have potential to create tunnel congestion because they occupy tunnel space going back and forth. A method to load steel plates onto rail car or electric vehicles at Adit 4 and unload at the tank gallery would have to be devised. The monorail system could be designed to operate from outside Adit 4 directly into the tank being worked on. All reconfigured tanks will need some sort of conveyance system.

A serious consideration when determining the conveying method for steel plate is the distances that these steel plates need to be moved. The closest tanks, Tanks 1 and 2, are approximately 600 feet from the door at Adit 4. The farthest tanks, Tanks 19 and 20, are approximately 2400 feet away and have a steady incline to get there. This is almost a half mile that materials need to be moved in a 12-feet wide and 12-feet tall tunnel. The first six hundred feet of access from Adit 4 to Tank 1 will be a limiting factor as all materials will enter through here. Adit 5 is not being considered for material access because there is insufficient staging area in front of the Adit and it is surrounded by steep hills (see topography above).

12-feet wide x 12-feet high tunnel inside Adit 4 door

Second access door before entering tank gallery.
This door and wall is required for ventilation system.

Looking down tunnel center below Tanks 1-2
Tank Gallery with no contractor equipment. Galleries are 200 feet apart

Tank 5 gallery with contractor activity

Looking down tunnel center below Tanks 1-2

Water pipe, sprinkler heads and electrical utilities impede access

Manhole on an in-service tank. Concrete pipe at left is tank vent pipe going under the floor. Ladder provides access to the gauging gallery at the top of the tank. All materials must be loaded through manhole. Note tank ventilation pipe left of the ladder.

All materials must be loaded through the 8-feet diameter tank manhole

2.0 TANK ACCESS CONSIDERATIONS FOR ALTERNATIVES 1D, 2A AND 3A

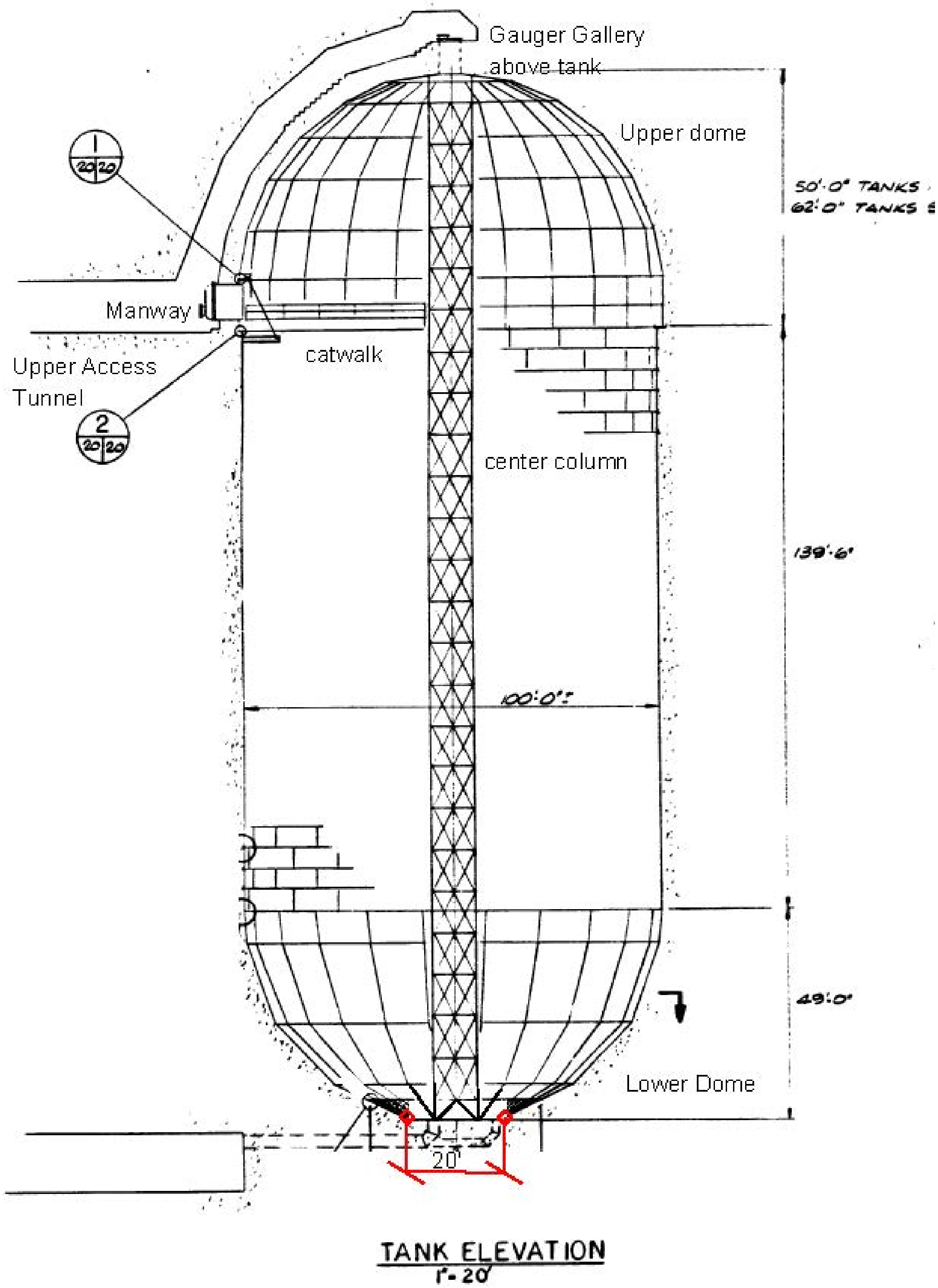
Drilling new tank access shafts was considered as a method to overcome the limitations of the existing tunnel access. A 12-inch to 24-inch diameter bore hole could be drilled from the top of Red Hill ridge down 100 feet to 175 feet to the top of the upper dome of each tank. This bore hole could be lined to provide tank access from above. A bent pipe (goose neck) could be installed at the top of the hill to prevent rain water and debris from entering the tank. This access could be used to increase tank venting for coating and welding operations. It could also be used as required for construction, such as concrete conveyance, and electric lines.

Consideration of boring an access shaft from the lower access tunnel into the bottom of the tank was also considered. Concrete coring equipment have been used to core 4-feet wide bore holes. There may be limits to the length and angle these units can achieve. Any reduction of structural tank integrity would also need to be considered.

Boring a 12-feet diameter hole from the top of the hill into the tank to provide access for steel plate and increase ventilation was also considered. This would alleviate tunnel congestion and reduce need for laydown area outside Adit 4. The main drawback to creating this access shaft is that the tank center tower structure would interfere and require modification or removal.

3.0 STAGING CONCEPTS FOR WORK INSIDE TANKS

As noted above, exceptional effort will have to be made to get equipment and materials to the tank manholes. Once there, the existing manholes are 2.5 feet above existing tunnel floor and 8-feet diameter. Once inside the manhole, material, equipment and personnel are 180 feet above the tank floor and limited to one 5-feet wide catwalk to the center tower and a small access platform. Contractors have successfully developed work methods and access means for Alternatives 1A and 1B repair alternatives. Alternatives 1D, 2A, 2B, and 3A will require a much different, more robust approach. There are several ways the contractor could design and install support structures for personnel, equipment and material. An access platform spanning the entire tank could be constructed at the current level of the catwalks. For alternatives 2A, 2B, and 3A in which the manhole will not be part of the hydraulic barrier of the tank, the contractor could remove the manway and remove concrete to the tunnel floor leaving a tombstone shaped entrance passage way. A coordinated design will have to be prepared that develops the plan to move steel plate from outside the tunnel into the desired tank.


Gauger Gallery
above tank
Upper dome
50'-0" TANKS
62'-0" TANKS
Manway
catwalk
Upper Access
Tunnel
center column
139'-6'
100'-0"
49'-0"
Lower Dome
20'
TANK ELEVATION
1"=20'

Catwalk and Small Access Platform from Tank Manhole. Note boom on right hand side.
Photo was taken from basket on boom.

3.1 Center Tower Booms and Baskets

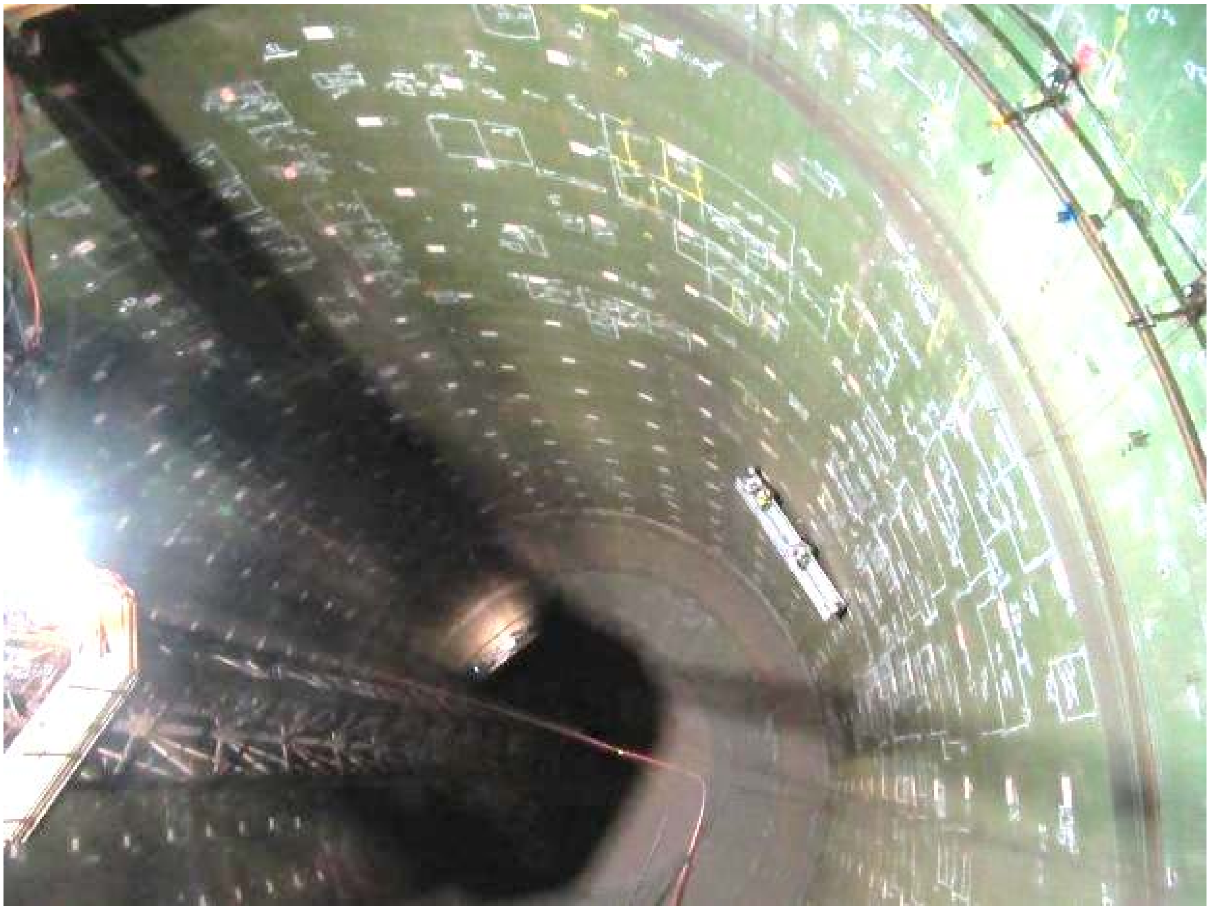
Historically contractors have installed booms with personnel platforms on the center tower for workers to clean, inspect, and repair the tanks. Typically, a personnel platform is first installed inside the center tower to inspect the tower. Once it is determined that the center tower is structurally sound, articulating booms with personnel platforms are bolted to the center tower. These booms can be designed to reach the tank barrel and upper dome. The boom is articulated by an operator on the catwalk who raises and lowers the boom and extends the boom to the tank wall. The personnel platforms can also be lowered to the tank floor for workers to access the tank floor for repairs. As booms can articulate 180 degrees, only two booms can be installed otherwise booms would overlap and personnel platforms could become tangled.

3.2 Conventional Staging

Conventional scaffolding would not be required for Alternatives 1A and 1B. Scaffolding would be a consideration for Alternatives 1D, 2A, 2B, and 3A to support plate positioning and tank welding efforts. The shape of the lower dome, however, makes installation of traditional scaffolding difficult. The tank bottom plate is 20-feet in diameter and the dome plates start curve steeply up to the tank barrel. Standard scaffolding is best when there is a flat plane as basis for installation. Special design and installation would be required to accommodate the sloping sides of the lower dome.

3.3 Monorail with Multiple Suspended Platforms

Several variations of monorail systems have also been used to perform work in Red Hill tanks. Structural support brackets are welded to tank shell to support a rail that circles the tank. Typically, the articulating boom baskets are installed first to provide access to tank wall for monorail support installation. Once the rail is installed, platforms can be suspended from the rail and raised and lowered to provide access to the tank wall. This type of monorail can increase work efficiency by improving access to the tank walls. Current contractor has installed a monorail at the upper dome spring line and is utilizing it for tank wall inspection. Other contractors have supported sand blasting crawlers from the monorail to coat the lower dome. As seen the photo below, current monorail has two platforms attached and in operation. This lightweight monorail system can be utilized for alternatives 1A and 1B but it is not designed to move the weight of steel necessary for Alternatives 1D, 2A, 2B, and 3A. The concept is viable for moving steel plates, however, the contractor would need to design a monorail for additional weight. Consideration could also be made to have a dual monorail system, with the inner monorail equipped with heavy capacity trolley and hoists, to maneuver the plates, and the second monorail for support of the work platforms. Ultimately, the choice of material and personal handling comes under contractor methods and means, and would be the responsibility of the contractor. Any staging, monorails, hoists and platforms come under strict NAVFAC and OSHA design criteria and requirements.



Personnel Platform utilizing Monorail System at Top Right.

3.4 Tank Conveyance Systems

Alternatives 1D, 2A, 2B, and 3A require a conveyance system to move steel plate from access point to the location it is needed. One method to achieve this would be to design and install a monorail system as describe above. This system would be designed to pick up steel plate from the manway in the Upper Tunnel and safely lower the plate into position at the necessary location in the tank. This monorail would be similar in design but structurally enhanced to handle the weight of the steel. The monorail would also have to match the diameter of the new tank shell to be effective. Another way would be to structurally enhance the center tower and articulating booms so they are capable of safely lowering steel plate to the location desired. Complete analysis of existing center tower to determine if the center tower can support added weight would have to be performed. Strengthening of the center tower would most likely be required.

4.0 TANK VENTILATION AND DEHUMIDIFICATION

There are two separate and distinct ventilation systems installed for Red Hill. The tunnel ventilation system which provides fresh air movement for all tunnel locations and the tank ventilation system which provides venting of the tanks.

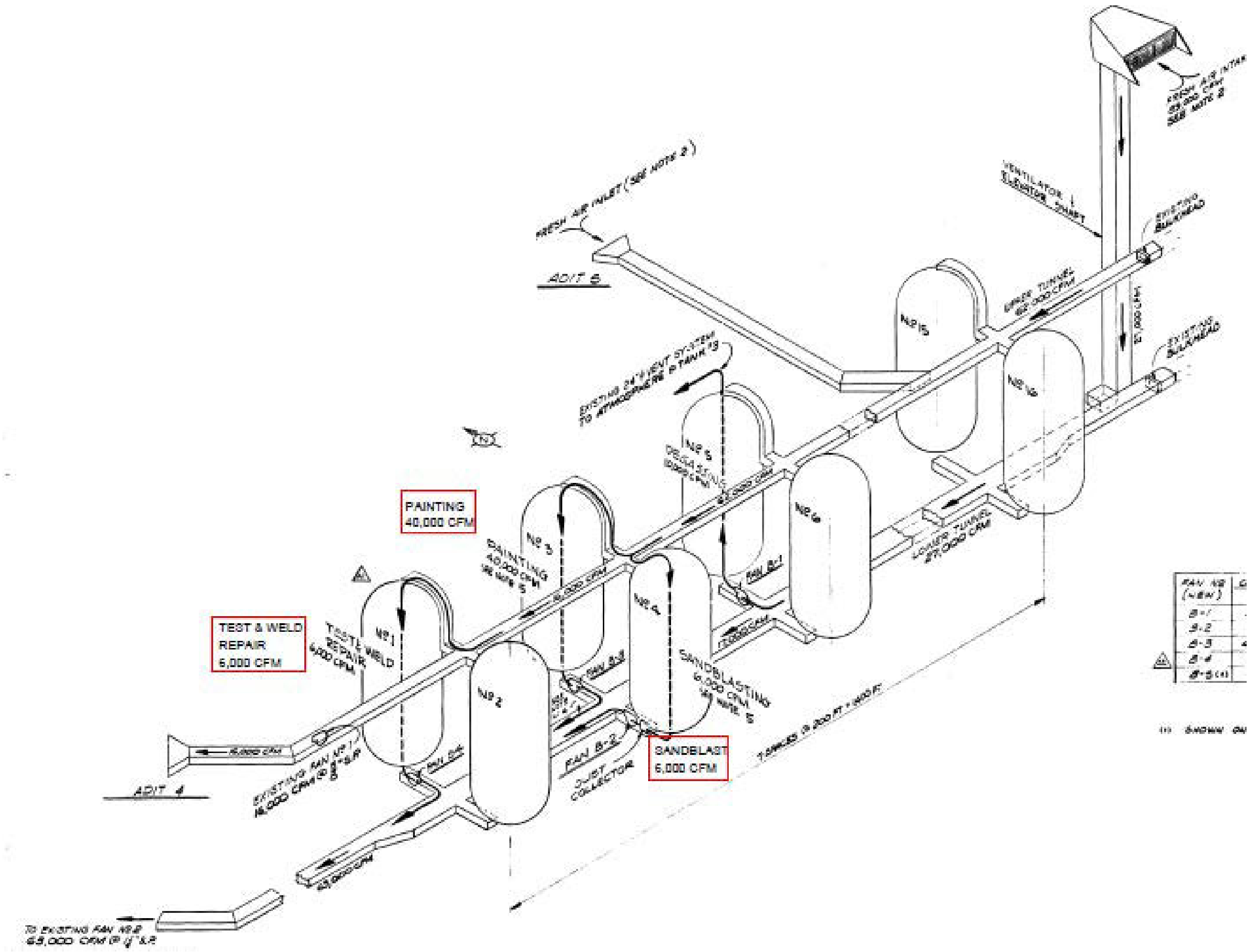
Tunnel ventilation is provided for personnel in the tunnel. Tunnel ventilation for Red Hill tank area was originally provided by two fans, one in the Upper Tunnel below Tanks 1 and 2 and one in the Lower Tunnel near the wye in Adit 3. A large, fresh air intake shaft daylights on the top of the Red Hill between Tanks 15 and 17. This shaft provides fresh air intake for both Upper and Lower Tunnels. For the Lower Tunnel, there is an exhaust portal above the water pumping station just inside Adit 3. For the Upper Tunnel, the exhaust goes out Adit 4. By design, the air flow in the Lower Tunnel is greater than the airflow in the Upper Tunnel.

Originally tank venting was accomplished by a 24-inch vent pipe encased in Gunite that runs from the top of each tank in the gauging gallery down to Upper Tunnel. The pipe then continued under the floor of the Upper Tunnel where it connected to the 24-inch tank vent header pipe that runs under the floor the entire length of the Upper Tunnel. Three 20-inch vent pipes run from the top of the tanks to the surface. These vent pipes are located at Tanks 2, 3 and 19. The vent pipes daylight into bombproof structures on the top of Red Hill.

When Tanks 17-20 were changed to distillate fuel service, tank and tunnel venting were modified. Under floor tank venting was severed by removal of pipe and placing concrete at the new bulkhead wall below Tanks 17-18. Venting for Tanks 17, 18 and 20 was changed from underfloor to overhead pipe with spectacle blinds that could be used to isolate the tanks. The overhead vent pipe for Tanks 17, 18 and 20 was connected overhead to Tank 19 which has the 20-inch pipe running to the surface. Surface vent outlet was modified with flame arresters as required for distillate fuels. At the same time, the underfloor tank vent pipe between Tanks 13 and 15 was brought above the floor near Adit 5. This pipe was continued above the floor down the access tunnel were it daylights at Adit 5 entrance. Tunnel ventilation was also changed with the addition of an exhaust vent on the top of Red Hill and a fan at Adit 6. The airflow in this scenario pulls air in from Adit 6 and exhausts it on top of Red Hill which is the opposite for the other tanks. For Tanks 1-16, fresh air is pulled from the top of Red Hill and exhausted at Adits 3 and 4.

When a tank is opened for cleaning, the tank itself becomes an air duct that connects the Upper and Lower Tunnels. Depending on the location, blocking or opening tank vents must considered as part of the ventilation plan. In areas where tank vents are connected via underfloor pipe, the tank vent has to be closed so that no in-service tank vapors flow into the tank being worked on. Additionally, consideration of whether the air flows down from above or flows up to Adit 6 must be considered. Temporary ventilation schemes that utilize existing tank and tunnel venting components have been successfully developed and executed for all welding, blasting, and coating applications that have been accomplished to date. Typically, temporary fans connected to temporary flexible exhaust ducts are installed in the tunnel to increase air flow in the tank or in the area required. These fans and ducts have been developed for single tank activities and may not be sufficient if multiple tanks are undergoing tasks that require high air flow such as tank coating simultaneously in more than one tank. See an example of tank venting scheme developed by the Navy for Modernization of tanks 1-16 below. Note: cubic feet per minute (CFM) for welding and blasting was 6,000 CFM and painting was 40,000 CFM.

Existing Upper Tunnel Exhaust Fan
Note temporary construction venting duct above fan



Ventilation Scheme - Excerpt from NAVFAC drawing 7019559 dated 1985

4.1 Ventilation Requirements during Welding

OSHA section 1910.252 (c)(2)(ii) stipulates a minimum flow rate of 2000 CFM for each welder in a confined space. If this CFM is not achieved, airline respirators would be required. OSHA caveats this minimum requirement to say that adequate ventilation to prevent oxygen deficiency and buildup of toxic materials is also required, thus the minimum CFM may not be adequate. OSHA requires performance of air monitoring to protect welders and workers. Welding lead substrate could reduce air quality. There has been lead identified in some of the tanks, and welding to substrate that contains lead has special considerations.

Due to limited welding required for existing repair operations, ventilation during welding has not historically been an issue. Alternatives 1A and 1B should also have sufficient ventilation capability. For Alternatives 1D, 2A, 2B, and 3A which involve considerably more welding, the contractor may need to develop overall ventilation plan for proposed welding and welding operations, including consideration of installing vent ducting to the top of Red Hill.

4.2 Ventilation and Dehumidification Requirements during Coating

Ventilation requirements for coating operations will vary depending on product to be applied and ambient temperature and relative humidity. All personnel applying coating inside the tanks after abrasive blasting will be outfitted with full face respirators with Type C NIOSH approval, thus ventilation will be for coating purposes, not personnel safety. Novolac products require venting but do not specify required air changes per hour. Industry rules of thumb recommend 1.5 to 3 air changes per hour for desiccant dehumidifiers and 2 to 4 changes per hour for refrigerant based dehumidifiers. (7) Using an approximate tank volume of 1,684,000 cubic feet, 40,000 CFM will provide approximately 1.5 air changes an hour. This is assumed to be acceptable as it has been successfully utilized the past coating applications.

5.0 ELECTRICAL POWER FOR CONSTRUCTION

5.1 Existing Electrical Power at Red Hill

Recent tank cleaning, inspection, and repair projects at Red Hill tanks have identified critical deficiencies in obtaining power for construction. Recent projects for Red Hill have indicated that there will be no power supply available to contractors in the immediate area. Due to concerns with power availability to satisfy a major tank repair program, of up to five tanks at a time, an evaluation into anticipated power loads and alternative means of providing for this load needs to be performed, including:

- Contractor supplied diesel driven generators and compressors
- Government sanctioned, contractor built temporary power primary voltage pole line from Adit 3 to Adit 4.

5.2 Temporary Overhead Power Supply

The Red Hill Fuel Storage Facility receives its electric power at Adit 3 via two Hawaiian Electric Company (HECO) 11.5 kV overhead feeder circuits originating in the HECO Hila Substation. One line is normally feeding the facility with the other as a redundant backup. It is assumed that the HECO Substation has sufficient capacity to support both lines simultaneously, and that the redundant line can be used to supply the temporary overhead line to the Adit 4.

One alternative for providing temporary construction power is to extend the existing 11.5 kV overhead power lines from privatized housing area to Adit 6. This 11.5 kV circuit is currently fed from Navy transformer outside Adit 3. The Navy has already started installing poles for this temporary power line to provide power for the 1000 KVA transformer installed for the fire protection building across from Adit 6. However, the Navy does not have a formal project or funding set aside to complete the work. Another alternative for primary power supply is to have HECO install temporary power lines on poles from the Halawa valley industrial complex to Adit 6 area. Easement issues through the valley would need to be resolved prior to this installation.

Assuming a 12 KV feed line can be obtained from either HECO or Navy overhead lines, the contractor can install electrical distribution equipment at Adit 6 to support construction work. An existing clean, inspect, repair contractor has developed a preliminary concept plan that calls for installation of 1500 KVA transformer to step three-phase 11.5kV to 480V near Adit 6. From this transformer, an outdoor pad mounted distribution panel to support three compressors would also be located at Adit 6. Four 480V field hardened panel boards would be fed utilizing 4/0 AWG mining cables. These cables would be run in Adit 6 and then up or down the existing elevator shaft to provide construction power in both Lower and Upper Tunnels.

The contractor could install skid mounted power stations in the Upper Tunnel. These power stations are designed with breakers that can be used to feed specific equipment and four welding machines. Current estimate is 20 KVA for ventilator, 50 KVA per welding line, and 150 KVA for single dehumidifying unit.

In general Type W flexible cables would be used to feed equipment from the skid mounted power station. Temporary lighting will include general lighting using LED from the man-lift baskets or scaffolding for task lighting to attain 30-foot candles (300 lux) of illumination.

5.3 Diesel Engine Generators for Temporary Power

Diesel engines were considered for use to directly drive air compressors and as prime movers for electric generators. However, new EPA regulations establish air quality control requirements that make maintaining a generator for the duration of the tank repair process an excessive burden. At the end of 2014, EPA began requiring that stationary diesel engines in use at a single location for more than one year be factory certified as Tier 4. To meet Tier 4, every generator must have an emission control package consisting of selective catalytic reduction (SCR) and particulate traps/filters to clean exhaust air. The SCR and air filter packages increase maintenance necessary on generators and are detrimental to generators that are not run at full load.

Additional requirements for diesel engines used at one site for more than one year include:

- Having to go through a permitting process for each size of generator used for more than a year in each location.
- Having to supply and store liquid urea in addition to diesel. The volume of urea is approximately 1:8 compared to diesel (approximately 1 gal for 8 gal of diesel).
- Having a trained power plant operator.
- Maintaining equipment logs.
- Submitting reports to the State Department of Health Clean Air Branch.
- Permitting may also require air quality modeling of the point sources to determine if it is necessary to provide stacks to elevate the point of exhaust discharge to obtain desired dispersion of the exhaust plume. It may be necessary to do this in each location for each source.
- Possibly having to provide emissions monitoring.

Although the new EPA regulations make utilizing a generator as primary power source for the construction activity not efficient, generator use to cover any temporary for short term load reduction could be considered. If for some reason, multiple tanks had to be dehumidified simultaneously, a temporary generator could be used for to increase available power until work is complete.

5.4 Temporary Power Conclusion

It is anticipated that three to five tanks could be worked on simultaneously, and that 1500 KVA transformer will be sufficient to support contractor efforts for all alternatives. Each tank would have a skid mounted power station that would provide safe electrical connection capability in the upper tunnel. If more than four welders are required simultaneously, multiple stations can be installed. The contractor would have to stagger work tasks to limit electrical load within 1500 KVA primary electrical power or provide temporary standalone generators to increase power for short periods as needed for work effort.

6.0 CONSTRUCTION DURATION

Construction duration is determined as an estimate of total execution time for one tank upgrade when combined with multiple tank execution strategies and is compared to the prerequisite time frame set by the Red Hill AOC SOW (September 28, 2037). The total comparison time is inclusive of typical government contracting and funding time elements. For this report, the current baseline estimation parameters designated by the Navy dictate that each upgrade cycle is to be considered as three tanks undergoing upgrade at a time with two shifts per day for six days a week.

To derive precise duration schedules involves the analysis of a multitude of parameters and execution elements as applied to the specific environment and conditions allowed. As this study is conceptual in nature, EEI has devised a model to factor a select number of critical path items to develop reasonable timeframes for ROM estimation purposes necessary to outline the realm of possibilities regarding the different TUAs being considered.

The approach separates the critical variables into three categories, namely Pre-execution, Execution, and Parallel Effort Efficiencies.

6.1 Pre-Execution

Pre-execution includes the project approvals, funding, acquisition, and design activities. These are the necessary steps to initiate the overall project. While these activities are necessary throughout the project, the initial efforts (Phase 0 Cycle) is the only additive factor included in the calculation of the overall timeline. Similar activities for follow-on cycles are expected to be conducted during execution of construction cycles and should not impact the project completion date. This is specific to the pre-work required for the next construction cycle and does not include any acquisition elements associated with contract modifications; a separate factor is allocated for that specific activity as it would affect the entire timeline throughout the life of the project.

For the base model, it is assumed NAVFAC HI will engage a qualified engineering firm to prepare a comprehensive bid package, for a design-bid-build acquisition and execution strategy. The alternative, preparing a Design/Build (6 Part) bid package, followed by bid and award is also possible. This strategy has been successfully employed on the current round of a two contract, five tank repair scheme. However, the resultant tank setup design phase, does add months to the schedule. This approach could be continued for Alternative 1A or 1B, but is not at all recommended for Alternatives 1D, 2A, 2B and 3A.

Once a construction contract is awarded, time is allotted for mobilization and site preparation. This is inclusive of activities such as contractor submittals, mobilization to the site, and field level preparations for tank work execution, etc.

6.2 Execution

Execution includes all the elements of physical work at the site. Time elements for this phase is allocated into nine construction activities as follows:

- Clean and Inspect - all tank prep activities such as venting, equipment and material/personnel access system set-up, cleaning, inspection, etc.
- Repair - all necessary repair work varying by the requirements of the specific TUA being analyzed.
- Demolition - applicable primarily to Alternative 1D to dissemble the current carbon steel shell prior to constructing the replacement tank shell.
- Construction - all necessary construction work varying by the requirements of the specific TUA being analyzed.
- Coatings - all necessary coating work varying by the requirements of the specific TUA being analyzed. For estimation purposes, a conservative approach was taken which includes all options as follows:
  - Alternative 1A - existing lower dome
  - Alternative 1B - all existing surfaces including lower dome, existing barrel, upper dome
  - Alternative 1D - all new interior surfaces (lower dome, barrel, and upper dome)
  - Alternative 2A - interior (product side) of the lower dome and barrel of the primary tank, existing upper dome, and existing 12-feet tall barrel extension (Tanks 5-20)
  - Alternative 2B - existing upper dome (all tanks), and existing 12-feet tall barrel extension (Tanks 5-20)
  - Alternative 3A - all interior surfaces of the new tank (lower dome, shell, and roof); all exterior surfaces of the new tank (shell and roof), barrel and upper dome of existing tanks, and existing 12-feet tall barrel extension. (Tanks 5-20)
- Pre-commissioning Inspection and Testing - all tank prep activities such as NDE, strapping charts, valves installments, secondary containment testing (if required), etc. necessary for returning the tank to operation.
- Commissioning - filling the tank per prescribed protocols.
- Tightness Testing - tightness certification as required.
- Contingency - as with all project management approaches, a contingency factor is applicable for unforeseen contracting and construction delays.

6.3 Parallel Effort Efficiencies

Parallel Effort Efficiencies includes the project management features that allows the construction contractor to take advantage of executing multiple tanks in multiple cycles using multiple crews and extended work periods. These efficiencies are derived from specific site historical execution data as well as industry subject matter expert experiences. The following key efficiencies can be applied to drive positive effects on productivity to create a more efficient process thereby reducing the overall timeline:

- Days / Week - increasing the standard five days / week work schedule to six or seven days/week schedule
- Shifts / Day - increasing the standard one shift / week work schedule to two or three shifts / week schedule
- Hours / Shift - increasing the standard eight hours / shift work schedule to ten or twelve hours / shift schedule
- Tanks / Cycle - the provided parameter allows for a three-tank per execution cycle strategy due to the efficiencies inherent in not executing each tank in series; additional efficiencies can be gained by increasing the number of tanks / cycle to a four- or five-tank / cycle strategy
- Overlapping Cycles - as with the tanks / cycle approach, additional overall timeline efficiencies can be gained by executing multiple cycles at a time; overlapping cycles provides a semi-parallel approach to project schedule on a macro level

While considering greater efficiencies, caution must be exercised with the "more is faster/better" approach as specific conditions of any project can drive inefficiencies through logistics bottlenecks, safety hazards due to overtime work, availability of additional required personnel due to expertise or security requirements, etc. Given the considerations of the elements contained in the other section of this Part G, enormous weight must be placed on the logistic, security and safety aspects of construction at Red Hill.

6.4 Factor Determinations

Given the numerous variables involved, a plethora of scenarios can be derived by changing a single element by minimal amounts. Baselines were established to develop a model for each given scenario. Determining the factors for this baseline was necessary to allocate the effective weights and efficiencies to be applied. The following factors and the baseline values were determined to be accurate for estimation purposes at this concept level:

- Start Date - the entire process hinges on the actual start date. The current value used is estimated at 2018.5 in anticipation of a final decision in late FY18.
- Funding - SRM or MILCON approval and allocation have different paths and associated timelines. The prevailing guidelines favor an SRM funding scheme, so that variable is used for all models presented in this report. The MILCON factor is available for "what-if" scenarios should the decision makers choose a different path. The baseline values are:
  - SRM = 36 months
  - MILCON = 60 months
- Acquisition - contracting actions have numerous mandatory requirements driven by the FAR and tend to have very little leeway. However, based on the acquisition strategy, various timelines can be estimated for the given TUAs. Additionally, the Environmental Assessments are included in this section with the assumption of parallel execution. In consultation with NAVFAC, the values used for each scenario are based on a Design-

Bid-Build strategy and a minimal allowance for a NEPA/CATEX. The baseline values used for acquisition are:

  - ➢ Alternative 1A = 6 months
  - ➢ Alternative 1B = 6 months
  - ➢ Alternative 1D = 9 months
  - ➢ Alternative 2A = 9 months
  - ➢ Alternative 2B = 9 months
  - ➢ Alternative 3A = 11 months

- Design - the time dedicated for design beyond the status quo varies among the different TUAs. Evaluation of construction logistics and potential design of modifications to the tunnel system would be additive to the individual tank upgrade designs and covered under the mobilization and preparation estimates. The provided design times are based on a normal schedule allowing for standard government reviews between submissions. However, design times can be reduced if the associated government review period is reduced accordingly and some interim submissions are deleted; this is an aggressive approach and would take special consideration. Therefore, the baseline values for design as estimates by EEI's SMEs are:
  - ➢ Alternative 1A = 0 months
  - ➢ Alternative 1B = 0 months
  - ➢ Alternative 1D = 9 months
  - ➢ Alternative 2A = 12 months
  - ➢ Alternative 2B = 12 months
  - ➢ Alternative 3A = 15 months
- Mobilization and Preparation - the timing between a contract award and actual work in the tank is derived from typical acquisition factors as well as Red Hill specific requirements for logistics analysis and coordination to include but not limited to submittals and reviews, site preparations such as laydown area /road setup /improvement, conveyance system construction, tunnel modifications, etc. The factors used for this element of pre-execution time are:
  - ➢ Alternative 1A = 3 months
  - ➢ Alternative 1B = 3 months
  - ➢ Alternative 1D = 12 months
  - ➢ Alternative 2A = 12 months
  - ➢ Alternative 2B = 12 months
  - ➢ Alternative 3A = 12 months
- Volume - each TUA derives a different volumetric capacity that is compared to the needs of the government. Based on the volumes associated with the status quo, an 18-tank or

20-tank strategy can be enlisted to obtain the volumes required to meet the current capabilities. Based on TUA volume calculations, the baseline values used for volumes are:

- Alternative 1A = 18 tanks
- Alternative 1B = 18 tanks
- Alternative 1D = 18 tanks
- Alternative 2A = 20 tanks
- Alternative 2B = 20 tanks
- Alternative 3A = 20 tanks

- Construction - each phase of construction has an estimated duration per the associated TUA. These values are determined specifically for application in Red Hill with consultation with industry experts. The durations per phase in number of months are:

TUA	Clean / Inspect	Repair / Demo	Construction	Coating	Testing	Commission	Tightness	Total per Tank
1A	6	6	0	2.12	1	3	0.25	18.37
1B	6	6	0	11.04	1	3	0.25	27.29
1D	1	6	15.55	11.04	1	3	0.25	37.83
2A	6	6	13.81	9.86	1	1.5	0.25	38.42
2B	6	6	13.81	1.61	1	1.5	0.25	30.17
3A	6	6	21.46	19.38	1	1	0.25	54.83

- Efficiencies - numerous efficiencies can be gained through compounding factor of accelerated and/or parallel execution activities. The values assigned to these efficiency factors are:
  - Days / Week
    - 5 days / week = 100%
    - 6 days / week = 85%
    - 7 days / week = 75%
  - Shift / Day
    - 1 shift / day = 100%
    - 2 shifts / day = 75%
    - 3 shift / day = 70%
  - Hours / Shift
    - 8 hours / shift = 100%

- 10 hours / shift = 90%
    - 12 hours / shift = 85%
  - Tanks / Cycle*
    - 3 tanks / cycle = 100%
    - 4 tanks / cycle = 77%
    - 5 tanks / cycle = 60%

      **more than 3-tanks/cycle is applicable to certain TUAs when the use of Tanks 1 and 19 are made available thereby adhering to the PACOM requirement to maintain at least 15 tanks in service at all times.*
  - Cycle Efficiency
    - 3-tanks / cycle = 85%
    - 4-tanks / cycle = 75%
    - 5-tanks / cycle = 65%
- Other - Other factors included in the variances are standard applied contingency for unforeseen issues and contract delays due to contractor mods. The baseline values assigned to these factors are:
  - Contract Mods = 5%
  - Contingency = 10%

6.5 Duration Determinations

By considering all the factors above, a duration can be estimated for any given scenario within the construct provided by the critical path items identified by these parameters. Once each factor is allocated to a specific scenario, the overall execution duration is calculated to determine if the specific TUA can meet the requirements of the Red Hill AOC SOW. Each variable can then be modified using scaled weights to determine specific elements that would derive a determination of the optimum solution set regarding duration for the given TUA. These solution sets can then be analyzed with a cost benefit approach to determine ROI, practicability, feasibility, etc.

Utilizing the timelines for the pre-execution, execution and efficiencies derived, EEI's demonstrated the complexities of each TUA and the various outcomes that can be driven by specifying each variable. Two of those scenarios are included in this report. While the summary for both scenarios are provided below, each of the TUAs are and their respective scenario details are contained in Part E.

The total duration estimates for each TUA given the specific government provided parameters are as follows:

TUA	Tanks per Cycle	Days per Week	Shifts per Day	Hours per Shift	Compliance Date	Completion Date	AOC
1A	3	6	2	10	2029.5	2031.2	Meets
1B	3	6	2	10	2034.4	2036.9	Meets
1D	3	6	2	10	2041.0	2044.4	Fails
2A	3	6	2	10	2043.3	2046.8	Fails
2B	3	6	2	10	2039.3	2042.1	Fails
3A	3	6	2	10	2050.2	2054.8	Fails

In that the overall objective is to meet the AOC, adjustment of one or several variables would be necessary to allow an associated TUA to effectively meet the compliance mandate set by the AOC. Therefore, EEI was asked to change a minimal number of parameters to demonstrate the minimum conditions necessary for any given TUA to reach the compliance goal. In that tanks per cycle is the most impactful determining factor, EEI chose to alter this one factor for any TUA not meeting compliance with the above stated parameters. This scenario also produces the most comparable timeline that is conducive for the Life Cycle Cost Analysis and will be used to determine the net present value for each project in the cost estimate section of this report. The following table demonstrates the minimum number of tanks per cycle that would allow the given TUA to meet the AOC mandate:

TUA	Tanks per Cycle	Days per Week	Shifts per Day	Hours per Shift	Compliance Date	Completion Date	AOC
1A	**3**	**6**	**2**	**10**	**2029.5**	**2031.2**	**Meets**
1B	**3**	**6**	**2**	**10**	**2034.4**	**2036.9**	**Meets**
1D	**4**	**6**	**2**	**10**	**2034.7**	**2037.8**	**Meets**
2A	**4**	**6**	**2**	**10**	**2037.0**	**2040.1**	**Meets**
2B	**4**	**6**	**2**	**10**	**2034.2**	**2036.8**	**Meets**
3A	**5**	**6**	**2**	**10**	**2034.9**	**2038.1**	**Meets**

While this model demonstrates the basic factors for gross estimates, a significantly more detailed analysis should be employed to derive detailed estimates for project execution. As shown above, each TUA is in the realm of possible for execution, but the number of tanks per cycle also drives a greater degree of execution complexity and significantly reduces the contingency buffer.

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PART H - RELATED RED HILL AOC SOW INITIATIVES

1.0 RED HILL AOC SOW SECTION 2.0 TANK INSPECTION REPAIR AND MAINTENANCE (TIRM)

Red Hill AOC SOW Section 2.2 TIRM Report discusses requirements to inspect and repair the existing tanks.

Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document discusses latest execution requirements, and refers back to TIRM 2.2.

2.0 RED HILL AOC SOW SECTION 4.0 RELEASE DETECTION / TANK TIGHTNESS TESTING

Red Hill AOC SOW Section 4.6 New Release Detection Alternatives Report discusses Release Detection / Tank Tightness Testing for tank upgrades.

3.0 RED HILL AOC SOW SECTION 5.0 CORROSION AND METAL FATIGUE PRACTICES

Red Hill AOC SOW Section 5.0 Corrosion and Metal Fatigue Report discusses Corrosion and Metal Fatigue Practices.

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PART I - COST ESTIMATES

1.0 BASIS OF CONSTRUCTION COST ESTIMATES

Probable construction cost estimates for each alternative are presented in the appendices. These cost estimates are established for budgeting and planning purposes only and have an accuracy of +30%.

The cost estimates were derived from a combination of budget level quotes from specialty contractors, material suppliers, fabricators, vendors, R.S. Means Construction Cost Data, and EEI's internal estimating database. Cost information from current and previous contract work in the Red Hill Facility was also evaluated and utilized as appropriate. Other military fuels contract costs for similar types of work were also considered. Discussions with several contractors familiar with work at Red Hill were held to determine difficulty, time to complete tasks, and overall manning requirements. This was necessary because there is very little fuel tank cost data published. Private sector fuel companies keep their project cost confidential for competitive reasons. Even if there was extensive published tank or pipe cost information, adaptations would be necessary for Red Hill.

The cost estimates are based on the following:

- Construction work is based on working two ten-hour shifts, 6 days a week.
- All alternatives were escalated to the mid-point of construction. The escalation year varied by alternative and is based on the mid-point of Phase 1 as identified in Part G Construction Duration Section 6.5.
- Estimating Contingency 10-20% depending on difficulty of alternative
- Hawaii General Excise Tax 4.712% multiplier
- DoD Oahu Area Cost Factor (2015) 2.2%

Construction budget estimates do NOT include government Supervision, Inspection and Overhead (SIOH), Government Contingency, Quality Assurance Supervision, and Post Construction inspection or engineering services. Upfront architect and engineering design cost is also NOT included.

As these tank upgrades are very specialized, it has been assumed that the government will provide a fully designed project for Invitation for Bid (IFB) procurement of a specialty contractor. Thus, the construction cost estimates do not include any allowance for the contractor to provide a contractor developed design package. Depending on the Alternative chosen, the contractor may still have significant effort to design temporary construction infrastructure for electrical, mechanical and conveying methods.

2.0 COST ESTIMATES BY ALTERNATIVE

Alternative	Cost per Tank
1A - Restoration of Existing Tank	[redacted]
1B - Restoration of Existing Tank Plus Interior Coating	[redacted]
1D - Remove Existing Steel Liner, Install New Steel Liner with Interior Coating	[redacted]
2A - Composite Tank (Double Wall) Carbon Steel, with Interior Coating	[redacted]
2B - Composite Tank (Double Wall) Stainless Steel	[redacted]
3A - Tank within a Tank (Carbon Steel), full Interior and Exterior Coating	[redacted]

3.0 GENERAL COST ESTIMATE ASSUMPTIONS

The current Hawaii construction market is already fully utilized for the Honolulu rail project and other large residential projects. The rail is estimated to be complete in 2025. Any sizeable project can drain the labor pool because it is not very large. Even without this labor drain, locally available welders certified at the level necessary for Red Hill tanks will be limited. Per diem costs for welders and other specialty workers have been included in the cost.

Due to the of the nature and complexity of the Alternatives, the bid pool may be small. Several contractors have not submitted bids after attending site walks and seeing the complexity and issues with performing work in Red Hill. There are also limited firms that specialize in tank fabrication. Companies may bid high on the safety/risk factor alone. It will have to be worth their efforts monetarily to accept the risk. Note that procurement of the upgrade will require the steel to be made in the U.S.A. per the "Buy American Act" 41 U.S.C. 8301-8305. This will particularly affect the cost of Alternatives 1D, 2A, 2B, and 3A due to the potential limited availability of the steel.

The Construction Execution section in Part G proposes various methods to overcome the issues such as moving steel plate and providing temporary power. For cost estimating purposes, the following construction support structures were chosen for all alternatives: a 1500 KVA transformer will be located at Adit 6, temporary mining cables will be installed from transformer to skid mounted panel boards, existing tunnel shafts will be used for ventilation purposes (no ancillary vent shaft to surface). For alternatives that require conveyance of steel plate, an overhead monorail from Adit 4 into the tanks will be used.

Safety is a major concern for all personnel working in the tunnels. Access and egress are very limited. Typically, personnel enter and leave the tanks through the 8-feet diameter manway at 180 feet above the tank floor. In an emergency, workers need to raise baskets from their current location up to the catwalk for egress. This can take 5-10 minutes. For workers working at the bottom of the tank, another means of egress is to climb up into the 32-inch pipe nozzle inside the tank and crawl 50 feet to the Lower Tunnel.

Worker standing next to 32-inch nozzle at the bottom of the tank. The worker would have to climb up into the nozzle, use the rope ladder hanging inside to climb down into pipe before crawling out.

Due to the extreme safety issues inherent in Red Hill tank and tunnel work, the Navy has traditionally required additional contractor provided safety oversight. It will be assumed that a full time Site Safety and Health Officer for each tank will be required for all alternatives.

Material costs, specifically steel, will be based on average cost for steel in 2017. Any significant escalation in steel cost will have large effect on the cost of Alternatives 1D, 2A, 2B, and 3A which utilize large quantities of steel.

4.0 COST ESTIMATE ASSUMPTIONS ALTERNATIVES 1A AND 1B

Alternatives 1A and 1B closely match the existing clean, inspect and repair projects that have been ongoing in Red Hill since 2004. These alternatives require more rigor in the inspection and repair process then previous contracts which makes them costlier. For these alternatives, every anomaly is double checked and proved up by an independent third party. Every repair weld will be inspected by independent third party. This added rigor in inspection process will probably increase identified anomalies in tank construction but it will improve tank integrity over time. The added scrutiny of tank structure does not change the required equipment or support structures to inspect and repair the tank. For Alternative 1A, it is assumed that two articulating booms and a monorail system will be installed. All activities including inspection, repair, and coating will be performed from these systems. It is assumed that no scaffolding or additional staging means will be required to perform work. For coating, it is assumed that contractor will utilize automated blasting equipment designed to crawl up and down the tank wall for blasting purposes. A lightweight monorail at the lower dome may be required. These units have a self-contained dust collector to minimize airborne discharge grit. This blasting method will only work for lower dome and barrel. For Alternative 1B, it is assumed that traditional abrasive blasting will be required for the upper dome. Once blasted, the coating will be performed from the tank floor or from personnel platforms as required.

5.0 COST ESTIMATE ASSUMPTIONS ALTERNATIVES 1D, 2A, 2B, AND 3A

Alternatives 1D, 2A, 2B, and 3A will require a significant escalation in work effort, material handling and skilled labor (welders) than current clean, inspect and repair contracts. It is assumed that the added complexity will require a complete overhaul of the Adit 4 area to create a proper laydown area. This cost is factored for the number of tanks included in the bid package.

It is assumed that two articulating booms and a dual monorail system will be installed inside the tanks. The dual monorail system has one structurally robust monorail designed to move steel plate into the tanks. It also has a separate monorail for personnel platforms. It is assumed that no scaffolding or additional staging means will be required to perform work. In addition to monorails in the tank, an overhead monorail rail system is included. This rail system is intended to move steel plate from Adit 4 to the tank gallery.

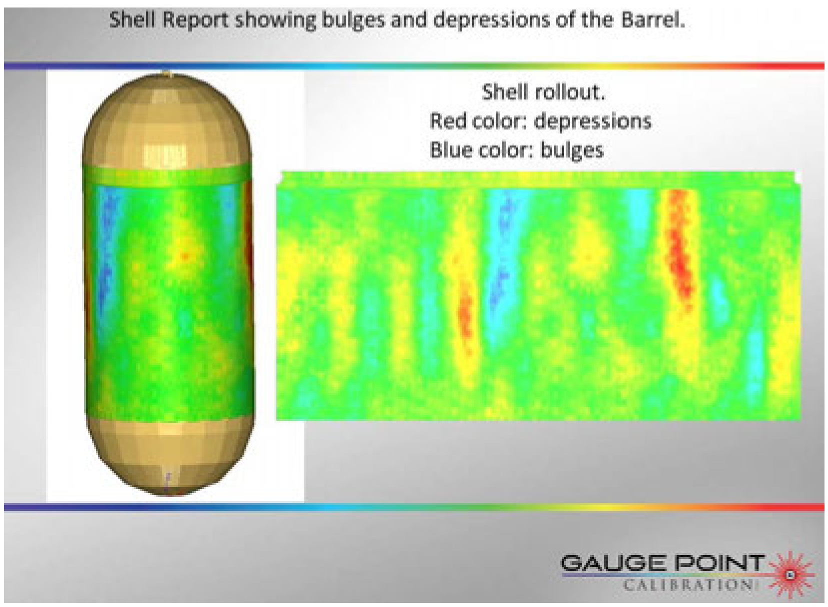
For cost estimating purposes, contract support structures such as overhead rail and ventilation are included in every tank cost. Even though some contractor installed systems such as overhead rail or temporary power could be utilized by follow on contractors, most contractors will not utilize support structures installed by another contractor. It is assumed that the same contractor will not win construction contract for more than one phase.

It is assumed that all steel plates for the new barrel will be rolled to the curvature of the barrel. There are one or two companies with capability to roll steel in Hawaii but this effort would be a large undertaking for them. Steel plate in the upper and lower dome are flat plates cut to form the dome. Flat plates can be utilized for these areas depending on the alternative. See upper dome diagram.

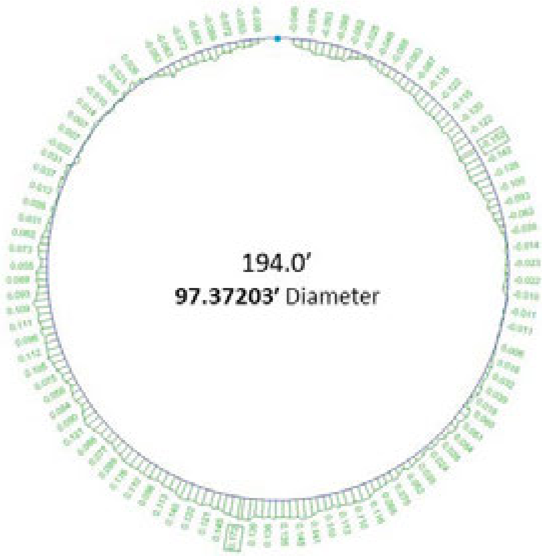
Upper Dome Diagram depicting how flat plates were used to create upper dome

The existing barrel is not completely cylindrical and the dome plates are not completely flat or neatly flush. Existing steel inner structure was installed first and concrete grout pumped behind the steel liner. This added backside pressure and welding practices have bent, dented and bowed the existing steel liner. For Alternatives 2A, 2B, and 3A which require attachment of steel plates or bracing to existing steel liner, it is assumed that this will add significant cost as braces or plates will have to be field adjusted to fit.

Additional cost is also assumed for Alternative 1D because plate is welded to existing embedded structural steel. This steel will follow the contour of existing shell making it difficult to install new plates that do not match the contour of the plate that was removed. In addition, the embedded steel that is needed structurally could be corroded or covered with grout. If the embedded steel is not viable structurally, dowels will have to be drilled into existing concrete to provide attachment point for steel plates.



Tank 5 section from recent tank gauging project. Large areas of the barrel are out of round and could cause issues



Tank 5 shell condition at 194 feet, note that it is 97.3 feet diameter

It is assumed that existing tunnel shafts can be utilized for ventilation but that there will be significant cost associated with this system for large welding or coating activities. It is also assumed that contractor will have to completely revise existing tunnel ventilation system for the duration of the contract. The contractor will have to design a tank and tunnel ventilation system based on the construction methods chosen. The contractor will also have to return the tunnel ventilation to pre-existing tunnel ventilation scheme when project is complete.

6.0 LIFE CYCLE COST ANALYSIS

Life cycle costs are developed for each Alternative for a 50-year period.

Alternative	Life Cycle Cost	Annual Value
1A	[redacted]	[redacted]
1B	[redacted]	[redacted]
1D	[redacted]	[redacted]
2A	[redacted]	[redacted]
2B	[redacted]	[redacted]
3A	[redacted]	[redacted]

A life cycle schedule for each Alternative is provided in Table I-1.

TABLE I-1
LIFE CYCLE SCHEDULE

Year	Alternative 1A Repair Existing Tank	Alternative 1B Repair Existing Tank plus Interior Coating	Alternative 1D Remove Existing Steel Liner, Install New Liner	Alternative 2A Composite Tank (Double Wall) Carbon Steel	Alternative 2B Composite Tank (Double Wall) Duplex Stainless Steel	Alternative 3A Tank within a Tank (Carbon Steel)
Notes	• Number of tanks per cycle: 3 • Number of cycles: 6 • Start date: 2020.3 • Cycle 1 Construction Cost: [redacted] in FY18 dollars escalated to midpoint of construction • Cycle 1 Clean, Inspect, Repair (CIR) 3 Tanks Cost: [redacted] in FY 18 dollars escalated to midpoint of construction. This cost is for future CIR after Cycle 1 upgrade is complete and tanks are returned to service • Annual Operating Cost: [redacted] per tank ([redacted] total 3 tanks) FY 18 dollars. Operating cost start at the finish of each cycle and continue each year thereafter. • Annual Maintenance Cost: [redacted] per tank ([redacted] total 3 tanks) FY 18 dollars. Maintenance costs start at the finish of each cycle and continue each year thereafter.	• Number of tanks per cycle: 3 • Number of cycles: 6 • Start date: 2021.3 • Cycle 1 Construction Cost: [redacted] in FY18 dollars escalated to midpoint of construction • Cycle 1 Clean, Inspect, Repair (CIR) 3 Tanks Cost: [redacted] in FY 18 dollars escalated to midpoint of construction. This cost is for future CIR after Cycle 1 upgrade is complete and tanks are returned to service • Annual Operating Cost: [redacted] per tank ([redacted] total 3 tanks) FY 18 dollars. Operating cost start at the finish of each cycle and continue each year thereafter. • Annual Maintenance Cost: [redacted] per tank ([redacted] total 3 tanks) FY 18 dollars. Maintenance costs start at the finish of each cycle and continue each year thereafter.	• Number of tanks per cycle: 4 • Number of cycles: 5 • Start date: 2023.3 • Cycle 1 Construction Cost: [redacted] in FY18 dollars escalated to midpoint of construction • Cycle 1 Clean, Inspect, Repair (CIR) 4 Tanks Cost: [redacted] in FY 18 dollars escalated to midpoint of construction. This cost is for future CIR after Cycle 1 upgrade is complete and tanks are returned to service • Annual Operating Cost: [redacted] per tank ([redacted] total 4 tanks) FY 18 dollars. Operating cost start at the finish of each cycle and continue each year thereafter. • Annual Maintenance Cost: [redacted] per tank ([redacted] total 4 tanks) FY 18 dollars. Maintenance costs start at the finish of each cycle and continue each year thereafter.	• Number of tanks per cycle: 4 • Number of cycles: 5 • Start date: 2023.3 • Cycle 1 Construction Cost: [redacted] in FY18 dollars escalated to midpoint of construction • Cycle 1 Clean, Inspect, Repair (CIR) 4 Tanks Cost: [redacted] in FY 18 dollars escalated to midpoint of construction. This cost is for future CIR after Cycle 1 upgrade is complete and tanks are returned to service • Annual Operating Cost: [redacted] per tank ([redacted] total 4 tanks) FY 18 dollars. Operating cost start at the finish of each cycle and continue each year thereafter. • Annual Maintenance Cost: [redacted] per tank [redacted] total 4 tanks) FY 18 dollars. Maintenance costs start at the finish of each cycle and continue each year thereafter.	• Number of tanks per cycle: 4 • Number of cycles: 5 • Start date: 2023.3 • Cycle 1 Construction Cost: [redacted] in FY18 dollars escalated to midpoint of construction • Cycle 1 Clean, Inspect, Repair (CIR) 4 Tanks Cost: [redacted] in FY 18 dollars escalated to midpoint of construction. This cost is for future CIR after Cycle 1 upgrade is complete and tanks are returned to service • Annual Operating Cost: [redacted] per tank [redacted] total 4 tanks) FY 18 dollars. Operating cost start at the finish of each cycle and continue each year thereafter. • Annual Maintenance Cost: [redacted] per tank ([redacted] total 4 tanks) FY 18 dollars. Maintenance costs start at the finish of each cycle and continue each year thereafter.	• Number of tanks per cycle: 5 • Number of cycles: 4 • Start date: 2023.4 • Cycle 1 Construction Cost: [redacted] in FY18 dollars escalated to midpoint of construction • Cycle 1 Clean, Inspect, Repair (CIR) 5 Tanks Cost: [redacted] in FY 18 dollars escalated to midpoint of construction. This cost is for future CIR after Cycle 1 upgrade is complete and tanks are returned to service • Annual Operating Cost: [redacted] per tank [redacted] total 3 tanks) FY 18 dollars. Operating cost start at the finish of each cycle and continue each year thereafter. • Annual Maintenance Cost: [redacted] per tank ([redacted] total 55 tanks) FY 18 dollars. Maintenance costs start at the finish of each cycle and continue each year thereafter.
FY18						
FY19						
FY20	• Upgrade 3 Tanks - Cycle 1 Start 2020.3					
FY21	• Upgrade 3 Tanks - Cycle 1	• Upgrade 3 Tanks - Cycle 1 Start 2021.3				
FY22	• Upgrade 3 Tanks - Cycle 1 Finish 2022.3 • Cycle 1 Operating Cost Start • Cycle 1 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 2 Start 2022.0	• Upgrade 3 Tanks - Cycle 1				
FY23	• Upgrade 3 Tanks - Cycle 2 • Upgrade 3 Tanks - Cycle 3 Start 2023.8	• Upgrade 3 Tanks - Cycle 1 • Upgrade 3 Tanks - Cycle 2 Start 2023.8	• Upgrade 4 Tanks - Cycle 1 Start 2023.3	• Upgrade 4 Tanks - Cycle 1 Start 2023.3	• Upgrade 4 Tanks - Cycle 1 Start 2023.3	• Upgrade 5 Tanks - Cycle 1 Start 2023.4

TABLE I-1 LIFE CYCLE SCHEDULE						
Year	**Alternative 1A** **Repair Existing Tank**	**Alternative 1B** **Repair Existing Tank plus Interior Coating**	**Alternative 1D** **Remove Existing Steel Liner, Install New Liner**	**Alternative 2A** **Composite Tank (Double Wall) Carbon Steel**	**Alternative 2B** **Composite Tank (Double Wall) Duplex Stainless Steel**	**Alternative 3A** **Tank within a Tank (Carbon Steel)**
FY24	• Upgrade 3 Tanks - Cycle 2 Finish 2024.1 • Cycle 2 Operating Cost Start • Cycle 2 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 3	• Upgrade 3 Tanks - Cycle 1 Finish 2024.2 • Cycle 1 Operating Cost Start • Cycle 1 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 2	• Upgrade 4 Tanks - Cycle 1	• Upgrade 4 Tanks - Cycle 1	• Upgrade 4 Tanks - Cycle 1	• Upgrade 5 Tanks - Cycle 1
FY25	• Upgrade 3 Tanks - Cycle 3 Finish 2025.9 • Cycle 3 Operating Costs Start • Cycle 3 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 4 Start 2025.6	• Upgrade 3 Tanks - Cycle 2	• Upgrade 4 Tanks - Cycle 1	• Upgrade 4 Tanks - Cycle 1	• Upgrade 4 Tanks - Cycle 1 • Upgrade 4 Tanks - Cycle 2 Start 2025.8	• Upgrade 5 Tanks - Cycle 1
FY26	• Upgrade 3 Tanks - Cycle 4	• Upgrade 3 Tanks - Cycle 2 Finish 2026.8 • Cycle 2 Operating Cost Start • Cycle 2 Maintenance Cost Start • • Upgrade 3 Tanks - Cycle 3 Start 2026.3	• Upgrade 4 Tanks - Cycle 1 • Upgrade 4 Tanks - Cycle 2 Start 2026.4	• Upgrade 4 Tanks - Cycle 1 • Upgrade 4 Tanks - Cycle 2 Start 2026.4	• Upgrade 4 Tanks - Cycle 1 Finish 2026.6 • Cycle 1 Operating Cost Start • Cycle 1 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 2	• Upgrade 5 Tanks - Cycle 1 • Upgrade 5 Tanks - Cycle 2 Start 2026.7
FY27	• Upgrade 3 Tanks - Cycle 4 Finish 2027.7 • Cycle 4 Operating Cost Start • Cycle 4 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 5 Start 2027.4	• Upgrade 3 Tanks - Cycle 3	• Upgrade 4 Tanks - Cycle 1 Finish 2027.4 • Cycle 1 Operating Cost Start • Cycle 1 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 2	• Upgrade 4 Tanks - Cycle 1 Finish 2027.5 • Cycle 1 Operating Cost Start • Cycle 1 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 2	• Upgrade 4 Tanks - Cycle 2	• Upgrade 5 Tanks - Cycle 1 • Upgrade 5 Tanks - Cycle 2
FY28	• Upgrade 3 Tanks - Cycle 5	• Upgrade 3 Tanks - Cycle 3 • Upgrade 3 Tanks - Cycle 4 Start 2028.8	• Upgrade 4 Tanks - Cycle 2	• Upgrade 4 Tanks - Cycle 2	• Upgrade 4 Tanks - Cycle 2 • Upgrade 4 Tanks - Cycle 3 Start 2028.3	• Upgrade 5 Tanks - Cycle 1 Finish 2028.4 • Cycle 1 Operating Cost Start • Cycle 1 Maintenance Cost Start • Upgrade 5 Tanks - Cycle 2
FY29	• Upgrade 3 Tanks - Cycle 5 Finish 2029.5 • Cycle 5 Operating Cost Start • Cycle 5 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 6 Start 2029.2	• Upgrade 3 Tanks - Cycle 3 Finish 2029.3 • Cycle 3 Operating Costs Start • Cycle 3 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 4	• Upgrade 4 Tanks - Cycle 2 • Upgrade 4 Tanks - Cycle 3 Start 2029.5	• Upgrade 4 Tanks - Cycle 2 • Upgrade 4 Tanks - Cycle 3 Start 2029.6	• Upgrade 4 Tanks - Cycle 2 Finish 2029.2 • Cycle 2 Operating Cost Start • Cycle 2 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 3	• Upgrade 5 Tanks - Cycle 2 • Upgrade 5 Tanks - Cycle 3 Start 2029.9

TABLE I-1 LIFE CYCLE SCHEDULE						
Year	**Alternative 1A** **Repair Existing Tank**	**Alternative 1B** **Repair Existing Tank plus Interior Coating**	**Alternative 1D** **Remove Existing Steel Liner, Install New Liner**	**Alternative 2A** **Composite Tank (Double Wall) Carbon Steel**	**Alternative 2B** **Composite Tank (Double Wall) Duplex Stainless Steel**	**Alternative 3A** **Tank within a Tank (Carbon Steel)**
FY30	• Upgrade 3 Tanks - Cycle 6	• Upgrade 3 Tanks - Cycle 4	• Upgrade 4 Tanks - Cycle 2 Finish 2030.5 • Cycle 2 Operating Cost Start • Cycle 2 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 3	• Upgrade 4 Tanks - Cycle 2 Finish 2030.6 • Cycle 2 Operating Cost Start • Cycle 2 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 3	• Upgrade 4 Tanks - Cycle 3 • Upgrade 4 Tanks - Cycle 4 Start 2030.8	• Upgrade 5 Tanks - Cycle 2 • Upgrade 5 Tanks - Cycle 3
FY31	• Upgrade 3 Tanks - Cycle 6 Finish 2031.2 • Cycle 6 Operating Cost Start • Cycle 6 Maintenance Cost Start	• Upgrade 3 Tanks - Cycle 4 Finish 2031.8 • Cycle 4 Operating Cost Start • Cycle 4 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 5 Start 2031.4	• Upgrade 4 Tanks - Cycle 3	• Upgrade 4 Tanks - Cycle 3	• Upgrade 4 Tanks - Cycle 3 Finish 2031.7 • Cycle 3 Operating Costs Start • Cycle 3 Maintenance Cost Start	• Upgrade 5 Tanks - Cycle 2 Finish 2031.7 • Cycle 2 Operating Cost Start • Cycle 2 Maintenance Cost Start • Upgrade 5 Tanks - Cycle 3
FY32		• Upgrade 3 Tanks - Cycle 5	• Upgrade 4 Tanks - Cycle 3 • Upgrade 4 Tanks - Cycle 4 Start 2032.6	• Upgrade 4 Tanks - Cycle 3 • Upgrade 4 Tanks - Cycle 4 Start 2032.7	• Upgrade 4 Tanks - Cycle 4	• Upgrade 5 Tanks - Cycle 3
FY33		• Upgrade 3 Tanks - Cycle 5 • Upgrade 3 Tanks - Cycle 6 Start 2033.9	• Upgrade 4 Tanks - Cycle 3 Finish 2033.7 • Cycle 3 Operating Costs Start • Cycle 3 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 4	• Upgrade 4 Tanks - Cycle 3 Finish 2033.8 • Cycle 3 Operating Costs Start • Cycle 3 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 4	• Upgrade 4 Tanks - Cycle 4 • Upgrade 4 Tanks - Cycle 5 Start 2033.4	• Upgrade 5 Tanks - Cycle 3 • Upgrade 5 Tanks - Cycle 4 Start 2033.2
FY34		• Upgrade 3 Tanks - Cycle 5 Finish 2034.4 • Cycle 5 Operating Cost Start • Cycle 5 Maintenance Cost Start • Upgrade 3 Tanks - Cycle 6	• Upgrade 4 Tanks - Cycle 4	• Upgrade 4 Tanks - Cycle 4	• Upgrade 4 Tanks - Cycle 4 Finish 2034.2 • Cycle 4 Operating Cost Start • Cycle 4 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 5	• Upgrade 5 Tanks - Cycle 3 Finish 2034.9 • Cycle 3 Operating Costs Start • Cycle 3 Maintenance Cost Start • Upgrade 5 Tanks - Cycle 4
FY35		• Upgrade 3 Tanks - Cycle 6	• Upgrade 4 Tanks - Cycle 4 • Upgrade 4 Tanks - Cycle 5 Start 2035.7	• Upgrade 4 Tanks - Cycle 4 • Upgrade 4 Tanks - Cycle 5 Start 2035.9	• Upgrade 4 Tanks - Cycle 5	• Upgrade 5 Tanks - Cycle 4
FY36		• Upgrade 3 Tanks - Cycle 6 Finish 2036.9 • Cycle 6 Operating Cost Start • Cycle 6 Maintenance Cost Start	• Upgrade 4 Tanks - Cycle 4 Finish 2036.8 • Cycle 4 Operating Cost Start • Cycle 4 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 5	• Upgrade 4 Tanks - Cycle 4 • Upgrade 4 Tanks - Cycle 5	• Upgrade 4 Tanks - Cycle 5 Finish 2036.8 • Cycle Operating Cost Start • Cycle 5 Maintenance Cost Start	• Upgrade 5 Tanks - Cycle 4
FY37			• Upgrade 4 Tanks - Cycle 5 Finish 2037.8 • Cycle 5 Operating Cost Start • Cycle 5 Maintenance Cost Start	• Upgrade 4 Tanks - Cycle 4 Finish 2037.0 • Cycle 4 Operating Cost Start • Cycle 4 Maintenance Cost Start • Upgrade 4 Tanks - Cycle 5		• Upgrade 5 Tanks - Cycle 4

TABLE I-1 LIFE CYCLE SCHEDULE						
Year	**Alternative 1A** **Repair Existing Tank**	**Alternative 1B** **Repair Existing Tank plus Interior Coating**	**Alternative 1D** **Remove Existing Steel Liner, Install New Liner**	**Alternative 2A** **Composite Tank (Double Wall) Carbon Steel**	**Alternative 2B** **Composite Tank (Double Wall) Duplex Stainless Steel**	**Alternative 3A** **Tank within a Tank (Carbon Steel)**
FY38				• Upgrade 4 Tanks - Cycle 5		• Upgrade 5 Tanks - Cycle 4 Finish 2038.1 • Cycle 4 Operating Cost Start • Cycle 4 Maintenance Cost Start
FY39				• Upgrade 4 Tanks - Cycle 5		
FY40				• Upgrade 4 Tanks - Cycle 5 Finish 2040.1 • Cycle Operating Cost Start • Cycle 5 Maintenance Cost Start		
FY41						
FY42	• Clean, Inspect, Repair 3 Tanks - Cycle 1					
FY43						
FY44		• Clean, Inspect, Repair 3 Tanks - Cycle 1				
FY45						
FY46					• Clean, Inspect, Repair 4 Tanks - Cycle 1	
FY47			• Clean, Inspect, Repair 4 Tanks - Cycle 1	• Clean, Inspect, Repair 4 Tanks - Cycle 1		
FY48						• Clean, Inspect, Repair 5 Tanks - Cycle 1
FY49						
FY50						
FY51						
FY52						
FY53						
FY54						
FY55						
FY56						
FY57						
FY58						
FY59						
FY60						
FY61						

TABLE I-1 LIFE CYCLE SCHEDULE						
Year	**Alternative 1A** **Repair Existing Tank**	**Alternative 1B** **Repair Existing Tank plus Interior Coating**	**Alternative 1D** **Remove Existing Steel Liner, Install New Liner**	**Alternative 2A** **Composite Tank (Double Wall) Carbon Steel**	**Alternative 2B** **Composite Tank (Double Wall) Duplex Stainless Steel**	**Alternative 3A** **Tank within a Tank (Carbon Steel)**
FY62						
FY63						
FY64						
FY65						
FY66						
FY67						
FY68						
FY69						
FY70						

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DEFINITIONS

The following terms are used in this report. The definitions are from 40 CFR 280 Final Rule.

- *Existing Tank System:* A tank system used to contain an accumulation of regulated substances or for which installation has commenced on or before December 22, 1988.
- *New Tank System:* A tank system that will be used to contain an accumulation of regulated substances and for which installation has commenced after December 22, 1988.
- *Release:* Any spilling, leaking, emitting, discharging, escaping, leaching or disposing from an UST into groundwater, surface water or subsurface soils.
- *Release Detection:* Determining whether a release of a regulated substance has occurred from the UST system into the environment or a leak has occurred into the interstitial space between the UST system and its secondary barrier or secondary containment around it.
- *Secondary Containment or Secondarily Contained:* A release prevention and release detection system for a tank or piping. This system has an inner and outer barrier with an interstitial space that is monitored for leaks. This term includes containment sumps when used for interstitial monitoring of piping.
- *Underground Storage Tank or UST:* Any one or combination of tanks (including underground pipes connected thereto) that is used to contain an accumulation of regulated substances, and the volume of which (including the volume of underground pipes connected thereto) is 10 percent or more beneath the surface of the ground. This term does not include: Storage tanks situated in an underground area (such as a basement, cellar, mine working, drift, shaft, or tunnel) if the storage tank is situated upon or above the surface of the floor.

Additional Definitions

- *Primary Tank:* The wall of the tank that provides primary containment, e.g. the wall of a single wall tank or the inner wall of a double wall tank.
- *Indications:* A discontinuity in a steel plate or weld. Indications include: pitting and corrosion in plates, and pitting, corrosion, cracks, porosity, lack of fusion, undercutting, underfill, slag inclusions, and flux inclusions in welds.
- *Rejectable Indications:* Rejectable indications are indications that fail acceptance criteria.

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5. **Red Hil AOC SOW Section 5.0 Corrion and Metal Fatigue Practices.**

6. **GSE Environmental .** GSE MineDrain Geocoposite. [Online] [Cited: September 16, 2017.] http://www.gseworld.com/content/documents/datasheets/Specialty_Geocomposite_Systems/MineDrain_Geocomp_ENGLISH_DS.pdf.

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PROJECT TEAM

Contracting Agenc**y:** NAVFAC Pacific

Prime Consultant: HDR.

Francis T. Hino, P.E.	Project Manager, responsible for overall management of A/E efforts on the Red Hill study and participant in discussions.

Subconsultant: Enterprise Engineering, Inc. (EEI). Tank Engineer/Subject Matter Specialist.

Kevin S. Murphy, P.E.	Principal in Charge
Stephen J. DiGregorio, P.E.	Project Manager/Lead Structural Engineer/API 653 Certified Aboveground Tank Inspector. Responsible for identifying available technologies, developing attribute definitions and rating system for Tank Upgrade Alternatives, and investigating BAPT tank upgrade alternatives
Stephen S. Brooks P.E.	Technical Specialist/Lead Mechanical Engineer/API 653 Certified Aboveground Tank Inspector. Responsible for overall technical review and Quality Assurance
Rowdy C. Griffin	Participant in developing attribute definitions and rating tank upgrade alternatives, and estimating construction duration
Terry Strack, P.E.	Responsible for investing construction execution considerations and preparing construction cost estimates
Power Engineers	Electrical Engineer (EEI subconsultant)
MOCA	Cost Estimator for preparing Life Cycle Cost Analyses

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APPENDIX A - REGULATORY REQUIREMENTS

The State of Hawaii has an approved UST regulation. Department of Health (DOH) rules remain in effect and governing for up to three years from the promulgation of 40 CFR 280 (as permitted under 40 CFR 280 subpart K).

1.0 40 CFR 280 Final Rule

Federal regulations pertaining to underground storage tanks (USTs) are contained in Code of Federal Regulations Title 40 Part 280 - Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST) (40 CFR Part 280).

In the 1988 underground storage tank (UST) regulation (40 CFR 280), UST systems with field-constructed tanks such as the Red Hill tanks were deferred from the following subparts of 40 CFR 280:

- Subpart B (UST Systems: Design, Construction, Installation and Notification)
- Subpart C (General Operating Requirements)
- Subpart D (Release Detection)
- Subpart E (Release Reporting, Investigation, and Confirmation)
- Subpart G (Out-of-Service UST Systems and Closure), and H (Financial Responsibility).

The Environmental Protection Agency (EPA) revised the 1988 underground storage tank (UST) regulation (40 CFR 280) and the 1988 state program approval (SPA) regulation. The final rule was signed 19 June 2015 and became effective 15 October 2015.

Table A-1 contains excerpts (quotes) from the final rule that pertain to the Red Hill tanks. EEI interpretations are indicated in blue italics. Items in red font highlight key items.

In summary the 40 CFR 280 Final Rule affects the Red Hill tanks as follows:

- The Red Hill tanks which were previously deferred from subparts B, C, D, E, G, and of 40 CFR 280 are no longer deferred and must meet the requirements for 40 CFR 280 Final Rule.
- The Red Hill tanks are currently in compliance with 40 CFR 280 Final Rule.
- Under 40 CFR 280, the Red Hill tanks are not required to be permanently removed service so long as they meet the requirements of 40 CFR 280 Final Rule.
- Under 40 CFR 280 Final Rule, the Red Hill tanks are not required to have secondary containment.

TABLE A 1
40 CFR 280 FINAL RULE

<table>
<tr><th colspan="2">Excerpts pertaining to Red Hill Tanks</th></tr>
<tr><td colspan="2">Preamble</td></tr>
<tr><td>Summary</td><td>Changes to the regulations include: adding secondary containment requirements for new and replaced tanks and piping; adding operator training requirements; adding periodic operation and maintenance requirements for UST systems; addressing UST systems deferred in the 1988 UST regulation; adding new release prevention and detection technologies; updating codes of practice; making editorial corrections and technical amendments; and updating state program approval requirements to incorporate these new changes.
Rule effective 90 days after date of publication in the Federal Register.</td></tr>
<tr><td>C. Addressing Deferrals</td><td>Final UST regulation removes the 1988 deferral and requires owners and operators of airport hydrant fuel distribution systems (referred to as airport hydrant systems) comply with applicable requirements.
In order to help owners and operators of these systems comply, today's final UST regulation adds subpart K (UST Systems with Field-Constructed Tanks and Airport Hydrant Fuel Distribution Systems) and places most regulatory requirements for both airport hydrant systems and field-constructed tanks in one location.
Final UST regulation requires airport hydrant systems and field-constructed tanks installed on or before the effective date of the final UST regulation begin meeting the requirements of subpart K according to the schedule below.
- Upgrading UST systems, general operating requirements, and operator training: Three years after the effective date of today's final UST regulation.
- Release detection: Three years after the effective date of today's final UST regulation.
- Release reporting, response, and investigation; closure; financial responsibility and notification, except as provided in § 280.251(2)(b): On the effective date of today's final UST.</td></tr>
</table>

TABLE A 1 40 CFR 280 FINAL RULE Excerpts pertaining to Red Hill Tanks	
Subpart A Program Scope and Installation Requirements for Partially Excluded UST System	
§280.10 Applicability	(a) The requirements of this part apply to all owners and operators of an UST system as defined in §280.12 except as otherwise provided in paragraphs (b) and (c) of this section. **(1) Previously deferred UST systems.** **(i) Airport hydrant fuel distribution systems and UST systems with field-constructed tanks must meet the requirements in subpart K** (ii) *EEI interpretation: Item (ii) not applicable to Red Hill tanks*. (iii) *EEI Interpretation: Item (iii) not applicable to Red Hill tanks.* (b) Exclusions. *EEI interpretation: (b) not applicable to Red Hill tanks.* (c) Partial Exclusions. *EEI interpretation: (c) not applicable to Red Hill tanks.*
§ 280.12 Definitions.	• *Existing tank system* means a tank system used to contain an accumulation of regulated substances or for which installation has commenced on or before December 22, 1988. • *New tank system* means a tank system that will be used to contain an accumulation of regulated substances and for which installation has commenced after December 22, 1988. • *Release* means any spilling, leaking, emitting, discharging, escaping, leaching or disposing from an UST into groundwater, surface water or subsurface soils. • *Release detection* means determining whether a release of a regulated substance has occurred from the UST system into the environment or a leak has occurred into the interstitial space between the UST system and its secondary barrier or secondary containment around it. • *Secondary containment or Secondarily contained* means a release prevention and release detection system for a tank or piping. This system has an inner and outer barrier with an interstitial space that is monitored for leaks. This term includes containment sumps when used for interstitial monitoring of piping. • *Underground storage tank or UST* means any one or combination of tanks (including underground pipes connected thereto) that is used to contain an accumulation of regulated substances, and the volume of which (including the volume of underground pipes connected thereto) is 10 percent or more beneath the surface of the ground. **This term does not include:** **(9) Storage tanks situated in an underground area (such as a basement, cellar, mineworking, drift, shaft, or tunnel) if the storage tank is situated upon or above the surface of the floor.**
Subpart B UST Systems: Design, Construction, Installation and Notification	

TABLE A 1 40 CFR 280 FINAL RULE Excerpts pertaining to Red Hill Tanks	
§280.21 Upgrading of Existing UST Systems	Owners and operators must permanently close (in accordance with subpart G) any UST system that does not meet the new UST system performance standards in § 280.20 or has not been upgraded in accordance with paragraphs (b) through (d) of this section. **This does not apply to previously deferred UST systems described in subpart K of this part** and where an upgrade is determined to be appropriate by the implementing agency.
Subpart D Release Detection	
§ 280.40 General Requirements for all UST Systems	(a) Owners and operators of new and existing UST systems must provide a method, or combination of methods, of release detection that; (1) Can detect a release from any portion of the tank and connected underground piping that routinely contains product; (2) Is installed and calibrated IAW with manufacturer's instructions; (3) Beginning on [INSERT DATE 3 YEARS AFTER EFFECTIVE DATE OF PUBLICATION IN THE FEDERAL REGISTER] is operated and maintained, and electronic and mechanical components are tested for proper operation. A test of the proper operation must be performed at least annually and, at a minimum, as applicable to the facility, cover the following components and criteria: (i) Automatic tank gauge and other controllers: test alarm; verify system configuration; test battery backup; (ii) Probes and sensors: inspect for residual buildup; ensure floats move freely; ensure shaft is not damaged; ensure cables are free of kinks and breaks; test alarm operability and communication with controller; (iii) Automatic line leak detector: test operation to meet criteria in § 280.44(a) by simulating a leak; (iv) Vacuum pumps and pressure gauges: ensure proper communication with sensors and controller; and (v) Hand-held electronic sampling equipment associated with groundwater and vapor monitoring: ensure proper operation. (4) Meets the performance requirements in § 280.43, § 280.44, or subpart K, as applicable, with any performance claims and their manner of determination described in writing by the equipment manufacturer or installer. In addition, the methods listed in § 280.43(b); § 280.43(c); § 280.43(d); § 280.43(h); § 280.43(i); § 280.44(a); § 280.44(b); and subpart K, must be capable of detecting the leak rate or quantity specified for that method in the corresponding section of the rule with a probability of detection of 0.95 and a probability of false alarm of 0.05.

TABLE A 1 40 CFR 280 FINAL RULE Excerpts pertaining to Red Hill Tanks	
§ 280.41 Requirements for Petroleum UST Systems	Owners and operators of petroleum UST systems must provide release detection for tanks and piping as follows: (a) *Tanks:* Tanks must be monitored for releases as follows: (1) Tanks installed on or before [INSERT DATE 270 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER] must be monitored for releases at least every 30 days using one of the methods listed in § 280.43(d) through (i) except that: (i) UST systems that meet the performance standards in §280.20 or §280.21, and the monthly inventory control requirements in §280.43(a) or (b), may use tank tightness testing (conducted in accordance with §280.43(c)) at least every 5 years until 10 years after the tank was installed; and (ii) This section applies to tanks with capacity of 550 gallons or less and is not applicable to the Red Hill tanks; (2) Tanks installed after [INSERT DATE 270 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER] must be monitored for releases at least every 30 days in accordance with §280.43(g). (b) **Piping.** Underground piping that routinely contains regulated substances must be monitored for releases in a manner that meets one of the following requirements: (1) Piping installed on or before [INSERT DATE 270 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER] must meet one of the following: (i) Pressurized Piping: See regulation (ii) Suction Piping: See regulation
§ 280.43 Methods of Release Detection for Tanks	Each method of release detection for tanks used to meet the requirements of §280.41, must be conducted in accordance with the following: (a) *Inventory control.* Product inventory control (or another test of equivalent performance) must be conducted monthly to detect a release of at least 1.0 percent of flow-through plus 130 gallons on a monthly basis (See final rule). (b) *Manual tank gauging.* See final rule for details. (c) *Tank tightness testing.* Tank tightness testing (or another test of equivalent performance) must be capable of detecting a 0.1 gallon per hour leak rate from any portion of the tank that routinely contains product while accounting for the effects of thermal expansion or contraction of the product, vapor pockets, tank deformation, evaporation or condensation, and the location of the water table. (d) *Automatic tank gauging*. Equipment for automatic tank gauging that tests for the loss of product and conducts inventory control must meet the following requirements: (1) The automatic product level monitor test can detect a 0.2 gallon per hour leak rate from any portion of the tank that routinely contains product; (2) The automatic tank gauging equipment must meet the inventory control (or other test of equivalent performance) requirements of § 280.43(a); and (3) The test must be performed with the system operating in one of the following

TABLE A 1 40 CFR 280 FINAL RULE	
Excerpts pertaining to Red Hill Tanks	
	modes: (i) In-tank static testing conducted at least once every 30 days; or (ii) Continuous in-tank leak detection operating on an uninterrupted basis or operating within a process that allows the system to gather incremental measurements to determine the leak status of the tank at least once every 30 days. (e) *Vapor monitoring.* Must be combined with inventory control, see Subpart K. (f) *Ground-water monitoring.* Must be combined with inventory control, see Subpart K. (g) *Interstitial monitoring.* See final rule for details. (h) *Statistical inventory reconciliation.* See final rule for details. (i) *Other methods.* See final rule for details.
§ 280.44 Methods of Release Detection for Piping	Each method of release detection for piping used to meet the requirements of §280.41 must be conducted in accordance with the following: (a) Automatic line leak detectors (b) Line tightness testing (c) Applicable tank methods: Except as described in §280.41(a), any of the methods in §280.43(e) through (i) may be used if they are designed to detect a release from any portion of the underground piping that routinely contains regulated substances.

TABLE A 1 40 CFR 280 FINAL RULE Excerpts pertaining to Red Hill Tanks	
Subpart K UST Systems with Field Constructed Tanks and Airport Hydrant Fuel Distribution Systems	
§ 280.251 General Requirements	(a) *Implementation of requirements*. Owners and operators must comply with the requirements of this part for UST systems with field-constructed tanks and airport hydrant systems as follows: (1) For UST systems installed on or before [INSERT DATE 90 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER] the requirements are effective according to the following schedule: - Upgrading UST systems, general operating requirements, and operator training: Three years after the effective date of today's final UST regulation. - Release detection: Three years after the effective date of today's final UST regulation. - Release reporting, response, and investigation; closure; financial responsibility and notification, except as provided in § 280.251(2)(b): On the effective date of today's final UST.
§ 280.252 Additions, Exceptions, and Alternatives for UST Systems with Field-Constructed Tanks and Airport Hydrant Systems	(b) *Upgrade requirements*. Not later than [INSERT DATE 3 YEARS AFTER EFFECTIVE DATE OF PUBLICATION IN THE FEDERAL REGISTER], airport hydrant systems and UST systems with field-constructed tanks where installation commenced on or before [INSERT DATE 90 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER] must meet the following requirements or be permanently closed pursuant to subpart G of this part. (1) *Corrosion protection*. **Preamble to 40 CFR 280 states: Metal tanks and piping which are encased or surrounded by concrete have no metal in contact with the ground and are not subject to the corrosion protection requirements, thus not applicable to Red Hill tanks.** (2) *Spill and overfill prevention equipment.* To prevent spilling and overfilling associated with product transfer to the UST system, all UST systems with field-constructed tanks and airport hydrant systems must comply with new UST system spill and overfill prevention equipment requirements specified in § 280.20(c). (c) *Walkthrough inspections*. See final rule. (d) *Release detection.* Owners and operators of UST systems with field-constructed tanks and airport hydrant systems must begin meeting the release detection requirements described in this subpart not later than [INSERT DATE 3 YEARS AFTER EFFECTIVE DATE OF PUBLICATION IN THE FEDERAL REGISTER]. (1) *Methods of release detection for field-constructed tanks.* Owners and operators of field-constructed tanks with a capacity less than or equal to 50,000 gallons must meet the release detection requirements in subpart D of this part. Owners and operators of **field-constructed tanks with a capacity greater than 50,000 gallons must meet either the requirements in subpart D (except § 280.43(e) and (f) must be combined with inventory control as**

TABLE A 1 40 CFR 280 FINAL RULE	
Excerpts pertaining to Red Hill Tanks	
	stated below) of this part or use one or a combination of the following alternative methods of release detection: (i) Conduct an annual tank tightness test that can detect a 0.5 gallon per hour leak rate; (ii) Use an automatic tank gauging system to perform release detection at least every 30 days that can detect a leak rate less than or equal to one gallon per hour. This method must be combined with a tank tightness test that can detect a 0.2 gallon per hour leak rate performed at least every three years; (iii) Use an automatic tank gauging system to perform release detection at least every 30 days that can detect a leak rate less than or equal to two gallons per hour. This method must be combined with a tank tightness test that can detect a 0.2 gallon per hour leak rate performed at least every two years; (iv) Perform vapor monitoring (conducted in accordance with § 280.43(e) for a tracer compound placed in the tank system) capable of detecting a 0.1 gallon per hour leak rate at least every two years; (v) Perform inventory control (conducted in accordance with Department of Defense Directive 4140.25; ATA Airport Fuel Facility Operations and Maintenance Guidance Manual; or equivalent procedures) at least every 30 days that can detect a leak equal to or less than 0.5 percent of flow-through; and (A) Perform a tank tightness test that can detect a 0.5 gallon per hour leak rate at least every two years; or (B) Perform vapor monitoring or groundwater monitoring (conducted in accordance with § 280.43(e) or (f), respectively, for the stored regulated substance) at least every 30 days; or (vi) Another method approved by the implementing agency if the owner and operator can demonstrate that the method can detect a release as effectively as any of the methods allowed in paragraphs (i) through (v) of this section. In comparing methods, the implementing agency shall consider the size of release that the method can detect and the frequency and reliability of detection.

2.0 Hawaii Department of Health HAR 11-281

Hawaii regulations pertaining to underground storage tanks (USTs) are contained in Hawaii Administrative Rule (HAR) Title 11 Chapter 281 (11-281) effective 9 August 2013. Changes to HAR 11-281 were proposed in March 2013. Public responses and comments were due 10 May 2013. A letter from the DOH dated 5 June, 2013 states that based on the response from the public, the DOH has deferred many of the proposed changes for a later date.

As Hawaii has an approved UST regulation, DOH rules remain in effect and governing for up to three years from the promulgation of 40 CFR 280 (as permitted under 40 CFR 280 subpart K). This provides time for the state to modify DOH regulations for conformance with EPA rules.

Current HAR 11-281 rules affects the Red Hill tanks as follows:

- §11-281-17 Secondary Containment: Requires a UST or tank system installed on or after the effective date of these rules (9 August 2013) must be provided with secondary containment. As the Red Hill tanks were constructed prior to 9 August 2013, the tanks are not required to have secondary containment.
- §11-281-51 General Requirements for all Underground Storage Tanks or Tank Systems: Requires owners and operators of new and existing USTs or tank systems provide a method, or combination of methods, of release detection that meets the performance requirements in section 11-281-52 or section 11-281-53 and be capable of detecting the leak rate or quantity specified for that method in section 11-281-52 (2) 1 (3) 1 or (4) or section 11-281-53(1) or (2), with a minimum probability of detection (Pd) of 0.95 and a maximum probability of false alarm (Pfa) of 0.05.

APPENDIX B - BAPT EVALUATION METHODOLOGY

The following methodology was used to identify and evaluate BAPT tank upgrades:

1. Step 1: Identify available tank upgrade technologies. Available technologies are grouped into the following categories and discussed in Appendix C:
   a. Tank Interior Upgrades (Repair existing steel liner and coatings)
   b. Tank Exterior Upgrades
   c. Upgrades to Provide Secondary Containment with Release Detection
2. Step 2: Screen available technologies for further investigation using the following criteria:
   a. Feasible
   b. Testable during construction
   c. Inspectable during future integrity assessments
   d. Repairable
3. Step 3: Develop candidate BAPT Alternatives
4. Step 4: Screen candidate alternatives for further evaluation using the following criteria:
   a. Practicable: Can the candidate alternative be completed inside of a Red Hill Tank?
   b. Suitable: Is the technology one that is established for the storage of petroleum products, and more importantly, military fuels that contain special additives?
   c. Constructible: Can the alternative be constructed with expectations of a successful contractor quality control program, and government quality assurance program?
   d. Desirable: When compared against the competing candidate alternatives, does it provide a better upgrade?
5. Step 5: Define attributes and develop attribute rating system to evaluate candidate alternatives
6. Step 6: Document specifics on each alternative and rate how the alternative meets the definition of the individual attribute
7. Step 7: Prepare BAPT Rating Matrix that permits evaluation of each BAPT along common attributes

APPENDIX C - TANK UPGRADE TECHNOLOGIES

1.0 Introduction

This section discusses the candidate technologies that EEI identified for tank upgrades and initial screening. Several single-wall tank, double-wall tank, and tank exterior upgrade technologies are identified. Most of the technologies use common engineered materials. Characteristics of the technologies are described, including discussion as to whether or not they were considered for further evaluation. Table C-1 lists candidate technologies that EEI identified for tank upgrades.

2.0 Resources Consulted

EEI, being involved in numerous tank repair projects throughout the world, has been engaged and executed a wide variety of minor and major tank repairs, and new tank engineering projects. Many of the ideas developed as candidate technologies for Red Hill are based on our individual and corporate experiences.

Additional resources consulted for ideas include industry and military fuel tank managers, internet searches, construction contractors and colleagues in the business.

3.0 Screening Criteria

The following criteria was used to screen technologies for further consideration:

- Feasible and Testable (after construction)
- Inspectable and Repairable (future integrity assessment)

Screening criteria was refined at the December 2016 Scoping meetings as follows:

Feasible: Can be constructed in the field at Red Hill using conventional construction means and methods.

- Any solution must be an adaptation of common or previously used methods, but still take advantage of innovative technology when appropriate.
- Must recognize the difficulty in bringing construction materials into the tanks through the limited access Upper Tunnel.

Testable: Can be tested and shown acceptable during construction and startup/commissioning.

- The contractor can provide adequate Quality Control (QC), and the government can provide adequate Quality Assurance checks (QA).
- Able to contain product for the foreseeable future, preferably for several inspection cycles.

Inspectable: Able to determine integrity on a periodic basis either in service, and/or out of service.

- Once placed into service, the integrity of the technology to contain product can be inspected in the future.

Repairable: Able to be repaired in field at Red Hill using conventional construction/repair means and methods.

- If a deficiency or integrity defect is discovered as a part of a future integrity inspection, the problem can be fixed.

Technologies passing these criteria were selected for further investigation. Technologies not passing these criteria were not selected for further investigation and comments are provided as to justification. In the event a technology passes the four criteria but was not selected for further investigation, comments are provided as to the reason for rejection.

4.0 Single Wall Tank Interior Upgrades

The following technologies represent single wall tank concepts to upgrade the present tanks.

4.1 Repair Existing Tank Shell – Patch Plates and Welding

General Description

This technology is similar to the current approach to inspect and repair the Red Hill tanks but uses procedures in Red Hill AOC SOW Section 2.2 TIRM Report established to assure the full integrity of the existing steel liner is investigated for long-term life extension repairs. The inspection process uses both qualitative and quantitative methods, and a qualified tank engineer. Once a tank inspection is complete, repairs are performed, inspected, and tested compliant with the TIRM Report. Tank repairs include repairing corroded and pitted areas and rejectable indications in the steel liner and repairing rejectable indications in welds (intermittent cracks, lack of fusion, porosity, and slag inclusions) in the steel liner. Use of various specialists and inspectors is made by the Navy to oversee compliance with the TIRM Procedure Report.

Feasible

This concept of tank upgrades is considered feasible based on being similar to what has already been done at Red Hill, as well as common application throughout the petroleum tank industry.

Testable (During Construction)

This technology can be tested/inspected during construction using non-destructive examination methods such as vacuum box testing to test patch plates welds and Balanced Field Electromagnetic Technique (BFET) to examine repaired welds in the steel liner for surface and near surface indications.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity assessments following Red Hill AOC SOW Section 2.2 TIRM Report. Inspection of the hydraulic boundary consists of visual inspection of the steel liner plates, patch plates, and welds for indications, scanning of the steel liner plates and patch plates using Low Frequency Electromagnetic Technique (LFET) to identify areas of corrosion and pitting, and scanning the liner welds and patch welds using Balanced Field Electromagnetic Technique (BFET) for surface and near surface indications.

Repairable

This technology can be repaired. Areas of corrosion and pitting can be repaired with patch plates and indications in liner welds and patch plate welds can be repaired by re-welding following procedures in Red Hill AOC SOW Section 2.2 TIRM Report.

Conclusion

Overall, inspection and repair is considered conventional construction, with the emphasis placed on thoroughness, appropriate contractor Quality Control (QC), and government oversight and Quality Assurance program. Selected for further investigation.

4.2 Replace/Provide Tell-tale System

The original tell-tale system had over 500 penetrations in the steel liner for the tell-tale pipes. The original tell-tale system failed in some tanks, from a combination of external corrosion and internal plugging.

Improvements were made to the original tell-tale system crca 1960-1972 (larger diameter tell-tales, schedule 80 pipe) that eliminated earlier weaknesses, and failed elements. Although reports indicate the modified tell-tales were working well, they eventually were disabled, and removed in many tanks. No tanks curretnly have an active remaining Tell Tale system.

Conclusion

The use of an updated form of tell-tales has been selected for further investigation. Limited discussion can be found in Part B Section 3.0 of this report. Historical information on the tell-tale system can be found in Red Hill AOC SOW Section 2.4 TIRM Procedure Decision Document ¶17-7.2a, and TIRM Procedures Report Attachment BF. Additional evaluation of the use of a tell-tale system has become the responsibility of Red Hill AOC SOW Section 4 Release Detection and Collection/Tank Tightness Testing.

4.3 Coating Systems on Existing Steel Liner

Coatings are an additional technology that can be applied over existing steel tank lining. The degree of inspection and repair of the existing steel as a substrate for the coating is dependent on the concept of the coating, i.e. a corrosion inhibiting feature, or a new, independent hydraulic envelope.

4.3.1 Epoxy Coating (Thin Film)

Epoxy coatings are very traditional, but have not been selected for further investigation as the current coating for tank interiors for all of DoD population of tanks, including Navy tanks is polysulfide modified epoxy novolac.

4.3.2 Polysulfide Modified Epoxy Novolac

General Description

Polysulfide modified epoxy novolac has been the Navy standard for several years and now is the DoD standard system for tank interior coatings and is specified in UFGS 09 97 13.15 "Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks". This coating system is a two-component system and is applied in two coats for a total dry film thickness of 24 to 30 mils. Surface preparation consists of cleaning to remove soluble salts and oils followed by abrasive blasting to SSPC 10 Near White Metal. Low voltage holiday testing is performed on the first coat to check for discontinuities. Holidays (discontinuities in the coating) are repaired before applying the second (finish) coat. (1)

Feasible

Polysulfide modified epoxy novolac is the DoD standard system for tank interior coatings.

Testable (During Construction)

Testing during construction includes checking the cleanliness of the steel substrate for oil and soluble salt contamination, checking the surface profile after abrasive blasting the steel substrate, monitoring humidity and temperature inside the tank during coating application, testing the coating for amine blush, checking coating thickness, and performing holiday testing to check for discontinuities.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity inspections. Inspection includes visual inspection for damaged coating such as scraped, peeling, and blistered areas. Holiday testing for discontinuities can also be performed.

Repairable

Holidays and other coating defects can be repaired in the field.

Conclusion

Selected for application if the tank upgrade calls for a coating

4.3.3 Urethane (Thin Film)

General Description

Urethane thin film coating was used on the Red Hill Tanks circa late 1960s and 1970s. (2) This was known as the NRL coating system and consisted of a wash primer, followed by three coats of a thin film proprietary urethane coating formulation, developed by the Naval Research Lab (NRL). Commercially available urethane coating systems are another coating that could be considered but would not necessarily present a different solution, only a permutation of type of coating.

Feasible

Urethane coatings have been used in the past in the Red Hill tanks.

Testable (During Construction)

Testing during construction includes checking the cleanliness of the steel substrate for oil and soluble salt contamination, checking the surface profile after abrasive blasting the steel substrate, monitoring humidity and temperature inside the tank during coating application, checking coating thickness, and performing holiday testing to check for discontinuities.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity inspections. Inspection includes visual inspection for damaged coating such as scraped, peeling, and blistered areas. Holiday testing for discontinuities can also be performed.

Repairable

Holidays and other coating defects can be repaired in the field.

Conclusion

Urethane coating is another coating that could be considered but would not necessarily present a different solution, only a permutation of type of coating.

Not selected for further investigation.

4.3.4 Polyurea (Thick Film)

General Description

Polyurea-based thick film coating materials are used for substrate protection and corrosion prevention. Polyurea coatings, and to a lesser degree their hybrids, do not have the ability to thoroughly wet-out the surface, and are therefore not considered surface tolerant materials. In general, these coatings will adhere tenaciously to the surface they are intimately in contact with during the relatively short gel time. However, if the substrate is contaminated or moisture is present on the surface, the coating will attach itself to the contaminants rather than the substrate. A pure polyurea will cure within 5-15 seconds. This relatively short surface-wetting time limits the adhesion properties of the coating. (3)

Feasible

This technology is feasible, but limited, as the coating has a very short cure time.

Testable (During Construction)

Testing during construction includes checking the cleanliness of the steel substrate for oil and soluble salt contamination, checking the surface profile after abrasive blasting the steel substrate, monitoring humidity and temperature inside the tank during coating application, checking coating thickness, and performing holiday testing to check for discontinuities.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity inspections. Inspection includes visual inspection for damaged coating such as scraped, peeling, and blistered areas. Holiday testing for discontinuities can also be performed.

Repairable

Holidays and other coating defects can be repaired in the field.

Conclusion

Not selected for further investigation due to very short cure time.

4.3.5 Thermal Spray Aluminum (Metalizing)

General Description

Thermal spray is an established industrial method for the surfacing and resurfacing engineered components. Metals, alloys, metal oxides, metal/ceramic blends, carbides, wires, rods, and various composite materials can be deposited on a variety of substrate materials to form unique coating microstructures or near-net-shape components. Thermal spray coatings provide a functional surface to protect or modify the behavior of a substrate material and/or component. A substantial number of the world's industries utilize thermal spray for many critical applications. Key application functions include restoration and repair, protection against corrosion and various forms of wear such as abrasion, erosion and scuff, heat insulation or conduction, oxidation and hot corrosion prevention, electrical conductors or insulators, near-net-shape manufacturing, seals, engineered emissivity, abradable coatings, decorative purposes, and more. (4)

Thermal spraying comprises a group of coating processes in which finely divided metallic or non-metallic materials are deposited in a molten or semi-molten condition to form a coating. The coating material may be in the form of powder, ceramic rod, wire or molten materials.

Thermal spray processes are now widely used to spray coatings to protect against wear and corrosion, heat (thermal barrier coating), and for functional purposes. Thermal spray coatings contain some defects as pores, often globular, formed during their generation, un-molten or partially melted particles that create the worst defects, exploded particles, and cracks formed during residual stress relaxation. Depending on the spray conditions and materials applied, the coatings are more or less porous and for certain applications must be sealed by appropriate means. Often-used organic sealants are epoxies, phenolics, furans, polymethacrylates, silicones, polyesters, polyurethanes, and polyvinyl esters. (5) Thermal spray coatings can be field-applied. Thermal spray aluminum metalizing consists of spraying/depositing aluminum on the substrate.

UFGS 09 97 01.00 10 "Metalizing: Hydraulic Structures" covers the requirements for preparation of surfaces and the application of metallized coatings for hydraulic structures and is intended for corrosion protection of cold and hot rolled steel. This specification was originally developed for USACE civil works projects.

NACE No. 12/AWS C2.23M/SSPC-CS 23.00 Joint Standard Specification for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel covers the application of thermal spray coatings.

Metalizing was a standard option for Navy tank rehabilitation during the 1970s – 1980s and was applied on the lower dome of the Red Hill tanks, but was discontinued due to high cost, and limited benefit. It has been reported that metalizing was discontinued because the metalizing disbonded from the steel substrate.

Feasible

Metalizing was a standard option for Navy tank rehabilitation during the 1970s – 1980s and was applied on the lower dome of the Red Hill tanks

Testable (During Construction)

Testing during construction includes checking the cleanliness of the steel substrate for oil and soluble salt contamination, checking the surface profile after abrasive blasting the steel substrate, monitoring humidity and temperature inside the tank during application, visual inspection for general appearance and discontinuities, and checking coating thickness and adhesion. (6)

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity inspections. Inspection consists of visual inspection for damaged areas.

Repairable

This technology can be repaired in the field.

Conclusion

Selected for further investigation.

4.3.6 Thermal Spray Ceramic

General Description

Thermal spray ceramic is another type of thermal spray where a ceramic-metallic coating is sprayed/deposited on a substrate. (7)

Feasible

Thermal spray ceramic can be applied in the field.

Testable (During Construction)

Testing during construction includes checking the cleanliness of the steel substrate for oil and soluble salt contamination, checking the surface profile after abrasive blasting the steel substrate, monitoring humidity and temperature inside the tank during application, visual inspection for general appearance and discontinuities, and checking coating thickness and adhesion. (6)

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity assessments. Inspection consists of visual inspection for damaged areas.

Repairable

This technology can be repaired in the field.

Conclusion

Ceramic coating is another type of thermal spray coating that could be considered but would not necessarily present a different solution, only a permutation of thermal spray, thus not considered separately.

4.3.7 Glass Coating

General Description

Glass coatings (enamels) on carbon steel substrates have been produced by spraying glass feedstock powders using combustion flame spraying. Enamels are impossible to scratch and products of any shape and color can be enameled. In conventional enamelling, the glass and the substrate are heated together one or more time in furnace to approximately 850 °C, whereas in combustion flame spraying the glass particles are melted in the flame and the temperature of the substrate is maintained at a relatively low level. Combustion flame spraying consists of injecting glass powder into a flame, where the particles are melted, accelerated and projected on a substrate to form a coating. (8) Glass coated bolted steel tanks are used for water, waste water, and other liquid storage uses. (9)

Feasible

This technology cannot be applied in the field, commercial applications glass coatings are only factory-applied. Once coated, steel plate cannot be welded.

Testable (During Construction)

This technology cannot be tested in the field, glass coatings are only factory-applied.

Inspectable (Future Integrity Assessment)

Not applicable, field-applied glass coatings are not feasible.

Repairable

Information on repairability not available.

Conclusion

Not selected for further investigation.

4.4 Single Wall Fiberglass

General Description

Fiberglass is a composite material that embeds fine glass fibers to into a resin matrix to increase overall strength. Single wall fiberglass was utilized in the 1980s and early 1990s to repair corrosion and pitting in aboveground storage tank floors and reduce product side corrosion of the steel. Fiberglass systems have also been applied to the floor and shell of cut and cover tanks and aboveground storage tanks. Fiberglass is applied over existing steel surfaces by applying resin to the steel surface and then embedding fiber mat or chopped fiber particles into the resin. The resin is applied as a liquid that hardens over time. Fibers utilized include carbon fiber, glass fiber, Kevlar and polyester. Resins can be polyester, vinyl ester, epoxy, polyurethane and phenolic. (10) (11)

Feasible

Fiberglass is economical, lightweight, and commercially available. Fiberglass can be installed over and around existing structural elements such as columns and internal pipe supports and be molded to the curvature of the floor and sumps. Mobilizing the necessary equipment and materials into a Red Hill tank could be accomplished. Experience, however, has shown that the fiberglass installed in tanks does not always remain tightly adhered, creating interstitial pockets between the steel and fiberglass lining. If there are holidays (discontinuities in the fiberglass), fuel can be trapped between the fiberglass and steel. Fiberglass linings do not perform well when external hydrostatic water pressure is present. If there is a breach in the steel liner, water pressure can cause the fiberglass to disbond from the steel.

Installing fiberglass on the floor of the lower dome of the Red Hill tanks is practicable as the floor is flat. Installing fiberglass on the lower dome walls becomes more difficult because of the inclined sides. Installing fiberglass on the barrel becomes even more difficult because of the height of the vertical walls and involves working from suspended platforms and holding the fiberglass sheets against the wall of the barrel while the fiberglass is rolled into the resin.

Testable (During Construction)

Because of the large surface area of the Red Hill tanks, performing adhesion tests on the entire surface of the fiberglass is not practicable; most likely adhesion tests would be performed on spot areas and suspect areas. Holiday testing can be performed to check for discontinuities (holidays) in the fiberglass.

Inspectable (Future Integrity Assessment)

Fiberglass systems can be tested for adhesion and inspected for holiday during future tanks integrity assessments using the same methods as used during installation, i.e. adhesion and holiday tests. Because of the surface area of the Red Hill tanks, performing adhesion tests on the entire surface of the fiberglass is not practicable; most likely adhesion tests would be performed on spot areas and suspect areas.

Depending on the thickness of the fiberglass lining, the underlying steel liner may not be inspectable. The fiberglass lining, however, prevents inspection of the welds of the steel liner.

Repairable

Holidays in the fiberglass ling are easily repaired and involve applying additional fiberglass over the area. Disbonded areas can be repaired but requires cutting out the disbonded areas and applying new fiberglass.

Conclusion

Single wall fiberglass systems have a very poor track record in tanks, compared to other linings/coatings.

Not selected for further investigation.

4.5 Bonded Rubber Lining

General Description

Rubber lining is used to increase the corrosion resistance of steel substrates and is very effective in protecting steel from highly caustic and abrasive products. Rubber lining materials include natural, flexible, semi rigid natural ebonite, triflex, chlorobutyl, neoprene, nitrile or Hypalon. It is usually applied using large rubber sheets. These sheets are cut and laid over steel that has had a primer and adhesive layer applied. The rubber sheet is then bonded together by hot vulcanizing, cold vulcanizing, internal pressure or exhaust cure methods. Of all the rubber sheet materials, only nitrile is recommended for use in contact with oil and petroleum products. (12) (13) (14)

Feasible

Rubber liners are lightweight and commercially available. Rubber lining material is more expensive than standard coating application or fiberglass. Material cost for 1/4-inch thick nitrile material is estimated at $9 per square foot without primers and adhesives. Rubber linings can be cut to form around existing structural elements such as columns and internal pipe supports. This effort, however, would be difficult and time consuming because sheet edges must line up exactly with each other or be beveled before edge bonding process can be performed. Mobilizing the necessary equipment and materials into a Red Hill tank could be accomplished. Rubber lining industry experts usually recommend that rubber linings be used to line tanks that hold highly abrasive or severely caustic chemical solutions.

Testable (During Construction)

Testing during construction before curing consists of visual inspection of the lining for pinholes, punctures and tears, and disbondment and holiday testing. Holiday testing can damage the lining if the voltage is not correctly specified and is too high. Inspection and testing after curing consist of checking the lining with a Shore “a” or “D” durometer to determine surface hardness. (15)

Inspectable (Future Integrity Assessment)

Rubber linings can be inspected during future integrity assessments. Inspection would consist of visual inspection of the lining for pinholes, punctures and tears, loose joints, and disbondment. The rubber lining, however, prevents inspecting the steel substrate (i.e. existing steel liner of the Red Hill tanks).

Repairable

The repair of small areas (less than 18 inches in width) is to fill in the area using the same gauge rubber as the original lining and to then overlay this area with the lining extending 2-inches beyond the fill-in patch. The reason a single fill-in patch is not recommended on small repairs is that the rubber tends to lift in one corner area of the repair, resulting in leakage. On large repairs, the single sheet rubber layer can be used if it does not receive the stress as in a small repair. (16)

Conclusion

Selected for further investigation.

4.6 Flexible Membrane Liner

General Description

A flexible membrane liner (FML) is a synthetic material that is used to provide a hydraulic barrier to contain liquids and are used to line ponds, lagoons, storage tanks, and containment dikes. FMLs are also used to fabricate "pillow" or "bladder" tanks and as a release prevention barrier below the floor of ASTs. FMLs can be reinforced with a fabric or unreinforced. Unreinforced FMLs include High Density Polyethylene (HDPE), Linear Low-Density Polyethylene (LLDPE), Poly Vinyl Chloride (PVC), Polypropylene (PP), and urethane materials. (17) Reinforced FMLs consist of a fabric that is coated with a polymer or urethane coating. FMLs used as a release prevention barrier below tank floors and in containment dikes are reinforced with a polyester fabric and have a urethane coating for fuel and abrasion resistance.

An FML inside the Red Hill Tanks would be a reinforced FML, 38 mils thick, with a urethane coating. The FML would not be bonded to the steel liner; rather it would be attached and held in place to the steel liner with steel batten bars that are fastened to the existing steel liner with steel studs welded to the steel liner. This concept is similar to attaching an FML in a containment dike to the concrete ringwall of an AST, or attaching an FML release prevention barrier below the floor of an AST to the dead shell of the AST. The FML would be supplied in large sheets as practical and fusion bonded together in the field. Note: This method of attachment results in multiple penetrations in the FML where the steel studs penetrate the FML which would need to be sealed.

Internal PVC Liner – Heartland Tank Services (18)

Bolted HDPE Liner inside Tank – GFR (19)

Feasible

FMLs are lightweight and commercially available and can be cut to form around existing structural elements such as columns and internal pipe supports. Mobilizing the necessary equipment and materials into a Red Hill tank could be accomplished. Vendors have identified problems with this concept due to pressure at bottom of tank which can force fuel into the liner fabric through cut edges in the liner at joints in the liner.

Testable (During Construction)

Testing during construction consists of visual inspection for pinholes and tears and air lacing to test field seams for adhesion.

Inspectable (Future Integrity Assessment)

FMLs inside the Red Hill Tank can be inspected after installation. Inspection would consist of visual inspection of the liner for pinholes, punctures and tears, disbonded seams, and loose nuts on the studs that attach the FML to the existing liner, and loose or missing batten bars. The FML, however, prevents inspecting the existing steel liner.

Repairable

Holes and punctures in the FML can be repaired by applying an FML patch over the area.

Conclusion

As the FML is not attached to steel liner at all points, it is not possible to obtain certified strapping tables due to draping of liner when tank empty. Additionally, vendors have identified problems with this concept due to pressure at bottom of tank which can force fuel into the liner fabric through cut edges in the liner at joints in the liner. As such, the FML may not be suitable for pressure at bottom of the Red Hill tanks.

Not selected for further investigation.

4.7 Carbon Fiber Sheet

General Description

Carbon fiber sheets are prefabricated composite panels fabricated from multiple layers of high strength carbon fiber prepared using high pressure molding process. The sheets are commonly available in 0.039 to 0.25 inch thickness and 4 feet x 8 feet sheets. Custom molded panels are available.

Feasible

Although carbon fiber sheets are readily available, field applied joint-connecting materials that are intended to create a liquid tight seam are not available. In addition, each carbon sheet would have to be custom fabricated to fit the tank profile as only the floor area has a flat profile. A flat 1/4-inch thick, 4 feet x 8 feet quasi-Isotropic sheet lists at $2800 excluding freight (20). Custom fabricated sheets would be even more costly.

Carbon fiber sheets, however, are not intended as a hydraulic barrier.

Testable (During Construction)

Testing during construction before curing consists of visual inspection of the lining for pinholes, punctures and tears, and disbondment.

Not applicable to Red Hill Tanks as carbon fiber sheets are not intended as a hydraulic barrier and thus are not feasible for the Red Hill tanks.

Inspectable (Future Integrity Assessment)

Inspection during future integrity assessment consists of visual inspection of the carbon fiber sheets for pinholes, punctures and tears, and disbondment.

Not applicable to Red Hill Tanks as carbon fiber sheets are not intended as a hydraulic barrier and thus, are not feasible for the Red Hill tanks.

Repairable

Holes and punctures in carbon fiber sheets can be repaired by applying carbon fiber patch over the area.

Conclusion

Not selected for further investigation. Carbon fiber sheets are not intended as a hydraulic barrier.

4.8 Composite Sandwich Panels

General Description

Composite sandwich panels are laminate sheets such as fiberglass or carbon fiber bonded to a foam on honeycomb core. (21)

Feasible

This technology is not feasible for the Red Hill tanks; carbon fiber sandwich panels are rigid and will not bend to fit curved surfaces such as the steel liner on the barrel of the Redhill tanks, are difficult to seal the joint between panels, and are not intended as a hydraulic barrier. Additionally, the foam or honeycomb core is susceptible to crushing.

Testable (During Construction)

Not applicable, carbon fiber sandwich panels are rigid and will not bend to fit curved surfaces such as the steel liner on the barrel are not intended as a hydraulic barrier and are not feasible for the Red Hill tanks.

Inspectable (Future Integrity Assessment)

Not applicable, carbon fiber sandwich panels are rigid and will not bend to fit curved surfaces such as the steel liner on the barrel are not intended as a hydraulic barrier and are not feasible for the Red Hill tanks.

Repairable

Damaged panels can only be repaired by replacement.

Conclusion

Not selected for further investigation. Carbon fiber sandwich panels are rigid and will not bend to fit curved surfaces such as the steel liner on the barrel of the Redhill tanks, are difficult to seal the joint between panels, and are not intended as a hydraulic barrier.

4.9 Weld Overlay

General Description

Weld overlay is a method to repair corroded and thin plates in tank floors, shells, and roofs by depositing weld metal to restore the thickness of the plate. API 653 establishes specific guidelines for location relative to existing butt welds and tank penetrations (nozzles, columns, etc.). (22)

Feasible

This repair method is feasible and can be performed on the Red Hill tanks.

Testable (During Construction)

Three separate testing methods can be performed after weld overlay is complete to ensure weld quality. Visual weld examination for gross defects, and liquid penetration examination to inspect for surface cracks and rejectable indications, and magnetic particle examination to inspect for surface and near surface cracks, rejectable indications, and discontinuities such as linear porosity and lack of fusion.

Inspectable (Future Integrity Assessment)

The same testing and inspection methods performed during construction can be used to inspect weld overlays during future integrity inspections.

Repairable

Repairs would include grinding to remove rejectable indications in the weld overlay and re-welding addition weld passes.

Conclusion

Although this technology could be applied in the Red Hill tank, it is not selected for further investigation as this technology is not intended for repair of large areas or areas having very little remaining metal thickness which if repaired by weld overlay could result in burn-through.

4.10 Concrete

General Description

This technology consists of placing reinforced concrete inside the Red Hill tanks, against the existing steel liner. Studs are welded to the steel liner to bond the concrete to the steel liner.

Feasible

Concrete tanks have been constructed for fuel storage. This technology would require constructing forms inside the Red Hill tanks to place the concrete and a means to convey concrete to the interior of the tanks. As concrete is permeable, it needs to be sealed to achieve a hydraulic barrier and prevent leaching through the concrete.

Testable (During Construction)

Testing during construction consists of testing the compressive strength of the concrete and visual inspection of proper placement of steel reinforcing bars.

Inspectable (Future Integrity Assessment)

Inspection during future integrity assessment consists of visual inspection for cracks, delaminations, spalls, and disbondment. Concrete, however, prevents inspecting the existing steel liner.

Repairable

Deteriorated areas can be repaired by saw-cutting and chipping to remove the deteriorated area and patching the area with a cement mortar.

Conclusion

Not selected for further investigation due to loss of hydraulic barrier if cracks develop in the concrete. Additionally, concrete prevents inspecting the existing steel liner.

4.11 Spray Applied Concrete

General Description

Spray-applied concrete, also referred to as Gunite or shotcrete, is small aggregate concrete that is pneumatically sprayed under pressure onto steel and concrete structures. Spray-applied concrete is used for swimming pools and other water containing structures but has never been used in petroleum storage tanks.

Feasible

Spray-applied concrete has been used to restore concrete bridges, dams, piers and can be applied to steel surfaces. As spray-applied concrete is permeable, it needs to be sealed to achieve a hydraulic barrier and prevent leaching through the concrete.

Testable (During Construction)

Limited, testing during construction consists of testing the compressive strength of the spray-applied concrete and visual inspection during application for coverage and thickness.

Inspectable (Future Integrity Assessment)

Inspection during future integrity assessment consists of visual inspection for cracks, delaminations, spalls, and disbondment. Spray-applied concrete, however, prevents inspecting the existing steel liner.

Repairable

Deteriorated areas can be repaired by saw-cutting and chipping to remove the deteriorated area and patching the area with a cement mortar.

Conclusion

Not selected for further investigation as spray-applied concrete can crack and disbond. Additionally, spray-applied concrete prevents inspecting the existing steel liner.

4.12 Ceramic Tile

General Description

Ceramic tile and brick linings are used to protect steel tanks from extreme chemical attack and high temperature conditions. Alumina-ceramic tiles are used to protect from extreme wear. This lining material is used extensively in mining and paper industries to protect tanks, chutes and hoppers. Usage in petrochemical industry is typically for acid tanks. (23) (24)

Feasible

Ceramic tile linings are lightweight, commercially available and can be cut to form around existing structural elements such as columns and internal pipe supports. Mobilizing the necessary equipment and materials into a Red Hill tank could be accomplished. Installation would be difficult to perform from a hanging basket as mortar or grout material must be troweled on to the wall before tiles can be placed. Tile is also not typically used to enhance tank hydraulic integrity but to protect steel tanks from caustic chemicals, high temperature, and excessive abrasion.

Testable (During Construction)

Ceramic tiles can be visually inspected for cracks and deteriorated joints

Inspectable (Future Integrity Assessment)

Ceramic tiles can be visually inspected for cracks and deteriorated joints. Ceramic tiles, however, prevent inspection of the existing steel liner.

Repairable

Ceramic tiles linings can be repaired by replacing cracked tiles, repointing joints, and reinstalling loose or missing tiles. Repairs to the existing steel liner, however, require removal of the ceramic tiles to access the steel liner.

Conclusion

Not selected for further investigation.

5.0 Upgrades to Provide Secondary Containment with Release Detection

5.1 Composite Tank (Carbon Steel)

General Description

A composite tank creates a double-wall tank with secondary containment and integral release detection. Only the lower dome and barrel will have a double wall. The upper dome will be inspected and repaired only to prevent infiltration of groundwater.

A composite tank consists of providing a 1/4-inch thick carbon steel liner inside the tank supported by structural steel angles welded to the existing steel liner. This new steel liner is the primary tank envelope and is separated from the existing steel liner by steel angles to create a 3-inch wide interstitial space for release detection. The interstitial space is filled with self-leveling concrete, non-shrink grout, or precast concrete panels to resist fluid pressure from tank contents. The product side of the primary steel liner will be coated with a polysulfide modified epoxy novolac in accordance with UFGS 09 97 13.15 "Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks". The existing steel liner will be inspected and repaired and becomes secondary containment. The existing steel liner will not be coated.

Composite Tank is further discussed in Part E - Tank Upgrade Alternative 2A.

Feasible

For application on these tanks, the exiting liner must receive rigorous inspection for integrity following the principles in the Red Hill AOC SOW 2.2 TIRM Report. This concept has been used on several large mined tanks at NAVSUP DFSP Hakozaki, Yokosuka, Japan. Refer to Appendix H for additional information.

Testable (During Construction)

All aspects of the composite tank can be fully tested for integrity and shown acceptable during construction (QC/QA) prior to filling and during startup/commissioning when filling.

Inspection of the existing steel liner consists of inspecting the steel liner plates and welds for indications such as corrosion and pitting.

Inspection of the primary steel liner consists of inspecting liner welds for rejectable indications and vacuum box testing of liner welds for leaks. As an alternative to vacuum box testing, the primary steel liner welds could be examined for breaches by injecting a detectable gas (helium) in the interstitial space and examining the primary steel liner from inside the tank for presence of the gas entering the tank through the primary steel liner welds.

Inspectable (Future Integrity Assessment)

The primary steel liner can be inspected during future integrity assessments. Future inspection of the primary steel liner will require tank draindown and cleaning. Integrity inspection would be no different than the current integrity inspections of existing tanks involving liner plate scanning and weld scanning following industry practices adapted to Red Hill conditions. Integrity testing of interstitial space and release detection system is provided by design features that will permit confirming the ability of the interstitial space leak detection system.

Future physical inspection of the existing steel liner is not possible, as it will be covered by concrete/grout in the interstitial space and the new primary steel liner. If it is determined the secondary containment barrier potentially has failed, and isolation/confirmation is required, the inner steel liner and concrete must be removed. The interstitial monitoring system will be used to isolate the failed section to either the lower dome, or 1/26th of the barrel.

Repairable

The primary steel liner can be repaired using conventional construction means and methods (patch plates and weld repairs).

All repairs to the primary steel liner, existing steel liner, and release detection piping require tank draindown and cleaning.

Corrosion in the primary steel liner plates and plate welds can be repaired using conventional industry practice repair methods (i.e. patch plates and welding). Repairs to the primary steel liner require removal of interior coating on the primary steel liner at area of repair to perform repairs followed by repair of the coating after repairs are complete.

Repair of the existing steel liner after new primary steel liner plates are installed is possible but would require removing the primary steel liner and concrete/grout fill in the interstitial space, locating the breach in the existing steel liner, repairing the existing steel liner, re-installing the primary steel liner at the repair area, and filling the interstitial space with concrete or grout.

Repair of the interior coating on the primary steel liner also requires draindown and cleaning and will follow industry practice.

Conclusion

Selected for further investigation.

5.2 Composite Tank (Duplex Stainless Steel)

General Description

The concept is the same as the Composite Tank (Carbon Steel) concept except uses duplex stainless steel as the primary tank liner instead of a carbon steel liner and eliminates the need to coat the product side of the primary steel liner.

Conclusion

Selected for further investigation.

5.3 Tank within a Tank (Carbon Steel)

General Description

This concept involves constructing a carbon steel tank within the existing tank. The existing tank provides secondary containment. The interior of the new tank the will be coated with polysulfide modified epoxy novolac in accordance with UFGS 09 97 13.15 "Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks". The exterior of the new tank and the steel liner on the barrel and upper dome of the existing tank will be coated with a zinc-rich epoxy/epoxy coating in accordance with UFGS 09 97 13.27 "Exterior Coating of Steel Structures". The normally provided urethane topcoat is not needed as the tank is not subject to UV from sunlight.

Tank within a Tank is further discussed in Part E - Tank Upgrade Alternative 3A.

Feasible

A tank within tank was construct inside a cut and cover tank NS Guantanamo Bay, Cuba but not of the size of a tank inside a Red Hill tank.

Testable (During Construction)

All aspects of the tank within a tank can be fully tested for integrity and shown acceptable during construction (QC/QA) prior to filling and during startup/commissioning when filling.

Inspectable (Future Integrity Assessment)

Future inspection of the primary tank is no different than integrity inspections of tanks in vaults following industry practices adapted to Red Hill conditions using conventional nondestructive examination methods. Additionally, the existing steel liner on the barrel is accessible for inspection.

Repairable

Both the existing steel liner and the primary tank can be repaired using conventional construction means and methods.

Conclusion

Selected for further investigation.

5.4 Tank within a Tank (Duplex Stainless Steel)

General Description

The concept is the same as the Tank within a Tank (Carbon Steel) concept except uses duplex stainless steel as the primary tank instead of a carbon steel and the primary. As the primary tanks is stainless steel, it does not need to be coated; only the carbon steel liner on the barrel and upper dome of the existing tank will be coated with a zinc-rich epoxy/epoxy coating in accordance with UFGS 09 97 13.27 “Exterior Coating of Steel Structures”.

Conclusion

Selected for further investigation.

5.5 Double Wall Fiberglass with Release Detection (TankBau System)

General Description

The system consists of manually applied layers of polyester resin, glass mat fabric and polyester resin sealant. The system is designed for application over steel or concrete understructure, necessary to support static fuel loads. The first layer of double polyester resin coating is placed on two textile glass mats and sealed with double polyester resin. This layer is then tested for impermeability with high voltage tester. An interstitial space is created using ball impact metal foil or spacer fabrics. Final layer is repeat of first layer of double polyester resin coating with double polyester resin sealant are installed on existing structures and in new construction. (25)

Feasible

Fiberglass is economical, lightweight, and commercially available. Fiberglass can be installed over and around existing structural elements such as columns and internal pipe supports and be molded to the curvature of the floor and sumps. Double wall fiberglass systems with interstitial space for leak detection monitoring have installed at military facilities throughout Europe. Mobilizing the necessary equipment and materials into a Red Hill tank could be accomplished. However, there are very few US companies that install this type of system as a retrofit to an existing tank. There is also a limit to the static pressure the interstitial space can support. One technical paper states the seam joints can only withstand 10 psi or about 30 feet of static head pressure. Also, as stated previously, installing fiberglass to the floor is achievable but successfully installing several layers up the walls would be very difficult.

Testable (During Construction)

This technology can be tested during construction.

Inspectable (Future Integrity Assessment)

This technology can be inspected during construction

Repairable

Information not available.

Conclusion

Selected for further investigation initially, however the manufacturer of this system withdrew due to difficulty in providing such a system on a tank as large as Red Hill, with pressures from the height of the fuel stored.

5.6 Steel Liner Plates Welded to Existing Steel Liner

General Description

This concept consists of welding 1/4-inch thick carbon steel plates on and in contact with the existing steel liner on the barrel and lower dome of the existing tanks. The new steel plates would terminate two feet below the expansion joint at the top of the tank barrel. The interface between existing steel liner and new steel liner serves as an "interstitial space" for release detection. The product side of the new plates will be coated.

Feasible

Installing new steel plates on the existing steel liner can be performed in the Red Hill tanks using conventional construction means and methods.

Testable (During Construction)

Welds attaching the new liner plates to the existing steel liner can be inspected for indications. NDE examinations include visual inspection of welds for appearance, profile, and size; liquid penetrant examination for surface indications, magnetic particle examination for surface and near surface indications, and vacuum box testing for porosity and breaches.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity assessments following requirements in Red Hill AOC SOW Section 2.2 TIRM Report. Inspection consists of visual inspection of the steel liner plates and welds for rejectable indications, scanning of the steel liner plates using Low Frequency Electromagnetic Technique (LFET) to identify areas of corrosion and pitting, and scanning the liner welds and patch welds using Balanced Field Electromagnetic Technique (BFET) for surface and near surface indications.

Repairable

The primary steel liner can be repaired using conventional construction means and methods. Corrosion in the primary steel liner plates and plate welds can be repaired using conventional industry practice repair methods (i.e. patch plates and welding). Repairs to the primary steel liner require removal of interior coating on the primary steel liner at area of repair to perform repairs followed by repair of the coating after repairs are complete.

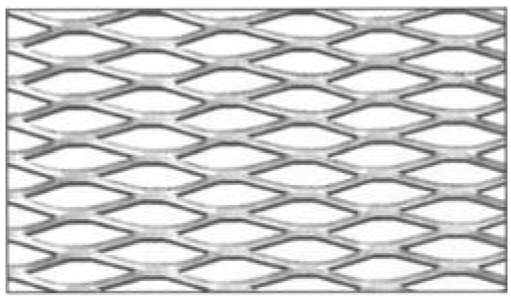
Conclusion

Selected for further investigation

5.7 Steel Liner Plates with Expanded Metal Welded to Existing Steel Liner

General Description

This concept is similar to welding steel plates over the existing steel liner except expanded metal plate is provided between the new liner plates and existing steel liner. The expanded metal plate creates a wider interstitial space than the "interstitial space" interface in the concept of welding steel plates over the existing steel liner.



Expanded Metal

Feasible

This concept can be performed in the Red Hill tanks using conventional construction means and methods.

Testable (During Construction)

Welds attaching the new liner plates to the existing steel liner can be inspected for indications. NDE examinations include visual inspection of welds for appearance, profile, and size; liquid penetrant examination for surface indications, magnetic particle examination for surface and near surface indications, and vacuum box testing for porosity and breaches.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity assessments following requirements in Red Hill AOC SOW Section 2.2 TIRM Report. Inspection of the consists of visual inspection of the steel liner plates and welds for indications, scanning of the steel liner plates using Low Frequency Electromagnetic Technique (LFET) to identify areas of corrosion and pitting, and scanning the liner welds and patch welds using Balanced Field Electromagnetic Technique (BFET) for surface and near surface indications.

Repairable

The primary steel liner can be repaired using conventional construction means and methods. Corrosion in the primary steel liner plates and plate welds can be repaired using conventional industry practice repair methods (i.e. patch plates and welding). Repairs to the primary steel liner require removal of interior coating on the primary steel liner at area of repair to perform repairs followed by repair of the coating after repairs are complete.

Conclusion

Selected for further investigation.

5.8 Stainless Steel Membrane over Existing Steel Liner (LNG Tank Concept)

General Description

This technology consisted of insulated panels with a thin stainless steel membrane liner that is installed inside LNG tanks. It is possible to monitor the space between the membrane liner system and storage tank.

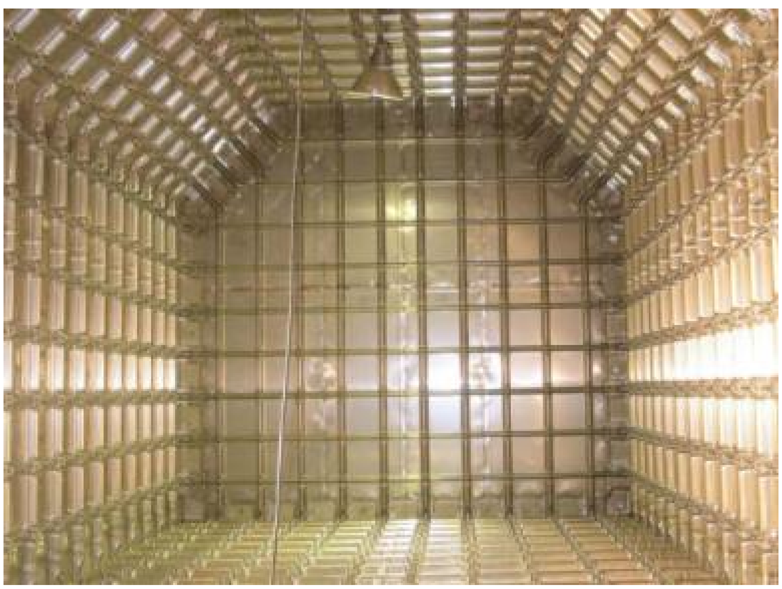


Image inside LNG Tank (26)

Feasible

This technology has been used in large concrete LNG tanks and LNG carrier tankers. (27)

Testable (During Construction)

This technology can be tested during construction. One vendor tests the stainless steel membrane by ammonia leak testing and/or by pressure change measurement. The ammonia leak test is performed introducing an inert gas mixed with ammonia to the internal space of the test material and then over-pressurizing the internal space. Ammonia sensitive paint is then spread over the weld seams to be tested. The pressure change test consists of measuring the internal space for pressure change over time to check for leaks. (28)

Inspectable (Future Integrity Assessment)

The same tests performed during construction can be performed during future integrity assessments

Repairable

This technology can be repaired.

Conclusion

Selected for further investigation.

5.9 Flexible Membrane Liner with Release Detection

General Description

This concept is similar to the FML concept discussed in Single Wall Tank Interior Upgrades except release detection piping inside the tank connected to the membrane liner is provided. The membrane liner is “hung” from the tank barrel and covers the lower dome and may have intermittent fastening to the existing steel liner. As the liner is not bonded to the existing steel liner, this concept provides an interstitial space between the membrane liner and existing steel liner with release detection piping inside the tank connected to the membrane liner to monitor the interstitial space. The membrane liner most likely would not be applied to upper dome due to difficulty in preventing the liner from sagging.

Feasible

FMLs are lightweight and commercially available and can be cut to form around existing structural elements such as columns and internal pipe supports. Mobilizing the necessary equipment and materials into a Red Hill tank could be accomplished. Vendors have identified problems with this concept due to pressure at bottom of tank which can force fuel into the liner fabric through cut edges in the liner at joints in the liner.

Testable (During Construction)

Testing during construction consists of visual inspection for pinholes and tears and air lacing to test field seams for adhesion.

Inspectable (Future Integrity Assessment)

FMLs inside the Red Hill Tank can be inspected after installation. Inspection would consist of visual inspection of the liner for pinholes, punctures and tears, disbonded seams, and loose nuts on the studs that attach the FML to the existing liner, and loose or missing batten bars. The FML, however, prevents inspecting the existing steel liner.

Repairable

Holes and punctures in the FML can be repaired by applying an FML patch over the area.

Conclusion

As the FML is not attached to steel liner at all points, it is not possible to obtain certified strapping tables due to draping of liner when tank empty. Additionally, vendors have identified problems with this concept due to pressure at bottom of tank which can force fuel into the liner fabric through cut edges in the liner at joints in the liner. As such, the FML may not be suitable for pressure at bottom of the Red Hill tanks.

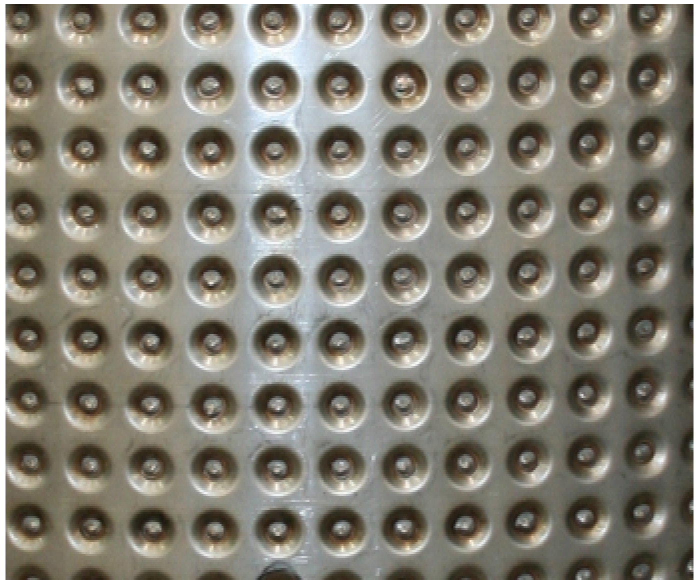
Not selected for further investigation.

5.10 Dimple Jacket Stainless Steel

General Description

Dimple jackets are typically used in tanks where uniform heating or cooling is required throughout the tank contents. Dimples are punched or pressing into thin gauge stainless steel sheets that are welded to the exterior of a tank. Dimple jackets are also available in thin gauge carbon steel. The dimple jacket creates turbulence in the heating or cooling fluid flowing over it. This increases heat transfer from heating or cooling medium to the product in the tank. (29)

Dimple Jacket Material



Closeup of Dimples in Jacket

Feasible

Although a dimple jacket could be added to the interior of Red Hill tanks to create an interstitial space, it would be remarkably costly. Dimple jackets are designed for heat transfer, not leak detection.

Testable (During Construction)

Installing a dimple jacket on the existing steel liner can be performed in the Red Hill tanks using conventional construction means and methods.

Inspectable (Future Integrity Assessment)

This technology can be inspected during future integrity assessments. Inspection would consist of visual inspection.

Repairable

Reparability is limited. Damaged areas can be cut out and new dimple jacket sections installed in the repair areas. Repair of the jacket is difficult as the dimple jacket material is typically thin gauge for heat transfer. (30)

Conclusion

Not selected for further investigation. Each dimple in the jacket has a hole for welding the jacket to the substrate which results in no secondary containment at each dimple weld.

6.0 Tank Exterior Upgrades

The following are concepts to upgrade the Red Hill tanks by performing upgrades to the exterior of the tanks.

6.1 Cementitious Grout

General Description

Cementitious grout is used for soil stabilization, settlement control, improve soil bearing capability, slow groundwater migration through soils, and prevent the migration of contaminants in soils. (31)

Feasible

Cementitious grouting at Red Hill is questionable due to highly variable nature of the lava rock stratigraphy at Red Hill.

Testable (During Construction)

This technology is not testable during construction, only the process of injecting grout into the soil can be performed. It is not possible to test whether the soil is fully grouted other than by probing.

Inspectable (Future Integrity Assessment)

This technology is not inspectable.

Repairable

Possibly, would require injecting additional grout but no means to test if the repair is complete.

Conclusion

Not selected for further investigation.

6.2 Chemical Grout

General Description

Chemical grout is used for soil stabilization, settlement control, improve soil bearing capability, and slow groundwater migration through soils. Chemical grouting permeates the pore spaces in granular soils with a low viscosity non-particulate grout which hardens to create a cemented mass. (32) (33). Chemical grouts include non-expanding chemical polyurethane resins, single component polyurethane, plural component polyurethane, and single component prepolymers. Prepolymer grout is injected into granular soils (i.e. sand) increase soil bearing capability and reduce soil permeability.

Feasible

Chemical grouting at Red Hill is questionable due to highly variable nature of the lava rock stratigraphy at Red Hill.

Testable (During Construction)

This technology is not testable during construction, only the process of injecting grout into the soil can be performed. It is not possible to test whether the soil is fully grouted other than by probing.

Inspectable (Future Integrity Assessment)

This technology is not inspectable.

Repairable

Possibly, would require injecting additional grout but no means to test if the repair is complete.

Conclusion

Not selected for further investigation.

6.3 Cut-off Pan

General Description

This concept consists of excavating below the Red Hill tanks to install a "cut-off pan" to contain releases. The cut-off pan could be reinforced concrete or other material.

Feasible

This technology is not feasible at Red Hill

Testable (During Construction)

This technology is not testable during construction.

Inspectable (Future Integrity Assessment)

This technology is not inspectable after installation.

Repairable

This technology is not repairable.

Conclusion

Not selected for further investigation.

6.4 Sheet Pile Wall

General Description

This concept consists of driving steel sheet piles around each of the Red Hill tanks to form containment around the tank. This concept does not provide containment below the tanks.

Feasible

This technology is not feasible at Red Hill. Sheet piles from the top of Red Hill to below the bottom of the tanks would require sheet piles over 440 to 450 feet long, driven through lava rock.

Testable (During Construction)

It is not possible to test the integrity of the sheet piles during construction.

Inspectable (Future Integrity Assessment)

It is not possible to inspect the integrity sheet piles after installation.

Repairable

It is not possible to repair damaged and corroded sheet piles.

Conclusion

Not selected for further investigation.

6.5 Cryogenic Encapsulation

General Description

Cryogenic encapsulation is a technology where an ice ring is used as an impervious barrier to a leak in LNG tanks in rock caverns. In the LNG concept, groundwater is removed from the rock and then a cavern is excavated. The cavern is then lined with prestressed concrete and a stainless steel membrane liner. After the LNG tank is constructed inside the cavern, groundwater is allowed to replenish the rock outside of the cavern and cools until it freezes as it comes in contact with the LNG cavern. It is the very low temperature of the LNG that provides the cooling/freezing effect. (34)

Feasible

Unlikely at Red Hill as the lava rock surrounding the tanks is porous and contains lava tubes making it difficult to hold water around the exterior of the tank until it freezes. Additionally, refrigeration equipment must be provided and maintained operational to free the water.

Testable (During Construction)

This technology is not testable during construction.

Inspectable (Future Integrity Assessment)

This technology is not inspectable after installation.

Repairable

Repairablity is questionable.

Conclusion

Not selected for further investigation.

TABLE C-1 CANDIDATE TANK UPGRADE TECHNOLOGIES					
Technology	**Screening Criteria**				**Comment**
	Feasible	**Testable**	**Inspectable**	**Repairable**	
Tank Interior Upgrades – Single Wall					
Repair Existing Steel Liner	The alternative requires sufficiently thorough inspection of the tank envelope (floor, lower dome, and barrel, expansion joint and upper dome) to identify all rejectable indications that once repaired; provide a life extension well beyond the next inspection cycle. Specifics are outlined in Red Hill AOC SOW Section 2.2 TIRM Report.				
Patch Plates and Welding	Yes	Yes	Yes	Yes	**Selected for further investigation** • Once the location and type of indications are identified, the actual repair is considered conventional, recognizing the difficulty of working in a Red Hill tank. The degree of repair may vary depending on the characteristics of final BAPT selected
Replace/provide release detection pipes (similar to original tell-tale system)	Yes	Yes	Yes	Yes	**Selected for further investigation** • This would be a sub alternative on any single wall tank alternative • The original tell-tale system failed early on in some tanks, from a combination of external corrosion and internal plugging. Later upgrades did not have the same limitations and did not fail.

TABLE C-1 CANDIDATE TANK UPGRADE TECHNOLOGIES					
Technology	**Screening Criteria**				**Comment**
	Feasible	**Testable**	**Inspectable**	**Repairable**	
Coatings	Coatings are considered an additional technology that can be applied over existing steel tank lining. The degree of inspection and repair of the existing steel as a substrate for the coating is dependent on the concept of the coating, i.e. a corrosion inhibiting feature, or a new, independent hydraulic envelope.				
Epoxy (Thin Film)	Yes	Yes	Yes	Yes	**Not selected for further investigation as the current coating for tank interiors for Navy tanks is polysulfide modified epoxy novolac** • Very traditional
Polysulfide Modified Epoxy Novolac	Yes	Yes	Yes	Yes	**Selected for application if the tank upgrade calls for a coating** • DoD standard coating system for tank interiors
Urethane (Thin Film)	Yes	Yes	Yes	Yes	**Not selected for further investigation** • Was used on the Red Hill Tanks circa late 1960s and 1970s (NRL system) • Urethane coating is coating that could be considered but would not necessarily present a different solution, only a permutation thus not considered separately.
Polyurea (Thick Film)	Yes	Yes	Yes	Yes	**Not selected for further investigation** • Cures within seconds, limiting adhesion properties
Thermal Spray Aluminum (Metalizing)	Yes	Yes	Yes	Yes	**Selected for further investigation** • Provides corrosion protection • In 70s-80s was a standard option for Navy tank rehabilitation, but was discontinued due to high cost, and limited benefit
Thermal Spray Ceramic	Yes	Yes	Yes	Yes	• Ceramic coating is another type of thermal spray coating that could be considered but would not necessarily

TABLE C-1 CANDIDATE TANK UPGRADE TECHNOLOGIES					
Technology	**Screening Criteria**				**Comment**
	Feasible	**Testable**	**Inspectable**	**Repairable**	
					present a different solution, only a permutation of thermal spray, thus not considered separately.
Glass	No	Yes	Yes	No	**Not selected for further investigation** • Performed only in factory, not available for field application • Once coated, steel plate cannot be welded
Liners	Liners generally are considered a form of new tank hydraulic envelope, inside of the original steel liner				
Single Wall Fiberglass	Yes	Yes	Yes	Yes	**Not selected for further investigation** • Very poor track record in tanks, compared to other linings/coatings
Bonded Rubber Lining	Yes	Yes	Yes	Yes	**Selected for further investigation**
Flexible Membrane Liner	Questionable	Limited	Yes	Yes	**Not selected for further investigation** • Not possible to obtain certified strapping tables due to draping of liner when tank empty • May not be suitable for pressure at bottom of the Red Hill tanks as pressure at bottom of tank can force fuel into the liner fabric through cut edges in the liner at joints in the liner.
Carbon Fiber Sheet	Yes	Yes	Yes	Yes	**Not selected for further investigation** • Not intended as a hydraulic barrier
Composite Sandwich Panel	No	Unknown	Yes	Unknown	**Not selected for further investigation** • Sandwich panels are rigid and cannot be formed to curvature of tank • Difficult to seal joint between panels

TABLE C-1 CANDIDATE TANK UPGRADE TECHNOLOGIES					
Technology	**Screening Criteria**				**Comment**
	Feasible	**Testable**	**Inspectable**	**Repairable**	
					• Not intended as a hydraulic barrier
Weld Overlay					**Not selected for further investigation**
Concrete					**Not selected for further investigation**
Spray-Applied Concrete					**Not selected for further investigation**
Ceramic Tile					**Not selected for further investigation**
Upgrades to Provide Secondary Containment with Release Detection					
Composite Tank (Carbon Steel)	Yes	Yes	Yes	Yes	**Selected for further investigation**
Composite Tank (Duplex Stainless Steel)	Yes	Yes	Yes	Yes	**Selected for further investigation**
Tank within a Tank (Carbon Steel)	Yes	Yes	Yes	Yes	**Selected for further investigation**
Tank within a Tank (Duplex Stainless Steel)	Yes	Yes	Yes	Yes	**Selected for further investigation**
Double Wall Fiberglass with Release Detection (TankBau system)	Unknown	Limited	Yes	Limited	**Initially Selected for further investigation, but manufacturer withdrew from consideration**
Steel Liner Plates Welded to Existing Steel Liner	Yes	Yes	Yes	Yes	**Selected for further investigation**
Steel Liner Plates with Expanded Metal Plate between Existing Steel Liner and Steel Liner	Yes	Yes	Yes	Yes	**Selected for further investigation**

TABLE C-1 CANDIDATE TANK UPGRADE TECHNOLOGIES					
Technology	**Screening Criteria**				**Comment**
	Feasible	**Testable**	**Inspectable**	**Repairable**	
Stainless Steel Membrane over existing steel liner (similar to LNG membrane tank concept)	Yes	Yes	Yes	Yes	**Selected for further investigation**
Flexible Membrane Liner with Release Detection Piping	Doubtful	Limited	Yes	Yes	**Not selected for further investigation** • Not possible to obtain certified strapping tables due to draping of liner when tank empty • May not be suitable for pressure at bottom of the Red Hill tanks as pressure at bottom of tank can force fuel into the liner fabric through cut edges in the liner at joints in the liner.
Dimple Jacket Stainless Steel	Questionable	Yes	Yes	Limited	**Not selected for further investigation** • Each dimple in the jacket has a hole for welding the jacket to the substrate which results in no secondary containment at each dimple weld.
Tank Exterior Upgrades					
Encapsulation					
Cementitious Grout	Doubtful	No	No	Questionable	**Not selected for further investigation** • Not testable • Not inspectable • Grouting at Red Hill is questionable due to highly variable nature of the lava rock stratigraphy at Red Hill
Chemical Grout (Types of chemical grout include urethane,	Doubtful	No	No	Questionable	**Not selected for further investigation** • Not testable

Technology	Screening Criteria				Comment
	Feasible	Testable	Inspectable	Repairable	
polyurethane, sodium silicate, and acrylic. Each have different properties and uses.)					• Not inspectable • Grouting at Red Hill is questionable due to highly variable nature of the lava rock stratigraphy at Red Hill
Cut-off Pan	Doubtful	No	No	No	**Not selected for further investigation**
Sheet Pile Wall	No	No	No	No	**Not selected for further investigation**
Cryogenic **(Ice layer outside Tank)**	No	No	No	Questionable	**Not selected for further investigation** • Requires water on exterior of tank and means to freeze the water

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APPENDIX D - CANDIDATE TANK UPGRADE ALTERNATIVES

1.0 Key Background Documents

The following key documents have addressed in the past, upgrade alternatives for the Red Hill Tanks:

- Repair Tank 19, Red Hill, 1997: EEI completed this study under contract to NAVFAC, to develop ideas for upgrades to out of service Tank 19.
- Red Hill Repair Tanks Options Study, 2008: EEI completed this study under contract to NAVFAC which updates and expands upon the 1997 Tank 19 report.

2.0 Candidate Tank Upgrade Alternatives Identified

From evaluation and screening of available technologies, the following candidate alternatives were identified. Further evaluation of these candidate alternatives resulted in some being ruled out; reasons why are provided in notes that follow.

1. Alt 1A: Restoration of Tank (see note 1 below)
2. Alt 1B: Restoration of Tank plus Interior Coating (see note 1 below)
3. Alt 1C: Restoration of Tank plus Metalizing (ruled out see note 2 below)
4. Alt 1D: Remove Existing Steel Liner, Install New Liner (see note 3 below)
5. Alt 1E: Rubber Liner Bonded to Existing Steel (ruled out, see note 4 below)
6. Alt 2A: Composite Tank – Carbon Steel
7. Alt 2B: Composite Tank – Stainless Steel
8. Alt 3A: Tank in Tank – Carbon Steel
9. Alt 3B: Tank in Tank – Stainless Steel
10. Alt 4: Double Wall Fiberglass with Release Detection (ruled out, see note 5 below)
11. Alt 5A: Steel Plates Welded to Existing Liner
12. Alt 5B: Steel Plates Welded to Existing Liner with Mesh in Interstice
13. Alt 6: Stainless Steel Membrane welded to Existing Steel Liner

Notes:

1. Alt 1A and Alt 1B: Alt 1A and Alt 1B were identified in available technologies as tank interior upgrades (patch plates and welding).

2. Alt 1C: Further evaluation of Alt 1C metallizing concept resulted in it being rejected from further consideration for the following reasons:

   a. Metalizing is no longer considered suitable technology for anything other than enhanced corrosion protection, or physical material build up in the most critical applications, with no other appropriate means of meeting the requirements, such as use of liquid applied coatings/linings

   b. Application requirements are stringent in terms of material surface preparation (white metal blast), exceeding that of spray-applied coatings.

   c. Metalizing is inherently porous, resulting in the need to apply a liquid lining/coating over the metalizing.

3. Alt 1D Remove Existing Steel Liner, Install New Liner was added after screening of available technologies.

4. Alt 1E: Further evaluation of the Alt 1E bonded rubber concept resulted in it being rejected from further consideration for the following reasons:

   a. The existing steel liner would need to be prepared to remove protrusions and coating systems that prevent bonding. The likelihood for successfully completing was not rated highly given the highly varied surface with considerable protrusions throughout the tank.

   b. There would be no added benefit of a thick rubber liner compared to a more conventional spray-applied coating system.

5. Alt 4: Further evaluation of Alt 4: Double Wall Fiberglass with Release Detection concept resulted in it being rejected from further consideration as the manufacturer has not performed testing to demonstrate that the double wall fiberglass system can withstand the pressure inside the Red Hill tanks without crushing.

3.0 Screening Criteria

The following primary criteria was used to screen candidate tank upgrade alternatives for further evaluation:

- **Practicable**: Can the candidate alternative be completed inside of a Red Hill Tank?
- **Suitable**: Is the technology one that is established for the storage of petroleum products, and more importantly, military fuels that contain special additives?
- **Constructible**: Can the alternative be constructed with expectations of a successful contractor quality control program, and government quality assurance program?
- **Desirable**: When compared against the competing candidate alternatives, does it provide a better upgrade?

4.0 Summary of Candidate Tank Upgrade Alternatives

Table D-1 presents the alternatives that were selected after screening for further evaluation.

TABLE D-1
CANDIDATE TANK UPGRADE ALTERNATIVES

Alternative	Concept	Comments
Single Wall – Existing Tank Upgrade Concepts		
1A	Restoration of Existing Tank (similar to current integrity inspection and repair approach, with improvements)	• Use of current concept to inspect and repair the existing tank • Will utilize procedures for inspection and repair specified AOC Section 2.2 TIRM Procedures Report. • The tank would not have secondary containment, thus must rely on release detection system and periodic tightness testing for environmental compliance. • Lower dome recoated with a coating/lining system such as polysulfide modified epoxy novolac (the DoD approved tank coating system). Existing steel barrel and upper dome liner not re-coated. • Alternative 1A includes integrity inspection and pressure testing of the existing single wall concrete encased piping from the tank to the first valve outside tank. • The physical volume of the container to contain liquid includes the lower dome, barrel, and upper dome and does not consider safe fill height, level alarm set point, or overfill protection shutoff.
1B	Restoration of Existing Tank plus Interior Coating	• Same as Alternative 1A except Upper Dome is also coated and barrel is coated with a coating/lining system such as polysulfide modified epoxy novolac (the DoD approved tank coating system). • The tank would not have secondary containment, thus

TABLE D-1 CANDIDATE TANK UPGRADE ALTERNATIVES		
Alternative	**Concept**	**Comments**
		must rely on release detection system and periodic tightness testing for environmental compliance. • Alternative 1B includes integrity inspection and pressure testing of the existing single wall concrete encased piping from the tank to the first valve outside tank. • Note that numerous alternative industrial grade coatings could be considered, but all must pass the criteria of surviving military additives in fuel. Any alternative would not necessarily present a different solution, only a permutation of Alternative 1B, thus not considered separately. • Storage volume consideration same as Alternative 1A.
1D	Remove existing steel liner and provide a new steel liner	• Alternative consists of removing the existing steel liner on all tank surfaces, assessing the steel support system and providing a new steel liner welded to original steel supports in the concrete. • Lower dome, barrel, and upper dome coated with a coating/lining system such as polysulfide modified epoxy novolac (the DoD approved tank coating system). • The tank would not have secondary containment, thus must rely on release detection system and periodic tightness testing for environmental compliance.
Secondary Containment Concepts Note: Secondary containment concepts include integral release detection barrier and release detection capability outside of the primary barrier (tank shell). Release detection sensors provide direct measurement/indication of a release.		
2A	Composite Tank (Double Wall) Carbon Steel	• Steel liner with concrete or grout filled (3-inch) interstitial space for release detection. • Existing steel shell becomes secondary containment envelope after inspection/repair. No coating repairs or renewal on existing steel liner. Steel liner requires inspection and integrity repairs per TIRM requirements, which may be same, or of different degree than that used for alternatives relying on existing liner as primary tank envelope. • Steel liner (primary tank envelope) could be pre-

TABLE D-1 CANDIDATE TANK UPGRADE ALTERNATIVES		
Alternative	**Concept**	**Comments**
		coated with final primer before installation and the final coating (polysulfide modified epoxy novolac) applied after erection. • Release detection provided by integral interstitial space between concrete fill and new shell, zoned by shell area, and piped by gravity to sensor racks in Lower Tunnel. Provides dynamic full-time release detection with sensors to alarm at central location. • This alternative includes replacing existing concrete encased piping from the tank (i.e. tank nozzles) to the first valve outside tank with double wall construction. • Upper dome would not receive composite liner and thus not be used for fuel storage; this results in a reduction in storage capacity.
2B	Composite Tank (Double Wall) Duplex Stainless Steel	• Alternative 2B is same as Alternative 2A except uses a duplex stainless steel liner instead of a carbon steel liner.
3A	Tank within a Tank (Carbon Steel)	• Alternative 3A consists of constructing a carbon steel tank within the existing tank. The existing tank provides secondary containment. • The interior of the new tank will be coated with polysulfide modified epoxy novolac in accordance with UFGS 09 97 13.15 "Low VOC Polysulfide Interior Coating of Welded Steel Petroleum Fuel Tanks". The exterior of the new tank will be coated with a zinc-rich epoxy/epoxy/polyurethane coating in accordance with UFGS 09 97 13.27 "Exterior Coating of Steel Structures". • The carbon steel liner on the barrel and upper dome of the existing tank will be coated with a zinc-rich epoxy/epoxy/polyurethane coating in accordance with UFGS 09 97 13.27 "Exterior Coating of Steel Structures".
3B	Tank within a Tank (Duplex Stainless Steel)	• Alternative 3B is the same as Alternatives 3A except Alternative 3B uses duplex stainless steel as the primary tank instead of a carbon steel and the primary. • As the primary tanks is stainless steel, it does not need

TABLE D-1 CANDIDATE TANK UPGRADE ALTERNATIVES		
Alternative	**Concept**	**Comments**
		to be coated; only the carbon steel liner on the barrel and upper dome of the existing tank will be coated with a zinc-rich epoxy/epoxy/polyurethane coating in accordance with UFGS 09 97 13.27 "Exterior Coating of Steel Structures".
5A	Steel Liner Plates Welded to Existing Steel Liner	• The interface between existing steel liner and new steel liner serves as an "interstitial space" for release detection.
5B	Steel Liner Plates Expanded Metal Plate between Existing Steel Liner and Steel Liner	• Alternative 5B is the same as Alternative 5B except Alternative 5B provides expanded metal plate between the new liner plates and existing steel liner. The expanded metal plate creates a wider interstitial space than the concept of welding steel plates over the existing steel liner. • The interstitial space between the new plate and existing liner plates provides capability for release detection.
6	Stainless Steel Membrane over Existing Steel Liner (similar to LNG membrane tank concept)	• Ability to provide release location not determined. • Stainless steel membrane may suffer damage during future inspection and cleaning. • Existing shapes/surfaces inside tank may make system difficult to install

Red Hill Duration Model

Input and Determinations		
Alternative	1A	Status Quo
Tanks Programmed	18	No. of Tanks Required
Initial Funding Timeline	3	SRM
Min. ACQ Actions Required	6.0	Contract Administration
No. of Cycles	6.0	Cycles Required
Tanks/Cycle	3	No. of Tanks / ACQ Action
Day/Week	6	No. of Work Days / Week
Shifts/Day	2	No. of Shifts / Day
Hours/Shifts	10	No. of Hours / Shift
Contract Mods	5%	Allowance for Mods
Contingency	10%	Allowance for Contingency
Cycle Efficiency	85%	Cycle Overlap
Start Date	2018.5	Decision Determination
Phase 0	1.75	Pre-Work
Effective Years/Multi-Cycles	1.78	Execution
Project Duration	12.75	Total Time Required
Legacy Tanks OOS Date	2029.5	Effective Compliance Date
Completion Date	2031.2	**Meets AOC**

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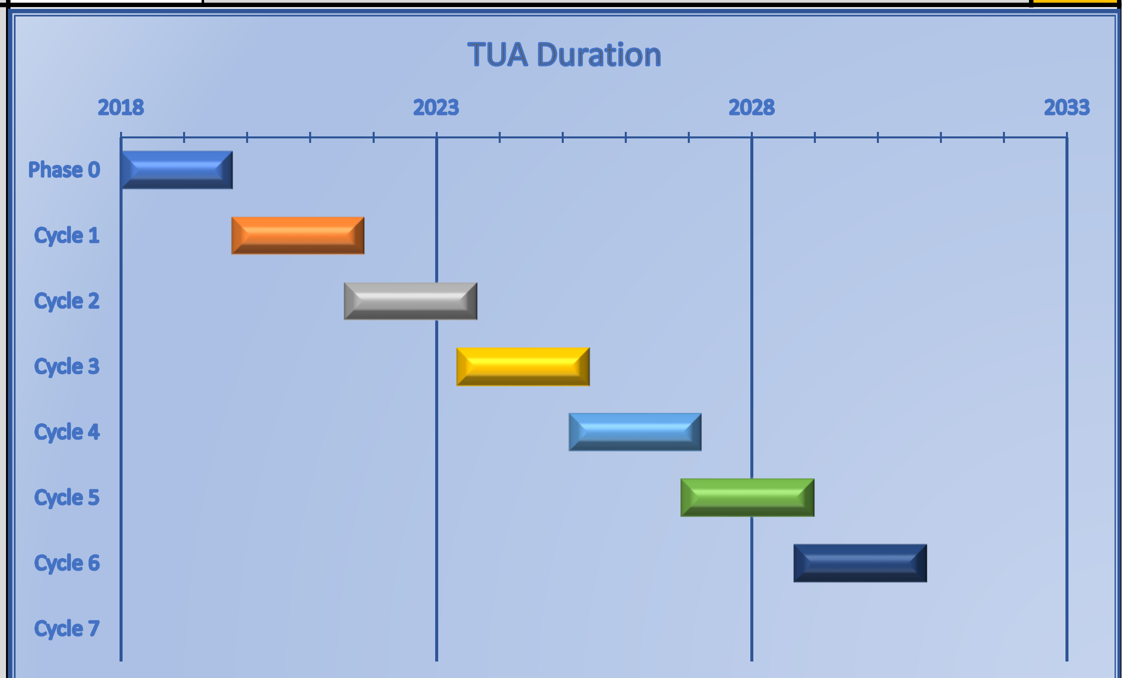
[redacted]

Segment	Gross Years	Macro Factor	Factored Years	Tanks per Cycle 85%	Shifts per Day 75%	Days per Week 85%	Hours per Shift 90%	Net Years
Funding	1.00	100%	1.0					1.0
Acquisition	0.50	100%	0.5					0.5
Design	0.25	100%	0.3					0.3
Mobilization	0.00	100%	0.0					0.0
Total Pre-Work			1.8					1.8
Clean & Inspect	0.50	100%	0.50	0.08	0.13	0.08	0.05	0.17
Repair / Demo	0.50	100%	0.50	0.08	0.13	0.08	0.05	0.17
Construction	0.00	100%	0.00	0.00	0.00	0.00	0.00	0.00
Coating	0.18	100%	0.18	0.03	0.04	0.03	0.02	0.06
Inspect/Test	0.08	100%	0.08	0.01	0.02	0.01	0.01	0.03
Commissioning	0.25	100%	0.25	0.04	0.06	0.04	0.03	0.09
Tightness	0.25	100%	0.25	0.04	0.06	0.04	0.03	0.09
Total Action			1.76	0.27	0.44	0.26	0.18	0.61
Contract Mods	0.03	100%	0.03					0.03
Contingency	0.06	100%	0.06					0.06
Per Tank Total								**0.70**



Red Hill Duration Model

Input and Determinations		
Alternative	1B	Status Quo + Coating
Tanks Programmed	18	No. of Tanks Required
Initial Funding Timeline	3	SRM
Min. ACQ Actions Required	6.0	Contract Administration
No. of Cycles	6.0	Cycles Required
Tanks/Cycle	3	No. of Tanks / ACQ Action
Day/Week	6	No. of Work Days / Week
Shifts/Day	2	No. of Shifts / Day
Hours/Shifts	10	No. of Hours / Shift
Contract Mods	5%	Allowance for Mods
Contingency	10%	Allowance for Contingency
Cycle Efficiency	85%	Cycle Overlap
Start Date	2018.5	Decision Determination
Phase 0	2.75	Pre-Work
Effective Years/Multi-Cycles	2.53	Execution
Project Duration	18.39	Total Time Required
Legacy Tanks OOS Date	2034.4	Effective Compliance Date
Completion Date	2036.9	Meets AOC

Segment	Gross Years	Macro Factor	Factored Years	Tanks per Cycle 85%	Shifts per Day 75%	Days per Week 85%	Hours per Shift 90%	Net Years
Funding	2.00	100%	2.0					2.0
Acquisition	0.50	100%	0.5					0.5
Design	0.25	100%	0.3					0.3
Mobilization	0.00	100%	0.0					0.0
Total Pre-Work			2.8					2.8
Clean & Inspect	0.50	100%	0.50	0.08	0.13	0.08	0.05	0.17
Repair / Demo	0.50	100%	0.50	0.08	0.13	0.08	0.05	0.17
Construction	0.00	100%	0.00	0.00	0.00	0.00	0.00	0.00
Coating	0.92	100%	0.92	0.14	0.23	0.14	0.09	0.32
Inspect/Test	0.08	100%	0.08	0.01	0.02	0.01	0.01	0.03
Commissioning	0.25	100%	0.25	0.04	0.06	0.04	0.03	0.09
Tightness	0.25	100%	0.25	0.04	0.06	0.04	0.03	0.09
Total Action			2.50	0.39	0.63	0.38	0.25	0.86
Contract Mods	0.04	100%	0.04					0.04
Contingency	0.09	100%	0.09					0.09
Per Tank Total								**0.99**

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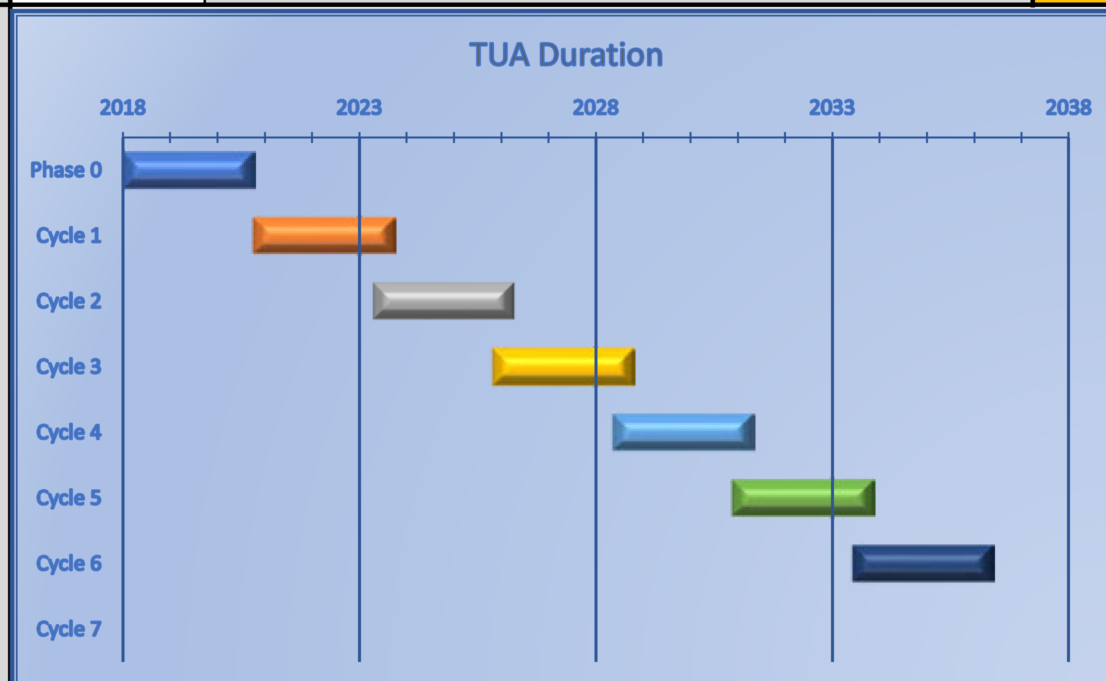
[redacted]



Red Hill Duration Model

Input and Determinations		
Alternative	1D	Replace Shell
Tanks Programmed	18	No. of Tanks Required
Initial Funding Timeline	3	SRM
Min. ACQ Actions Required	5.0	Contract Administration
No. of Cycles	4.5	Cycles Required
Tanks/Cycle	4	No. of Tanks / ACQ Action
Day/Week	6	No. of Work Days / Week
Shifts/Day	2	No. of Shifts / Day
Hours/Shifts	10	No. of Hours / Shift
Contract Mods	5%	Allowance for Mods
Contingency	10%	Allowance for Contingency
Cycle Efficiency	75%	Cycle Overlap
Start Date	2018.5	Decision Determination
Phase 0	4.75	Pre-Work
Effective Years/Multi-Cycles	3.12	Execution
Project Duration	19.32	Total Time Required
Legacy Tanks OOS Date	2034.7	Effective Compliance Date
Completion Date	2037.8	Meets AOC

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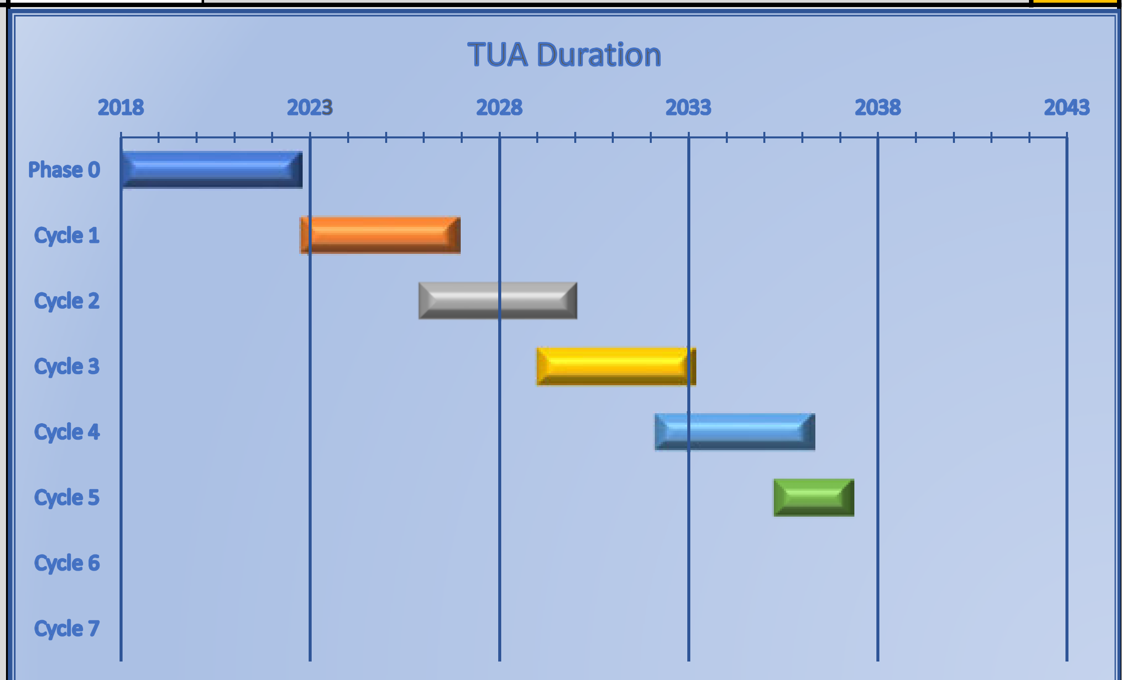
[redacted]

Segment	Gross Years	Macro Factor	Factored Years	Tanks per Cycle	Shifts per Day	Days per Week	Hours per Shift	Net Years
				77%	75%	85%	90%	
Funding	3.00	100%	3.0					3.0
Acquisition	0.75	100%	0.8					0.8
Design	1.00	100%	1.0					1.0
Mobilization	0.75	100%	0.8					0.8
Total Pre-Work			4.8					4.8
Clean & Inspect	0.08	100%	0.08	0.02	0.02	0.01	0.01	0.02
Repair / Demo	0.50	100%	0.50	0.12	0.13	0.08	0.05	0.13
Construction	1.30	100%	1.30	0.30	0.32	0.19	0.13	0.35
Coating	0.92	100%	0.92	0.21	0.23	0.14	0.09	0.25
Inspect/Test	0.08	100%	0.08	0.02	0.02	0.01	0.01	0.02
Commissioning	0.25	100%	0.25	0.06	0.06	0.04	0.03	0.07
Tightness	0.25	100%	0.25	0.06	0.06	0.04	0.03	0.07
Total Action			3.38	0.79	0.85	0.51	0.34	0.90
Contract Mods	0.05	100%	0.05					0.05
Contingency	0.09	100%	0.09					0.09
Per Tank Total								**1.04**



Red Hill Duration Model

Input and Determinations		
Alternative	2A	Composite Tank (Carbon)
Tanks Programmed	20	No. of Tanks Required
Initial Funding Timeline	3	SRM
Min. ACQ Actions Required	5.0	Contract Administration
No. of Cycles	5.0	Cycles Required
Tanks/Cycle	4	No. of Tanks / ACQ Action
Day/Week	6	No. of Work Days / Week
Shifts/Day	2	No. of Shifts / Day
Hours/Shifts	10	No. of Hours / Shift
Contract Mods	5%	Allowance for Mods
Contingency	10%	Allowance for Contingency
Cycle Efficiency	75%	Cycle Overlap
Start Date	2018.5	Decision Determination
Phase 0	4.75	Pre-Work
Effective Years/Multi-Cycles	3.17	Execution
Project Duration	21.64	Total Time Required
Legacy Tanks OOS Date	2037.0	Effective Compliance Date
Completion Date	2040.1	Meets AOC

Segment	Gross Years	Macro Factor	Factored Years	Tanks per Cycle 77%	Shifts per Day 75%	Days per Week 85%	Hours per Shift 90%	Net Years
Funding	3.00	100%	3.0					3.0
Acquisition	0.75	100%	0.8					0.8
Design	1.00	100%	1.0					1.0
Mobilization	1.00	100%	1.0					1.0
Total Pre-Work			4.8					4.8
Clean & Inspect	0.50	100%	0.50	0.12	0.13	0.08	0.05	0.13
Repair / Demo	0.50	100%	0.50	0.12	0.13	0.08	0.05	0.13
Construction	1.15	100%	1.15	0.27	0.29	0.17	0.12	0.31
Coating	0.82	100%	0.82	0.19	0.21	0.12	0.08	0.22
Inspect/Test	0.08	100%	0.08	0.02	0.02	0.01	0.01	0.02
Commissioning	0.13	100%	0.13	0.03	0.03	0.02	0.01	0.03
Tightness	0.25	100%	0.25	0.06	0.06	0.04	0.03	0.07
Total Action			3.43	0.80	0.86	0.51	0.34	0.92
Contract Mods	0.05	100%	0.05					0.05
Contingency	0.09	100%	0.09					0.09
Per Tank Total								**1.06**

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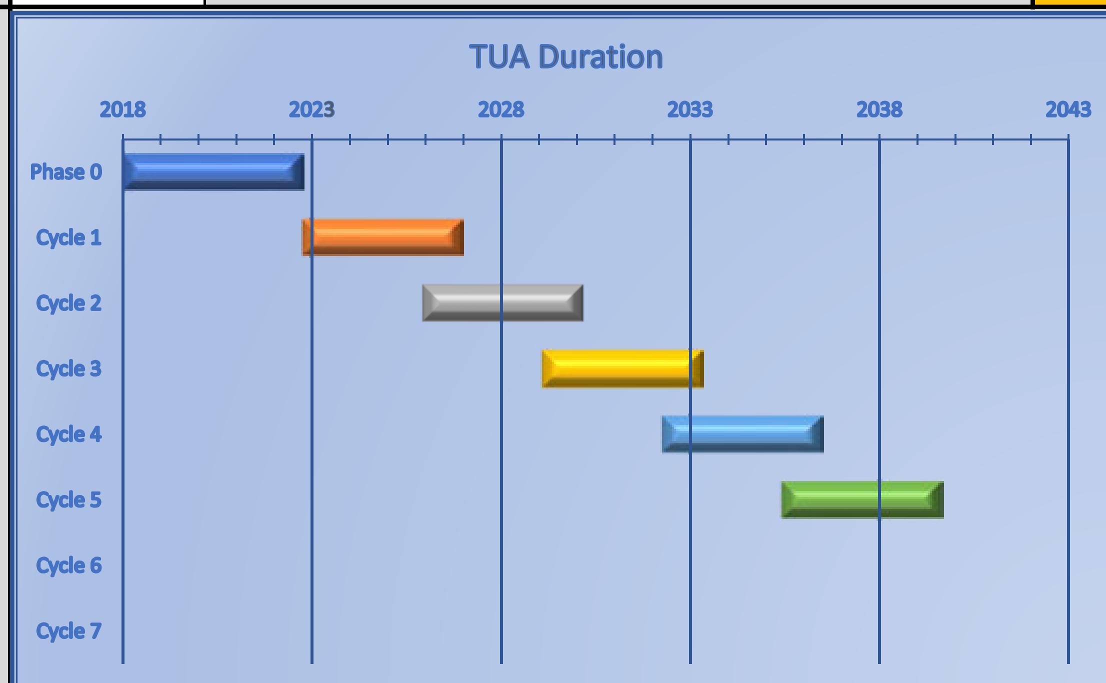

Red Hill Duration Model

Input and Determinations		
Alternative	2B	Composite Tank (Stainless)
Tanks Programmed	20	No. of Tanks Required
Initial Funding Timeline	3	SRM
Min. ACQ Actions Required	5.0	Contract Administration
No. of Cycles	5.0	Cycles Required
Tanks/Cycle	4	No. of Tanks / ACQ Action
Day/Week	6	No. of Work Days / Week
Shifts/Day	2	No. of Shifts / Day
Hours/Shifts	10	No. of Hours / Shift
Contract Mods	5%	Allowance for Mods
Contingency	10%	Allowance for Contingency
Cycle Efficiency	75%	Cycle Overlap
Start Date	2018.5	Decision Determination
Phase 0	4.75	Pre-Work
Effective Years/Multi-Cycles	2.53	Execution
Project Duration	18.25	Total Time Required
Legacy Tanks OOS Date	2034.2	Effective Compliance Date
Completion Date	2036.8	**Meets AOC**

Segment	Gross Years	Macro Factor	Factored Years	Tanks per Cycle 77%	Shifts per Day 75%	Days per Week 85%	Hours per Shift 90%	Net Years
Funding	3.00	100%	3.0					3.0
Acquisition	0.75	100%	0.8					0.8
Design	1.00	100%	1.0					1.0
Mobilization	1.00	100%	1.0					1.0
Total Pre-Work			4.8					4.8
Clean & Inspect	0.50	100%	0.50	0.12	0.13	0.08	0.05	0.13
Repair / Demo	0.50	100%	0.50	0.12	0.13	0.08	0.05	0.13
Construction	1.15	100%	1.15	0.27	0.29	0.17	0.12	0.31
Coating	0.13	100%	0.13	0.03	0.03	0.02	0.01	0.04
Inspect/Test	0.08	100%	0.08	0.02	0.02	0.01	0.01	0.02
Commissioning	0.13	100%	0.13	0.03	0.03	0.02	0.01	0.03
Tightness	0.25	100%	0.25	0.06	0.06	0.04	0.03	0.07
Total Action			2.74	0.64	0.69	0.41	0.27	0.73
Contract Mods	0.04	100%	0.04					0.04
Contingency	0.07	100%	0.07					0.07
Per Tank Total								**0.84**

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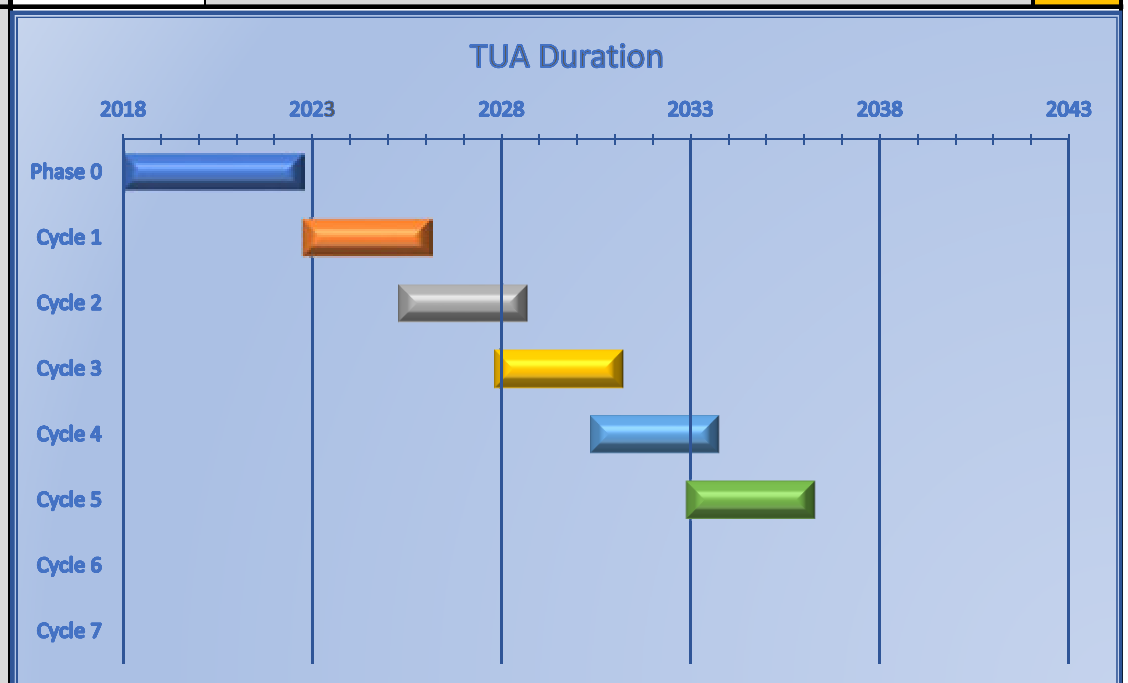

Red Hill Duration Model

Input and Determinations		
Alternative	3A	Tank w/i a Tank
Tanks Programmed	20	No. of Tanks Required
Initial Funding Timeline	3	SRM
Min. ACQ Actions Required	4.0	Contract Administration
No. of Cycles	4.0	Cycles Required
Tanks/Cycle	5	No. of Tanks / ACQ Action
Day/Week	6	No. of Work Days / Week
Shifts/Day	2	No. of Shifts / Day
Hours/Shifts	10	No. of Hours / Shift
Contract Mods	5%	Allowance for Mods
Contingency	10%	Allowance for Contingency
Cycle Efficiency	65%	Cycle Overlap
Start Date	2018.5	Decision Determination
Phase 0	4.92	Pre-Work
Effective Years/Multi-Cycles	3.24	Execution
Project Duration	19.64	Total Time Required
Legacy Tanks OOS Date	2034.9	Effective Compliance Date
Completion Date	2038.1	**Meets AOC**

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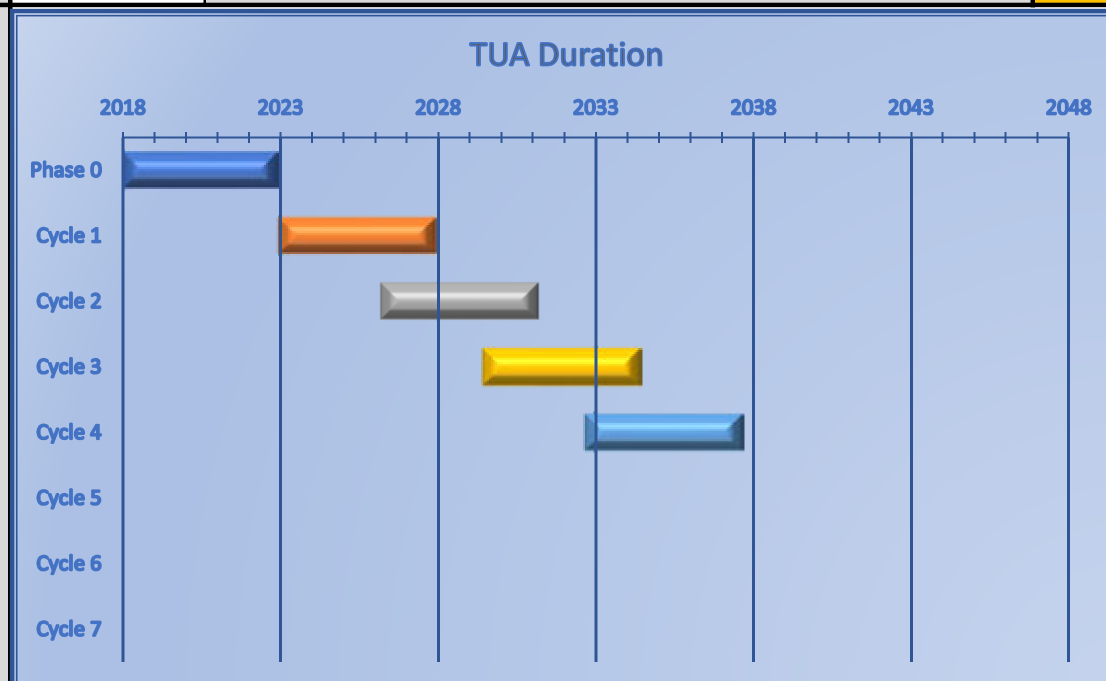
Segment	Gross Years	Macro Factor	Factored Years	Tanks per Cycle 69%	Shifts per Day 75%	Days per Week 85%	Hours per Shift 90%	Net Years
Funding	3.00	100%	3.0					3.0
Acquisition	0.92	100%	0.9					0.9
Design	1.00	100%	1.0					1.0
Mobilization	1.25	100%	1.3					1.3
Total Pre-Work			4.9					4.9
Clean & Inspect	0.50	100%	0.50	0.16	0.13	0.08	0.05	0.10
Repair / Demo	0.50	100%	0.50	0.16	0.13	0.08	0.05	0.10
Construction	1.79	100%	1.79	0.55	0.45	0.27	0.18	0.34
Coating	1.61	100%	1.61	0.50	0.40	0.24	0.16	0.31
Inspect/Test	0.08	100%	0.08	0.03	0.02	0.01	0.01	0.02
Commissioning	0.08	100%	0.08	0.03	0.02	0.01	0.01	0.02
Tightness	0.00	100%	0.00	0.00	0.00	0.00	0.00	0.00
Total Action			4.57	1.42	1.14	0.69	0.46	0.87
Contract Mods	0.04	100%	0.04					0.04
Contingency	0.09	100%	0.09					0.09
Per Tank Total								**1.00**



PROJECT: Red Hill Fuel Storage Tank Upgrade
PROJECT SITE: Pearl Harbor, Hawaii
A/E NAME: Enterprise Engineering, Inc.
PROJECT SIZE: 1.00 LS
CONSTRUCTION FUNDS AVAILABLE, DOLLARS: $0

ESTIMATOR:
CAT CODE:
UIC:
PROJECT #: Alt 1A
DATE OF ESTIMATE: 11-28-17
BID DATE:

WBS CODE	DESCRIPTION	COST/WBS BASED ON 1 LS	COST/ WBS UNIT	TOTAL MARKED UP COSTS MATL	LABOR	EQUIP	UNIT COST	TOTAL

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Multiplier Development

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

A--System Report
SUBMITTAL: 25% Progress Concept
SOFTWARE VERSION: SUCCESS 6.X
REPORT REVISION: Nov. 5 2003
ESTIMATE SAVED AS: Red Hill - Alt 1B.PWS

CONSTRUCTION CONTRACT: N62742-13-D-001
DATABASE USED: Worksheet
PRINTING DATE: 28 November 2017
Page No. 1

PROJECT: Red Hill Fuel Storage Tank Upgrade
PROJECT SITE: Pearl Harbor, Hawaii
A/E NAME: Enterprise Engineering, Inc.
PROJECT SIZE: 1.00 LS
CONSTRUCTION FUNDS AVAILABLE, DOLLARS: $0

ESTIMATOR:
CAT CODE:
UIC:
PROJECT #: Alt 1B
DATE OF ESTIMATE: 11-28-17
BID DATE:

WBS CODE	DESCRIPTION	COST/WBS BASED ON 1 LS	COST/ WBS UNIT	TOTAL MARKED UP COSTS MATL	LABOR	EQUIP	UNIT COST	TOTAL

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Multiplier Development

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

A--System Report
SUBMITTAL: 25% Progress Concept (R113017)
SOFTWARE VERSION: SUCCESS 6.X
REPORT REVISION: Nov. 5 2003
ESTIMATE SAVED AS: Red Hill - Alt 1D Rev113017.PWS

CONSTRUCTION CONTRACT: N62742-13-D-001
DATABASE USED: Worksheet
PRINTING DATE: 30 November 2017
Page No. 1

PROJECT: Red Hill Fuel Storage Tank Upgrade
PROJECT SITE: Pearl Harbor, Hawaii
A/E NAME: Enterprise Engineering, Inc.
PROJECT SIZE: 1.00 LS
CONSTRUCTION FUNDS AVAILABLE, DOLLARS: $0

ESTIMATOR:
CAT CODE:
UIC:
PROJECT #: Alt 1D
DATE OF ESTIMATE: 11-30-17
BID DATE:

				TOTAL MARKED UP COSTS				
WBS CODE	DESCRIPTION	COST/WBS BASED ON 1 LS	COST/ WBS UNIT	**MATL**	**LABOR**	**EQUIP**	**UNIT COST**	**TOTAL**

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

ALTERNATIVE 1D REMOVE AND REPLACE STEEL PLATE - FULL RE-COAT

Red Hill Fuel Storage Facility

NAVSUP FLC Pearl Harbor, Hawaii

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Multiplier Development

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

A--System Report
SUBMITTAL: 25% Progress Concept (R113017)
SOFTWARE VERSION: SUCCESS 6.X
REPORT REVISION: Nov. 5 2003
ESTIMATE SAVED AS: Red Hill - Alt 2A Rev113017.PWS

CONSTRUCTION CONTRACT: N62742-13-D-001
DATABASE USED: Worksheet
PRINTING DATE: 30 November 2017
Page No. 1

PROJECT: Red Hill Fuel Storage Tank Upgrade
PROJECT SITE: Pearl Harbor, Hawaii
A/E NAME: Enterprise Engineering, Inc.
PROJECT SIZE: 1.00 LS
CONSTRUCTION FUNDS AVAILABLE, DOLLARS: $0

ESTIMATOR:
CAT CODE:
UIC:
PROJECT #: Alt 2A
DATE OF ESTIMATE: 11-30-17
BID DATE:

WBS CODE	DESCRIPTION	COST/WBS BASED ON 1 LS	COST/ WBS UNIT	TOTAL MARKED UP COSTS				
				MATL	LABOR	EQUIP	UNIT COST	TOTAL

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Multiplier Development

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

A--System Report
SUBMITTAL: 25% Progress Concept (R113017)
SOFTWARE VERSION: SUCCESS 6.X
REPORT REVISION: Nov. 5 2003
ESTIMATE SAVED AS: Red Hill - Alt 2B Rev113017.PWS

CONSTRUCTION CONTRACT: N62742-13-D-001
DATABASE USED: Worksheet
PRINTING DATE: 30 November 2017
Page No. 1

PROJECT: Red Hill Fuel Storage Tank Upgrade
PROJECT SITE: Pearl Harbor, Hawaii
A/E NAME: Enterprise Engineering, Inc.
PROJECT SIZE: 1.00 LS
CONSTRUCTION FUNDS AVAILABLE, DOLLARS: $0

ESTIMATOR:
CAT CODE:
UIC:
PROJECT #: Alt 2B
DATE OF ESTIMATE: 11-30-17
BID DATE:

WBS CODE	DESCRIPTION	COST/WBS BASED ON 1 LS	COST/ WBS UNIT	TOTAL MARKED UP COSTS MATL	LABOR	EQUIP	UNIT COST	TOTAL

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Multiplier Development

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

A--System Report
SUBMITTAL: 25% Progress Concept (R113017)
SOFTWARE VERSION: SUCCESS 6.X
REPORT REVISION: Nov. 5 2003
ESTIMATE SAVED AS: Red Hill - Alt 3A Rev113017.PWS

CONSTRUCTION CONTRACT: N62742-13-D-001
DATABASE USED: Worksheet
PRINTING DATE: 30 November 2017
Page No. 1

PROJECT: Red Hill Fuel Storage Tank Upgrade
PROJECT SITE: Pearl Harbor, Hawaii
A/E NAME: Enterprise Engineering, Inc.
PROJECT SIZE: 1.00 LS
CONSTRUCTION FUNDS AVAILABLE, DOLLARS: $0

ESTIMATOR:
CAT CODE:
UIC:
PROJECT #: Alt 3A
DATE OF ESTIMATE: 11-30-17
BID DATE:

WBS CODE	DESCRIPTION	COST/WBS BASED ON 1 LS	COST/ WBS UNIT	TOTAL MARKED UP COSTS MATL	LABOR	EQUIP	UNIT COST	TOTAL

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Multiplier Development

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

NIST BLCC 5.3-17: Summary LCC

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

General Information

File Name:	S:\PROJECT\1728-01A Red Hill Tanks, Pearl Harbor, HI\1. Final (12-01-17)\5. Deliverable MM-DD-YY\LCCA\Red Hill Tanks.xml
Date of Study:	Fri Dec 01 09:49:22 CST 2017
Analysis Type:	MILCON Analysis, Non-Energy Project
Project Name:	Red Hill Fuel Storage Facility
Project Location:	Hawaii
Analyst:	MOCA Systems
Comment:	Tank Upgrade Alternatives Study, Pearl Harbor, Hawaii
Base Date:	March 1, 2018
Beneficial Occupancy Date:	March 1, 2018
Study Period:	21 years 0 months (March 1, 2018 through February 28, 2039)
Discount Rate:	2.5%
Discounting Convention:	Mid-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: 1A Repair Existing Tanks

LCC Summary

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 1B Repair Existing Tank plus Interior Coating

LCC Summary

Present Value Annual Value

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 1D Remove Existing Steel Liner, Install New Liner

LCC Summary

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 2A Composite Tank (Double Wall) Carbon Steel

LCC Summary

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 2B Composite Tank (Double Wall) Duplex Stainless Steel

LCC Summary

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 3A Tank Within A Tank (Carbon Steel)

LCC Summary

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

NIST BLCC 5.3-17: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology in OMB Circular A-94

General Information

File Name:	S:\PROJECT\1728-01A Red Hill Tanks, Pearl Harbor, HI\1. Final (12-01-17)\5. Deliverable MM-DD-YY\LCCA\Red Hill Tanks.xml
Date of Study:	Fri Dec 01 09:47:26 CST 2017
Analysis Type:	MILCON Analysis, Non-Energy Project
Project Name:	Red Hill Fuel Storage Facility
Project Location:	Hawaii
Analyst:	MOCA Systems
Comment:	Tank Upgrade Alternatives Study, Pearl Harbor, Hawaii
Base Date:	March 1, 2018
Beneficial Occupancy Date:	March 1, 2018
Study Period:	21 years 0 months (March 1, 2018 through February 28, 2039)
Discount Rate:	2.5%
Discounting Convention:	Mid-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: 1A Repair Existing Tanks

Component: 1A Cycle 1

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 1 Operating

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 1 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1A Cycle 2

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1A Cycle 2 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 2 Operating

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 2 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1A Cycle 3

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1A Cycle 3 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 3 Operating

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 3 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1A Cycle 4

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1A Cycle 4 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 4 Operating

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Usage Indices

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 4 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1A Cycle 5

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1A Cycle 5 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 5 Operating

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1A Cycle 6

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1A Cycle 6 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 6 Operating

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1A Cycle 6 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 1B Repair Existing Tank plus Interior Coating

Component: 1B Cycle 1

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1B Cycle 1 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 1 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 1 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1B Cycle 2

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1B Cycle 2 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 2 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 2 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

Component: 1B Cycle 3

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1B Cycle 3 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 3 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 3 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1B Cycle 4

Component: 1B Cycle 4

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1B Cycle 4 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 4 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 4 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1B Cycle 5

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1B Cycle 5 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 5 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 5 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1B Cycle 6

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1B Cycle 6 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 6 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1B Cycle 6 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 1D Remove Existing Steel Liner, Install New Liner

Component: 1D Cycle 1

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 1 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 1 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1D Cycle 2

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Cost-Phasing

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1D Cycle 2 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 2 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 2 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1D Cycle 3

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1D Cycle 3 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 3 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 3 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1D Cycle 4

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1D Cycle 4 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 4 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 4 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 1D Cycle 5

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 1D Cycle 5 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 1D Cycle 5 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 2A Composite Tank (Double Wall) Carbon Steel

Component: 2A Cycle 1

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 1 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 1 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2A Cycle 2

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 2 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 2 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2A Cycle 3

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2A Cycle 3 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 3 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 3 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2A Cycle 4

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2A Cycle 4 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 4 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 4 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2A Cycle 5

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2A Cycle 5 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 5 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2A Cycle 5 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 2B Composite Tank (Double Wall) Duplex Stainless Steel

Component: 2B Cycle 1

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2B Cycle 1 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 1 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 1 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2B Cycle 2

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2B Cycle 2 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 2 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 2 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2B Cycle 3

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2B Cycle 3 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 3 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 3 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2B Cycle 4

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2B Cycle 4 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 4 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 4 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 2B Cycle 5

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 2B Cycle 5 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 5 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 2B Cycle 5 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Alternative: 3A Tank Within A Tank (Carbon Steel)

Component: 3A Cycle 1

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 3A Cycle 1 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 1 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 1 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 3A Cycle 2

Initial Investment

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 3A Cycle 2 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 2 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 2 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 3A Cycle 3

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 3A Cycle 3 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 3 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 3 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Component: 3A Cycle 4

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Major Repair and Replacement: 3A Cycle 4 CIR

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 4 Operations

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

Routine Recurring OM&R: 3A Cycle 4 Maintenance

Privileged, Highly Procurement Sensitive, Source Selection Information, See FAR 2.101 and 3.104, 5 U.S.C. 552(b)(3), 5 USC 552(b)(5)

[redacted]

APPENDIX H

IMPLEMENTATION OF ALTERNATIVES 2A AND 3A AT OTHER FACILITIES

SUCCESSFUL IMPLEMENTATION OF ALTERNATIVES 2A AND 3A AT OTHER FACILITIES

1.0 BACKGROUND

This Appendix discusses examples where Alternatives 2A – Composite Tank and Alternative 3A – Tank within a Tank concepts have been successfully implemented other at other facilities.

The NAVSUP Fleet Logistics Center, Yokosuka (FLCY) Fuels Department is responsible for the management of nine major Defense Fuel Support Points (DFSPs), situated over three geographical areas throughout Japan and two remote locations in Guam and Diego Garcia. The Mainland Japan locations include the Kanto Plain terminals (DFSPs Hakozaki, Tsurumi and Atsugi), the Sasebo terminals (DFSPs Akasaki, Iorizaki and Yokose), and DFSP Hachinohe in northern Japan with an overall capacity more than 8,000,000 Bbls. DFSPs Guam and Diego Garcia round out the list of terminals across the enterprise to establish FLCY as the largest and most diverse Department of Defense (DoD) fuel storage operation.

Two of FLCY's terminals provide exceptional design and construction examples of successful implementation of recent retrofit upgrades of existing tanks constructed in the same era as Red Hill for FLC Pearl Harbor's Tank Upgrade Alternatives 2A and 3A.

- FLCY's Hakozaki Terminal (≈2,137,000 Bbl. capacity) includes examples of the composite approach to relining older style steel lined concrete tanks. Eight of 12 underground tanks (≈800,000 Bbls.) underwent the transformation in the mid to late 1980s.

- Two of FLCY's Sasebo Terminals, Iorizaki (≈1,3231,000 Bbl. capacity) and Yokose (≈2,734,000 Bbl. capacity), retrofitted their older style steel lined concrete tanks using the tank within a tank (Alternative 3A) approach in the same time frame. Seven of the Yokose Terminal's eight product tanks (≈2,500,000 Bbl. capacity) were reconstructed with this approach.

2.0 ALTERNATIVES 2A / 2B – COMPOSITE TANK (DOUBLE WALL)

2.1. General Description

Alternatives 2A and 2B – Composite Tank creates a double-wall tank with secondary containment and integral release detection. Only the lower dome and barrel will have a double wall. The upper dome will be inspected and repaired only to prevent infiltration of groundwater. This concept consists of providing a 1/4-inch thick carbon steel liner inside the tank supported by structural steel angles welded to the existing steel liner. This new steel liner is the primary tank envelope and is separated from the existing steel liner by steel angles to create a 3-inch wide interstitial space for release detection. The interstitial space is filled with self-leveling concrete, non-shrink grout, or some other material to resist fluid pressure from tank contents. The existing steel liner will be inspected and repaired and becomes secondary containment. The steel liner of the existing tank will not be coated.

2.2. Existing Tanks with Similar Designs

The approach to providing a composite double wall to an older style steel lined concrete tank has been applied to the NAVSUP FLC Yokosuka Hakozaki terminal in Japan. Tanks 101, 103, 104, 107, 108, 109, 112 and 113, constructed circa 1930s, were a nominal 120 ft. diameter, 100 ft. tall with average capacities of ≈200,000 Bbls. To varying degrees, the original riveted shells received a new steel liner approximately 0.177 inches thick with a concrete infill. The created interstitial space has leak detection capability, terminating to a sample point in the tunnel below the tank floor level.

2.2.1. Construction Considerations

Having been constructed over several years, the designs of the tanks vary widely. However, the approach for refit was generally the same. The construction considerations centered around risk reduction associated with underground storage tanks that originally used riveted construction techniques designed for a much different product than currently in use. While reports indicate that the rivets, seems, and joints were seal-welded during a previous rehabilitation, the documentation for the latest upgrade focused on enhancing the single wall tanks by creating a double wall version that utilized the original tank liner as secondary containment.

Refer to the specific tank data for information on how a composite tank concept has been used . A general description of applicable work elements included:

- Provide groundwater drainage system for wall and bottom
- Provide hydrocarbon detection system
- Provide reinforced concrete bottom and steel bottom liner
- Provide reinforced concrete wall and steel wall liner
- Modify and provide tank nozzles, piping, valves, and accessories for tank inlet, outlet, low suction nozzle, water draw-off, groundwater drainage, and hydrocarbon detection line
- Apply fluoropolyurethane coating system over tank interior including tank wall liner, bottom liner, and structures fixed to the wall and bottom liner such as ladder, interior piping, etc.
- Perform all specified tests and inspections including pneumatic pressure test of pipeline system and leak test of the tank when filled with fuel oil
- Perform various other related incidental repairs and improvements

Specific callouts regarding the construction of the double wall and floor include:

- Provide gravel base over the existing steel plate bottom liner
- Provide a new reinforced concrete slab over the gravel base
- Provide a steel plate bottom liner over the new reinforced concrete slab

- Provide a precast high-strength reinforced concrete segment wall lined with steel plates
- Provide and prestress wire strands around the lowest part of the new precast concrete wall
- Place sand fill between the existing steel plate wall liner and new precast walls with cast-in-place plain concrete collars at the top and bottom around the precast walls

Unfortunately, there are insufficient records to determine the level of scrutiny on decision making at the time of upgrade. Therefore, there can be no direct comparison of the associated attributes including cost, construction options, duration expectations, etc. to Alternatives 2A / 2B. However, the basic approach was documented in the criteria package for the JFIP Project No. NA 466-D titled "Reconstruct Tank 102, Hakozaki Fuel Terminal, U.S. Navy Fuel Detachment, Tsurumi".

2.2.2. System Operation

Having been constructed over several years, the designs of the tanks vary widely. However, the general approach to providing release detection is operated in a similar fashion on all tanks that received the shell and bottom upgrades. As a daily check, operations personnel note if any site glasses contain fluid and then verifies the type of fluid if any is present. Some systems did not include a site glass and the operators simply open a tell-tale valve into a reservoir and check for presence of fuel. If fuel is not present, the release valves are opened to drain the systems. If fuel is present, protocols are in place for immediate actions. To date, operators have not reported a leak on any of these upgraded tanks.

2.2.3. Maintenance

These systems require very little maintenance. Operations personnel perform basic preventative and/or corrective maintenance on the manual valves incorporated throughout the various systems. These are strictly manual systems as there are no automated alarms. Visual and physical checks are performed on a routine basis.

2.2.4. Performance

These upgraded tanks have performed well over the decades. They have undergone integrity inspections and successful tank tightness testing over the last 10 years and have a long useful remaining life for DoD fuel storage.

3.0 ALTERNATIVE 3A – TANK WITHIN A TANK

3.1. General Description

Alternative 3A involves constructing a carbon steel tank within the existing tank. The new tank will have a 90’-0” diameter compared to the existing tank’s 100’-0” diameter to provide a 5’-0” wide annular space around the tank that allows inspection of the exterior of the new tank shell and the steel liner on the barrel and upper dome of the existing tank. The new tank will be designed in accordance with the applicable sections of API 650. The tank will be anchored and braced laterally with struts to the existing tank to resist rocking from seismic ground motion. The existing steel liner on the tank barrel and lower dome is inspected and repaired to perform as secondary containment.

3.2. Existing Tanks with Similar Designs

DFSP Yokose – The tank within a tank approach to upgrade older “mined” style steel lined concrete tanks has been applied to the NAVSUP FLC Yokosuka Yokose terminal in Japan. Tanks Y-1 through Y-7 are underground, steel-lined, concrete fuel storage tanks. The tanks were originally constructed in the 1920’s by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tanks with steel lining were added inside the existing tanks in 1991 by the Government of Japan. The nominal tank diameter is 278’-6” and the height is 36’-9” with a (nominal) shell capacity of 373,000 Bbls. The new tank is of concrete construction with a steel liner made of butt-welded shell plates and lap-welded floor plates with a cone down tank floor and center sump.

While the construction of these tanks are not direct comparisons to Alternative 3A, the concept of monitoring the interstitial space with personnel access is the focus of this comparison. The Yokose tank design includes an accessible “gallery” space approximately four feet wide and 41 feet high between the interior of the original tank shell and the exterior of the new shell. This space also includes drainage sumps as culmination points for a series of channels located under the tank floor for leak detection. Each sump is equipped with an oil sensor that alarms when petroleum products are present.

3.2.1. Construction Considerations

Like the Yokose tanks, Alternative 3A consists of a self-supporting tank structure that is independent of the existing tank shell. The focus of the construction consideration is on leak detection and secondary containment applications. The shell of the Yokose tank is surrounded with a cofferdam and is visually inspectable. The double bottom contains channels to allow any released fuel to gravity flow towards alarmed collection sumps.

Unfortunately, there are insufficient records to determine the level of scrutiny on decision making at the time of upgrade. Therefore, there can be no direct comparison of the associated attributes including cost, construction options, duration expectations, etc.

The only Yokose product tank not currently utilizing the tank within a tank concept is Y-8. This tank is much smaller in size and was originally constructed during the upgrade phase of the other seven tanks.

3.2.2. System Operation

Operators report these systems work as advertised. To the specific point of release detection and spill containment, a real-world example resulted from a cargo pump alignment issue on Tank Y-2 that caused a hole to form in the sump. Fuel was released and flowed through the designated channels in the secondary containment under the tank to an alarmed sump in the gallery. Terminal personnel responded to the local tank alarm and took immediate action to drain the tank to minimize the release. According to the incident reports, the tank had 355,451 Bbls. of fuel at the time of the release; only approximately 30,000 gallons of fuel was released into the containment where it could be recovered, and no fuel reached the environment.

3.2.3. Maintenance

These systems require very little maintenance. Operations personnel perform basic preventative and/or corrective maintenance on the manual valves, oil sensors, and alarms incorporated throughout the various systems. These are a combination of manual and automated systems. Visual and physical checks are performed on a routine basis.

3.2.4. Performance

These upgraded tanks have performed well over the decades of use. They have undergone integrity inspections and successful tank tightness testing over the last 10 years and have a long useful remaining life for DoD fuel storage.

Specific to the release incident noted above, EEI inspected Tank Y-2 with the primary goal of locating a reported release and identify the repair method. An additional goal was to evaluate the leak and determine if the leak was related to the design of the tank or other cause. The project also included a baseline API 653 inspection and evaluation of the entire tank.

An initial walk-through found the wear area with a 1/8-inch x 1/4-inch diameter hole in the south side of the tank sump. The wear hole appeared to have been caused by the screen of the sump pump wearing against the sump wall. After the hole is the sump was discovered, EEI performed helium leak testing of the tank floor and shell to determine whether there were any other hydraulic compromises in the tank. The helium leak testing of the welded joints in the tank floor and shell plates detected no indication of helium, which led to the conclusion that the leak in Tank Y-2 was attributed exclusively to the hole in the sump.

Post inspection and repair, Tank Y-2 was successfully returned to service and remains in flawless operation today.

4.0 HAKOZAKI – COMPOSITE TANK (DOUBLE WALL)

Specific data for each tank series is provided in their respective sections below. A summary of the original tank construction details is included in the table below:

	Tank ID	101	103	104
General Info	Facility number	33	36	37
	Location	DFSP Hakozaki	DFSP Hakozaki	DFSP Hakozaki
	Product	JP-8	JP-8	F-76
	GPS coordinates	UNKNOWN	UNKNOWN	UNKNOWN
Construction Details	Construction date	1937	1937	1936
	Tank configuration	UST - Vertical	UST - Vertical	UST - Vertical
	Nominal capacity (gal / bbls)	203.7 mbbl	203.6 mbbl	203.5 mbbl
	Safe fill capacity (gal / bbls / ft)	193.5 mbbl	193.4 mbbl	193.3 mbbl
	Diameter	124' 08"	124' 08"	124' 08"
	Height	95' 00"	93' 04-3/8"	93' 04"
	Tank material / construction	Concrete riveted steel lined	Concrete riveted steel lined	Concrete riveted steel lined
	Number of shell courses	16	16	16
	Design standard	UNKNOWN	UNKNOWN	UNKNOWN
	Design pressure	Atmospheric	Atmospheric	Atmospheric
	Foundation configuration (if applicable)	Concrete slab	Flat concrete slab	Flat concrete slab
	Bottom type (flat / cone-up / cone-down)	cone-down	cone-down	cone-down
	Sump location (center / edge)	center	center	center
	Type of roof (if applicable)	Concrete w/steel truss	Concrete w/steel truss	Concrete w/steel truss
	If floating, can tank have high legs installed?	N/A	N/A	N/A
	Roof vent details	10" Varec	10" Varec	10" Varec
Other Tank Details	Cathodic protection and type	None	None	None
	ATG size & location, if present (center / off center / edge)	edge	edge	edge
	Stilling well details (slotted, non-slotted, not present)	slotted	slotted	slotted
	Manual gauging stilling well details	6", edge, slotted	6", edge, slotted	6", edge, slotted
	Water probe stilling well size & location, if present	None	None	None

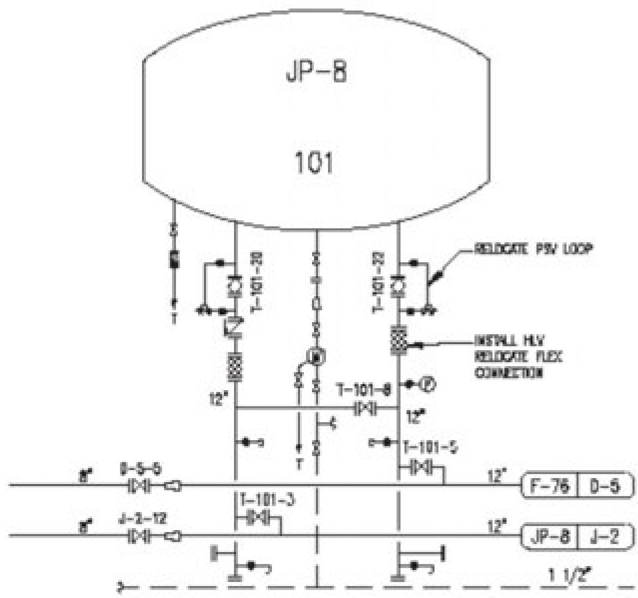
	Tank ID	106	107	109
General Info	Facility number	40	43	45
	Location	DFSP Hakozaki	DFSP Hakozaki	DFSP Hakozaki
	Product	F-76	JP-5	F-76
	GPS coordinates	UNKNOWN	UNKNOWN	UNKNOWN
Construction Details	Construction date	1936	1936	1923
	Tank configuration	UST - Vertical	UST - Vertical	UST - Vertical
	Nominal capacity (gal / bbls)	209.2 mbbl	193.4 mbbl	144.3 mbbl
	Safe fill capacity (gal / bbls / ft)	186.8 mbbl	183.7 mbbl	137.1 mbbl
	Diameter	124' 08"	122' 04-1/2"	102' 08-5/16"
	Height	95' 08-3/8"	92' 01-7/8"	96' 07-7/8"
	Tank material / construction	Concrete riveted steel lined	Concrete welded steel lined	Concrete welded steel lined
	Number of shell courses	16	13	13
	Design standard	UNKNOWN	UNKNOWN	UNKNOWN
	Design pressure	Atmospheric	Atmospheric	Atmospheric
	Foundation configuration (if applicable)	Concrete pad	Concrete pad	Concrete pad
	Bottom type (flat / cone-up / cone-down)	cone-down	cone-down	cone-down
	Sump location (center / edge)	center	center	center
	Type of roof (if applicable)	fixed - flat	Fixed - flat	Fixed - cone
	If floating, can tank have high legs installed?	N/A	N/A	N/A
	Roof vent details	10" Pressure/Vacuum vent	10" pressure/vacuum vent	10" pressure/vacuum vent
Other Tank Details	Cathodic protection and type	None	None	None
	ATG size & location, if present (center / off center / edge)	edge	edge	edge
	Stilling well details (slotted, non-slotted, not present)	slotted	slotted	slotted
	Manual gauging stilling well details	6", edge, slotted	6", edge, slotted	6", edge, slotted
	Water probe stilling well size & location, if present	None	None	None

	Tank ID	112	113
General Info	Facility number	162	161
	Location	DFSP Hakozaki	DFSP Hakozaki
	Product	JP-5	JP-5
	GPS coordinates	UNKNOWN	UNKNOWN
Construction Details	Construction date	1928	1928
	Tank configuration	UST - Vertical	UST - Vertical
	Nominal capacity (gal / bbls)	132.4 mbbl	132.6 mbbl
	Safe fill capacity (gal / bbls / ft)	125.8 mbbl	126.0 mbbl
	Diameter	102' 08-3/16"	102' 08-7/8"
	Height	102' 11-1/16"	102' 11-11/16"
	Tank material / construction	Concrete riveted or welded steel lined	Concrete riveted steel lined
	Number of shell courses	17	17
	Design standard	UNKNOWN	UNKNOWN
	Design pressure	Atmospheric	Atmospheric
	Foundation configuration (if applicable)	Concrete slab	Concrete slab
	Bottom type (flat / cone-up / cone-down)	cone-down	cone-down
	Sump location (center / edge)	center	center
	Type of roof (if applicable)	Fixed - cone	Fixed - cone
	If floating, can tank have high legs installed?	N/A	N/A
	Roof vent details	250 DN pressure/vacuum vent	250 DN pressure/vacuum vent
Other Tank Details	Cathodic protection and type	None	None
	ATG size & location, if present (center / off center / edge)	edge	edge
	Stilling well details (slotted, non-slotted, not present)	slotted	slotted
	Manual gauging stilling well details	6", edge, slotted	6", edge, slotted
	Water probe stilling well size & location, if present	None	None

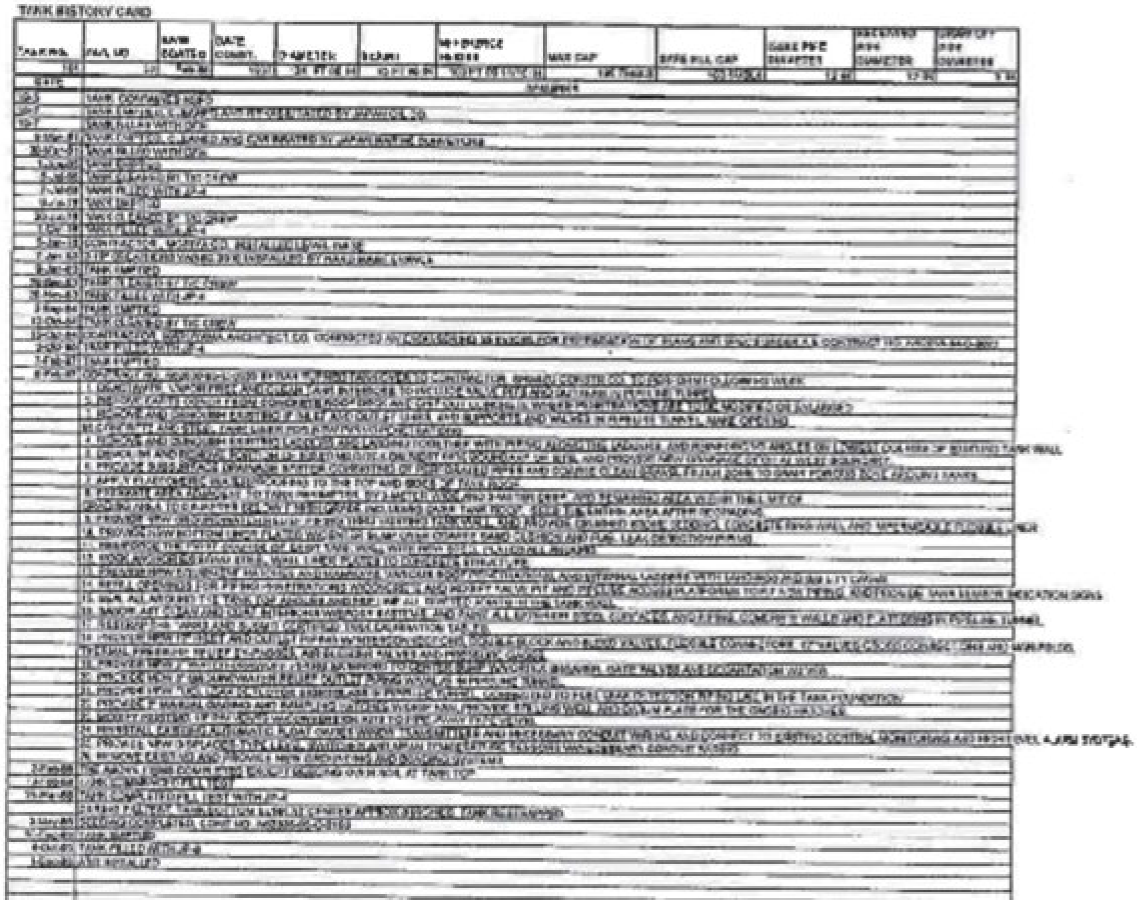
4.1. Tank 101

Modification to Tank 101 occurred during the mid to late 1980’s upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of lower sections of existing tank shell and the entire bottom with an interstitial space filled with sand, concrete and/or a flexible liner. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.



Tank 101 – Tank Top


TANK HISTORY CARD

4.2. Tank 102

Initially constructed in 1936, Tank 102 was modified in 1979 during a product change event. The hydraulic integrity improvements included the construction of multiple enhanced features including ground water collection and drainage, leak detection, and coating systems.

The integrity system consisted of coating the lower sections of the existing tank riveted shell and the entire concrete bottom with a fiberglass liner. The drainage structures were designed to direct any escaping fuel to the leak detection system that utilized a French drain around the tank perimeter to collect any fuel exiting the tank shell / bottom and divert it into a pump-out collection pit in the piping tunnel.

Upon initial fill post upgrade, fuel was observed in the leak detection system. The tank was drained and repaired with additional welding of riveted joints and doubling the fiberglass liner in the bottom sections of the tank. The tank was successfully returned to service for the next 20 years with regularly scheduled inspections.

"In 1992, a criteria package for JFY92 Facility Improvement Program (JFIP) Project titled Reconstruct Tank 102, Hakozaki Fuel Terminal, U.S. Navy Fuel Detachment, Tsurumi, Project No. NA 466-D" was initiated with a goal to effect similar double wall upgrades as the other tanks in this series. There are insufficient records available to ascertain the reason why this project was not executed. Tank 102 was never upgraded to double wall construction.

According to a 2001 API inspection report, numerous deficiencies were found during the inspection of Tank 102 which precluded it from returning to service. Key items included the failing fiberglass liner which had several areas of significant delamination with fuel trapped between the liner and the concrete bottom and the remaining large sections of the un-welded, riveted steel shell. These key elements in addition to other deficiencies with appurtenances dictated a major reconstructive effort to return the tank to a standard suitable condition for safe operation. Tank 102 was decommissioned.

The host nation agreement between the U.S. and Japan allows for JFIP funding to construct replacement in kind facilities. A revised JFIP project was executed to replace the capacity for Tank 102. It also incorporated the replacement of additional capacity from the decommissioned Tank 105. In that the only foot print available would impact Tank 111, it was also decommissioned and subsequently demolished to make room for the new, larger Tanks 102 and 105. The new construction facilities designated Tanks 102 and 105 have equal capacity to the original Tanks 102, 105 and 111.

Tank 102 – Tank Top

Tank 102 Valves

GENERAL TANK INFORMATION

Customer Name	U.S. Navy - FISC
Location:	Yokosuka, Japan
Job Site:	Hakozaki Fuel Terminal
Tank No:	102
FAC. No:	34
Height:	94' 1"
Diameter:	124' 8"
Current Product Stored:	DFM
Specific Gravity:	App. .85
Maximum Capacity:	206.0 MBLS
Safe Fill Capacity:	203.0 MBLS
Current Product Temp:	Ambient
Manufactured By:	Unknown
Specification Built To:	Unknown
Year Built:	1937
Year Last Coated:	Jan 1979
Roof Construction:	---
Material -	Concrete
Support System -	Steel Truss
Liner Material -	None
Shell Construction:	---
Shell Material -	Concrete
Support System -	Vertical Steel Truss
Liner Material -	Riveted Carbon Steel Plates, 16 Courses High X 12 Plates Around
Liner Thickness -	12mm - 1st thru 13th Courses, 10mm – 13th thru 16th Courses
Double Liner Material -	Reinforced Fiberglass Resin, Bottom Three Quarters of the First Course only
Bottom Construction:	---
Original Floor Material -	Flat, Concrete Slab
Liner Material -	Reinforced Fiberglass Resin
Liner Design -	Flat, with Sump located near outer edge of Floor
Liner Foundation -	Original Concrete Slab
Appurtenances:	---
Inlet Pipe -	8" Diameter (with Gate Valve)
Outlet Pipe -	8" Diameter (with Gate Valve)
Draw Off Pipe -	None
Bottom Drain -	2" Diameter, attached to small Sump
Pres./ Vacuum Vents -	Two - 10" Varec, Fig. 2010
Automatic Float Gage -	Yes
Gage Hatch -	Yes
Sample Hatch -	Yes
High Level Indicator -	Yes
Temp. Measurement -	Yes
Ground Water Relief -	Yes
Leak Detection -	Yes

TANK HISTORY CARD

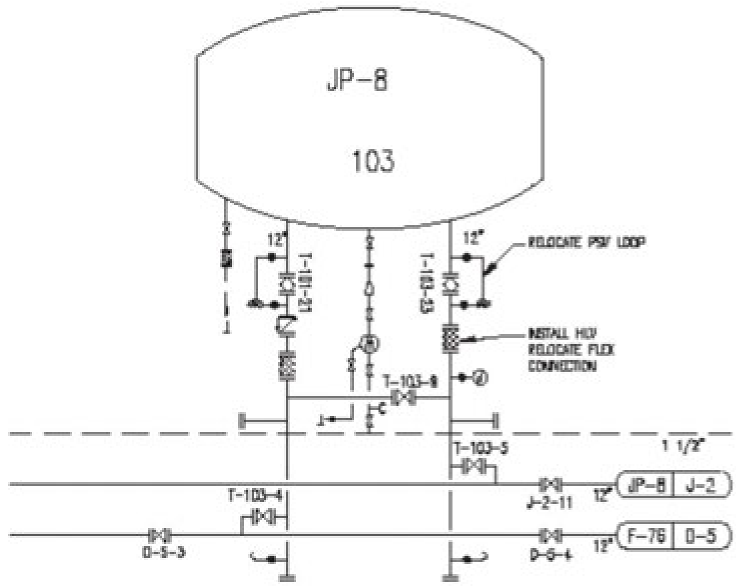
TANK NO.	FAC. NO.	DATE COATED	DATE CONST.	DIAMETER	HEIGHT	REFERENCE HEIGHT	MAX CAP	SAFE FILL CAP	ISSUE PIPE DIAMETER	RECEIVING PIPE DIAMETER	DRAW OFF PIPE DIAMETER
102	54	Jan-79	1942	104 FT 03 IN	24 FT 1 IN	[illegible] 20 3/4 IN	206.3MBLS	223.0MBLS	8 IN	3 IN	3 IN

DATE	REMARKS
1945	TANK CONTAINED BLACK OIL
3-Jun-47	TANK EMPTIED CLEANED AND REHABILITATED BY JAPAN OIL COMPANY
8-Jun-47	TANK FILLED WITH NSFO
1-Dec-56	TANK EMPTIED
6-Jan-57	TANK CLEANED
6-Jan-57	TANK FILLED WITH NSFO
1-Jul-61	TANK EMPTIED AND CLEANED
1-Aug-61	TANK CALIBRATED BY JAPAN MARITIME SURVEYORS
2-Aug-61	TANK FILLED WITH NSFO
1-Jun-63	TANK EMPTIED
1-Jul-63	TANK CLEANED BY NC CREW
2-Jun-67	TANK FILLED WITH NSFO
[illegible]	TANK EMPTIED
1-May-71	TANK CLEANED BY NC CREW
15-Jun-71	TANK INTERIOR INSPECTED BY CPOIC & JN SUPV CONFIRMING
	1 RECEIVE ISSUE PIPES 20" HIGH FROM BOTTOM
	2 DRAW OFF PIPE FLUSH WITH DECK LOCATED BETWEEN REC/ISSUE PIPES
	3 ANGLE STIFFENERS THROUGHOUT TANK
	4 BOTTOM PORTION OF TANK ALONG SHELL CONTAINS NUMEROUS PITS AROUND RIVETS
	5 STANDPIPE WITH VALVE 30 FT HIGH FROM BOTTOM
	6 OVERALL CONDITION OF TANK IS GOOD
13-Jun-71	1-2" DRAW OFF VALVE TESTED BY MAINTENANCE
8-Sep-71	TANK FILLED WITH NAVY DISTILLATE
1-[illegible]-75	NAVY DISTILLATE REGRADED TO DFM
21-May-74	WATER FLOWING OUT THRU FRENCH DRAIN, APPROX ONE GAL/30 SEC SOON AFTER 115,436 BBLS RECEIVED OFF TANKER. HEAD WAS 91'-11"
21-Jun-74	LEAK THRU FRENCH DRAIN CEASED AT LEVEL OF 80'-04"
2-Aug-77	TANK EMPTIED
23-Sep-77	TANK CLEANED BY T/C CREW
1-Oct-77	TANK INSPECTED BY CPOIC. NO SERIOUS DEFECT FOUND
23-Dec-77	TANK FILLED WITH DFM
22-Jan-78	TANK EMPTIED
11-Jan-79	TANK CLEANED BY T/C CREW
17-Jan-79	CONTRACTOR, WAKACHIKU CONSTR CO. RECEIVED TANK MADE FOLLOWING WORK
	1 SANDBLAST AND PROVIDE F.R.P. ON BOTTOM AND LINER UP TO 3 FEET HIGH FROM BOTTOM
	2 WELD AND REINFORCE RIVETED JOINTS
	3 SANDBLAST AND EPPOXY COAT ALL INTERIOR SURFACES AND TRUSSES
	4 RUN VACCUME TEST
	5 RESTRAP TANK
23-Mar-80	THE ABOVE ITEMS 1-5 COMPLETED
1-Mar-80	2-8" BREATHERS INSTALLED BY JAHD MAINTENANCE
8-Mar-80	TANK FILLED WITH JP-5
21-Mar-80	LEAKAGE THRU FRENCH DRAIN OBSERVED. APPROX ONE GAL/MIN. ULLAGE WAS 92'-00 3/2"
21-Mar-80	TANK ULLAGE LOWERED TO 92'-00", STILL LEAKING APPROX 11 BBLS ON 10 HOURS
2-Jun-80	TANK EMPTIED
1-May-80	CONTRACTOR, MARUICHI CONSTR CO. RECEIVED FOLLOWING WORK
	1 REINFORCE RIVETED JOINTS AND LINER WITH WELDING AND EPOXY COATING
1-Aug-80	THE ABOVE ITEM COMPLETED
20-Aug-80	TANK FILLED WITH JP-5
[illegible]	TANK EMPTIED
5-Nov-81	TANK CLEANED BY T/C CREW
2-Apr-82	TANK FILLED WITH JP-5
12-Nov-85	TANK EMPTIED
22-Nov-85	TANK FILLED WITH F-76
10-Sep-03	TANK EMPTIED FOR PREPARATION OF SURVEY BY TCI TO REPAIR. BUT THIS PROJECT WAS CANCELLED
8-Jun-05	CONTRACTOR SUMITOMO H. Co. STARTED FOLLOWING WORK, CONTRACT NO. N62836-C-0137
	1 CLEAN AND VAPOR FREE THE TANK NO. 102
31-Aug-05	ABOVE ITEM COMPLETED AND PROVIDED FINAL INSPECTION BY ROICC, CODE 04 AND NAKO JN SUP
20-Nov-05	FILLED WITH JP-8 FROM TANK 101
1-Sep-06	ATG INSTALLED
25-Jan-09	TANK EMPTIED
27-Jan-09	FILLED WITH DFM

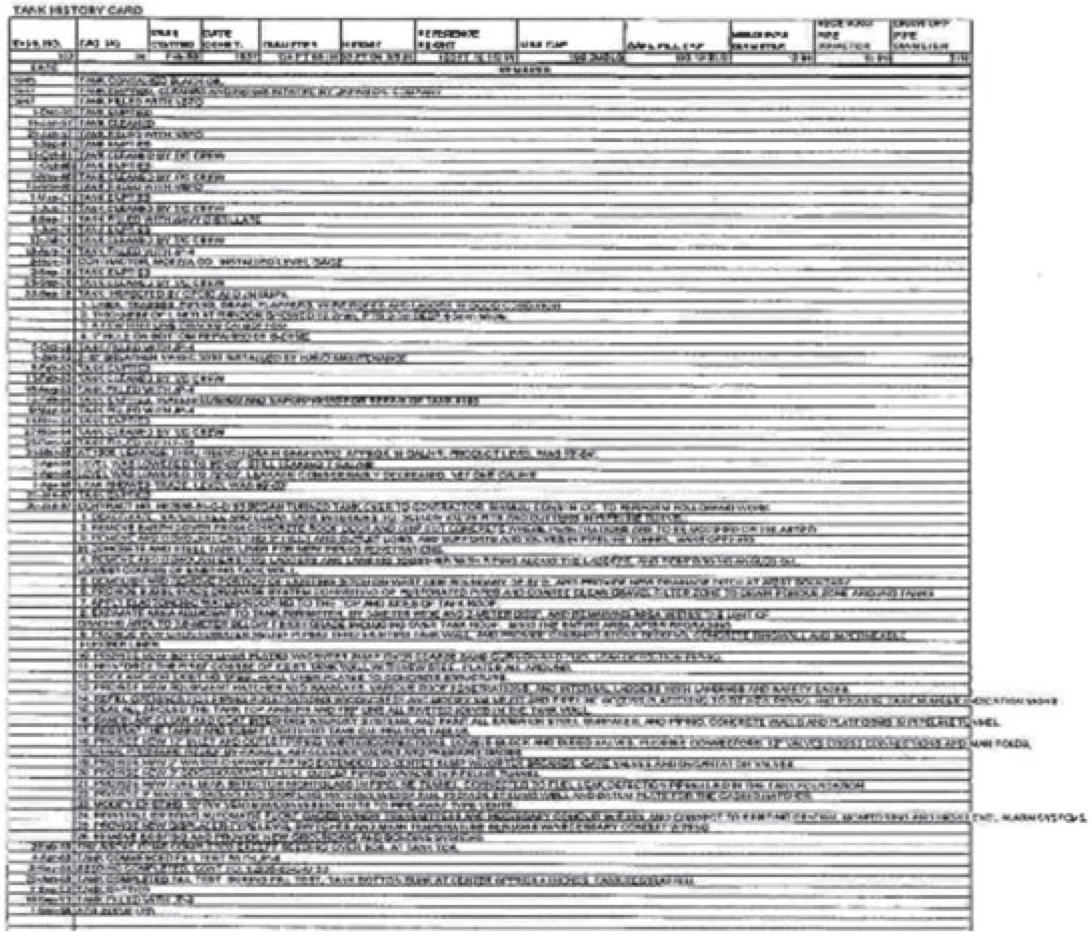
4.3. Tank 103

Modification to Tank 103 occurred during the mid to late 1980's upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of lower sections of the existing tank shell and total bottom with an interstitial space filled with sand, concrete and/or a flexible liner. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.



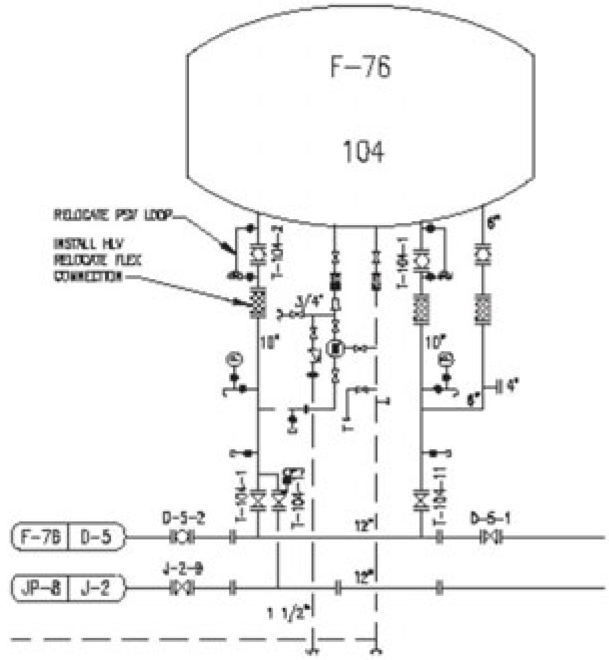
Tank 103 – Tank Top


TANK HISTORY CARD

4.4. Tank 104

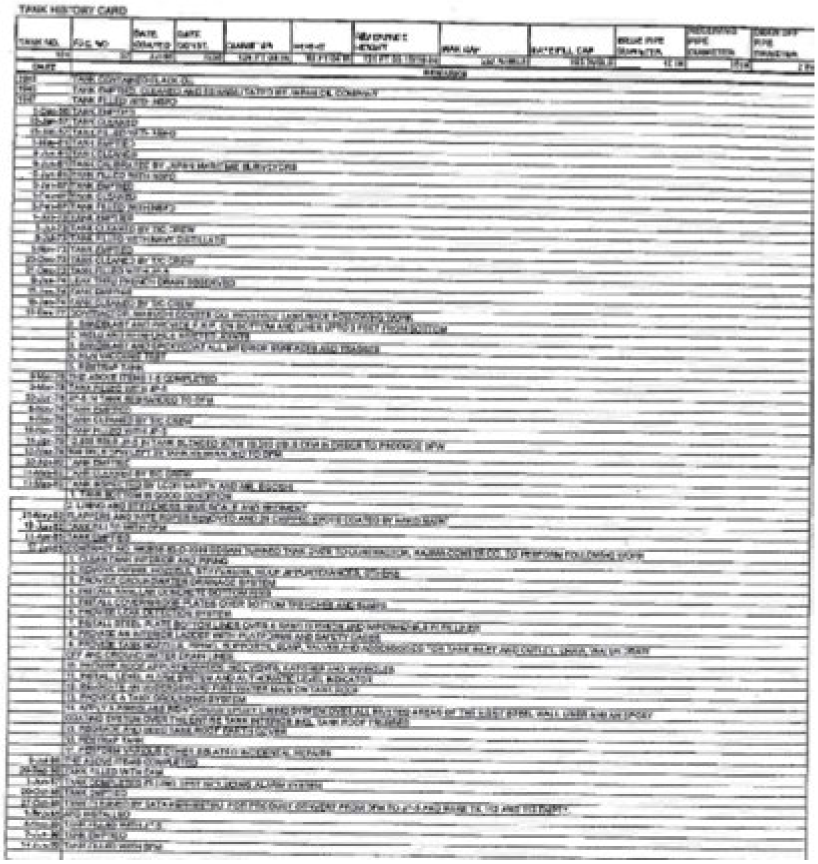
Modification to Tank 104 occurred during the mid to late 1980's upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of lower sections of the existing tank shell and total bottom with an interstitial space filled with sand, concrete and/or fiberglass / flexible liners. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.


F-76
104
RELOCATE PSV LOOP
INSTALL HLV
RELOCATE FLEX
CONNECTION
T-104-2
T-104-1
3/4"
10"
10"
6"
6"
4"
T-104-I
T-104
T-104-II
D-5-2
D-5-1
F-76
D-5
JP-8
J-2
J-2-8
12"
12"
1 1/2"


104

Tank 104 – Tank Top



TANK HISTORY CARD

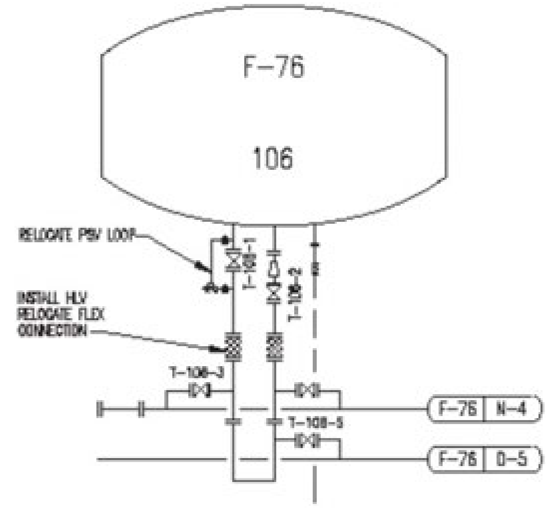
Tank 104 Leak Detection System with Site Glass

Tank 104 Valves

4.5. Tank 106

Unlike most of its sister tanks, only minimal modification to Tank 106 occurred during the mid to late 1980's upgrade project. The hydraulic integrity improvements included the construction of enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of the bottom having an interstitial space filled with sand, and/or a flexible liner and the shell receiving a fiberglass liner. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel at the bottom. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank bottoms when drained into a pump-out collection pit in the piping tunnel.



F-76
106
RELOCATE PSV LOOP
INSTALL HLV
RELOCATE FLEX
CONNECTION
T-106-1
T-106-2
T-106-3
T-106-5
F-76
N-4
F-76
D-5

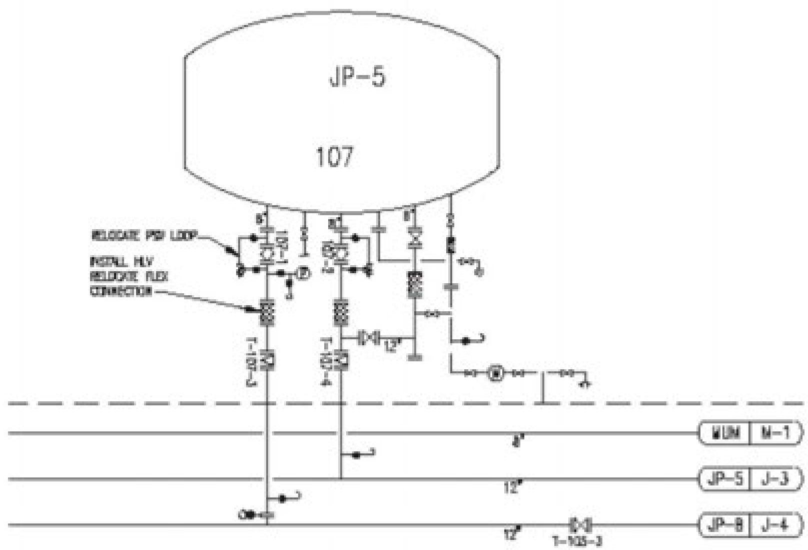
Tank 106 – Tank Top

Tank 106 Interior

4.6. Tank 107

Modification to Tank 107 occurred during the mid to late 1980's upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

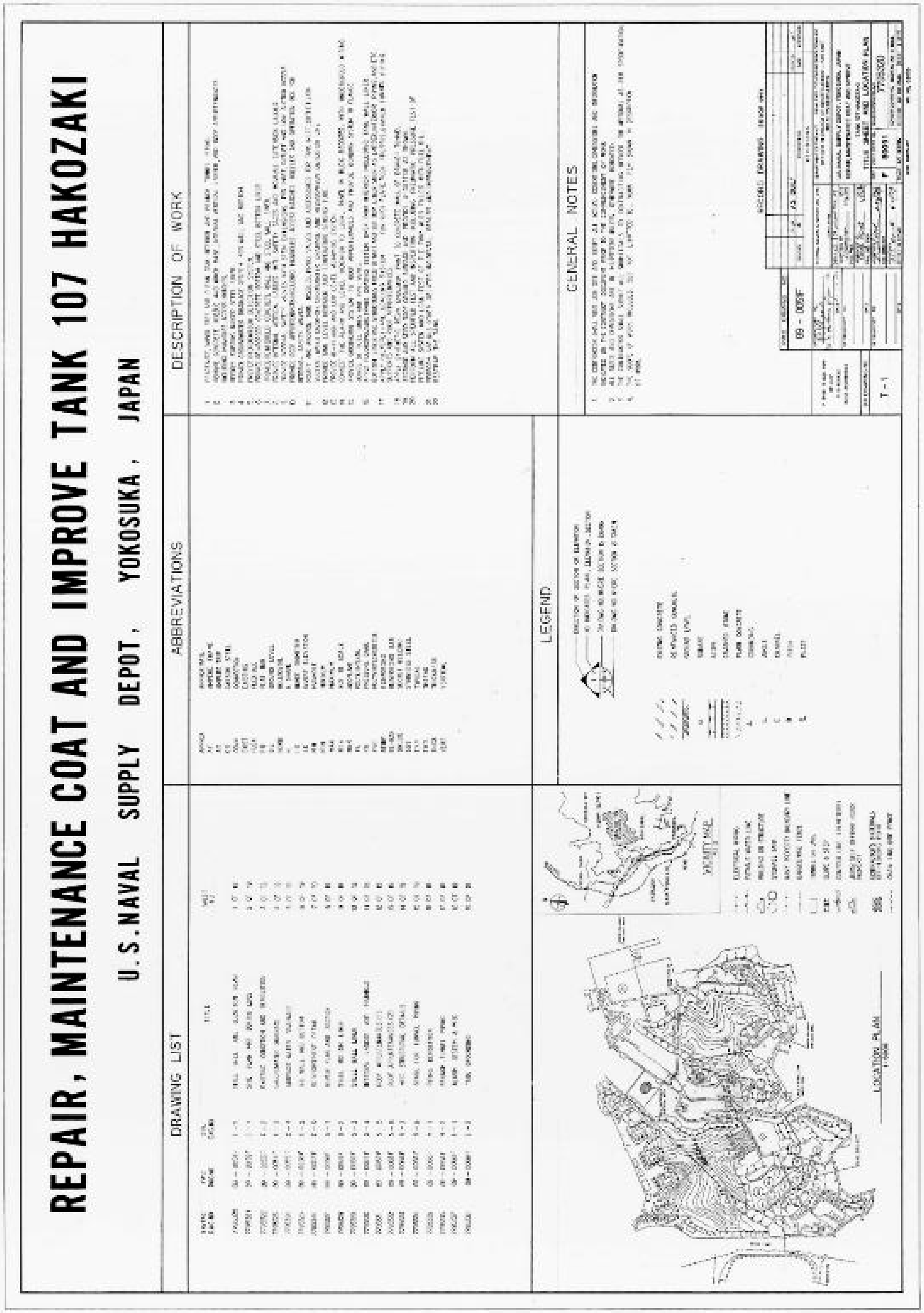
The containment system consists of the existing tank shell and bottom with an interstitial space filled with sand and concrete. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.

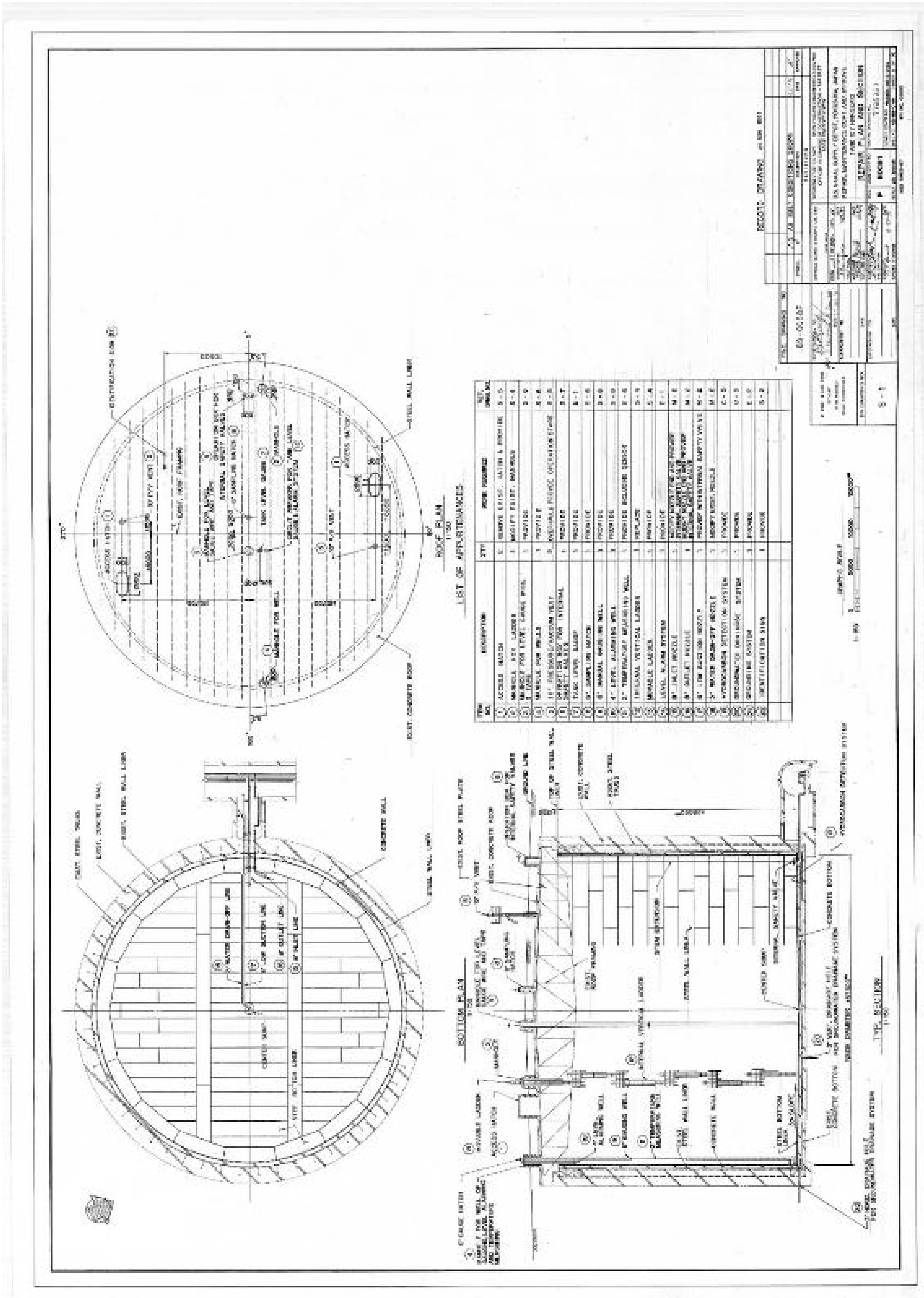


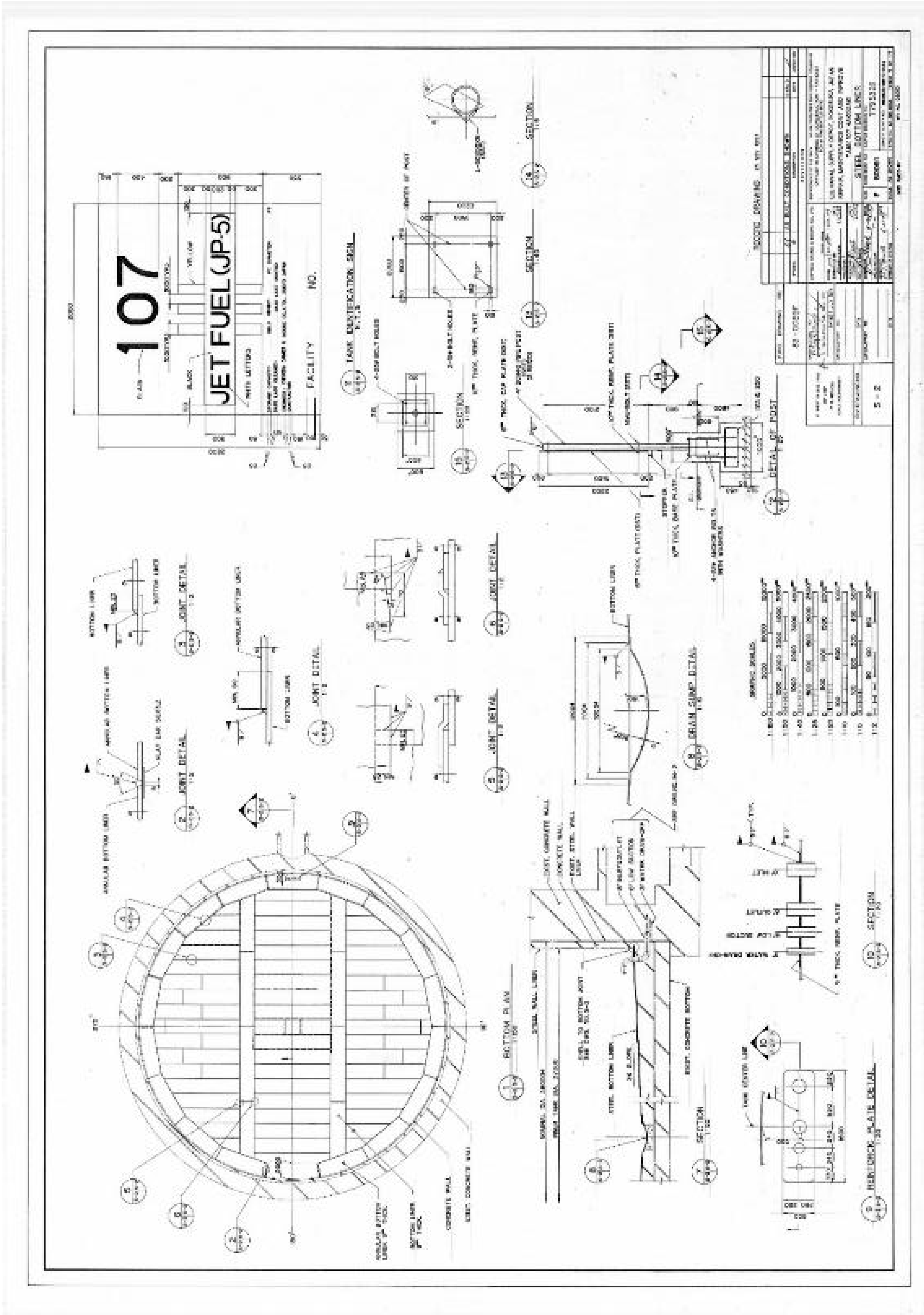
Tank 107 – Tank Top

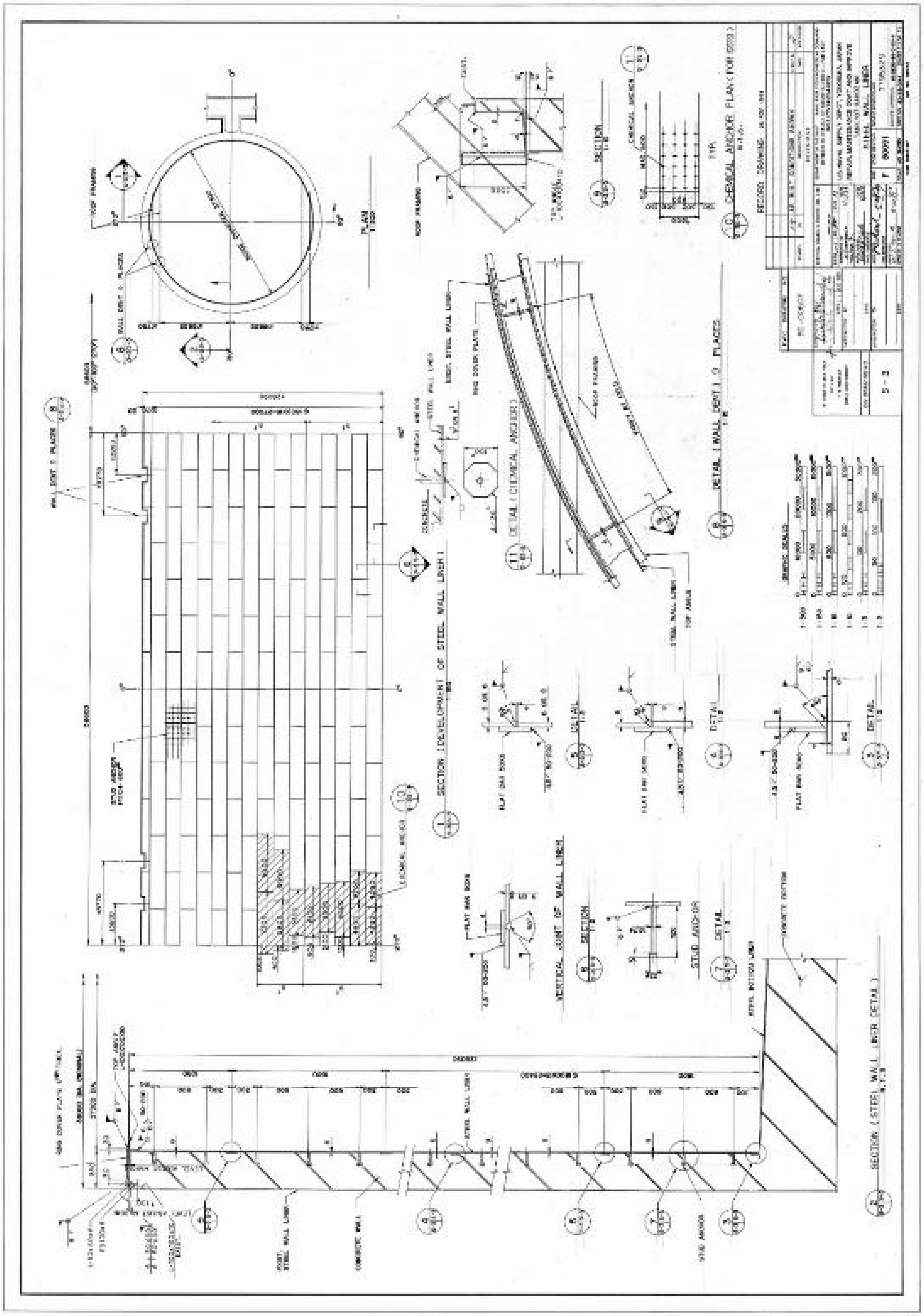
DESCRIPTION OF WORK

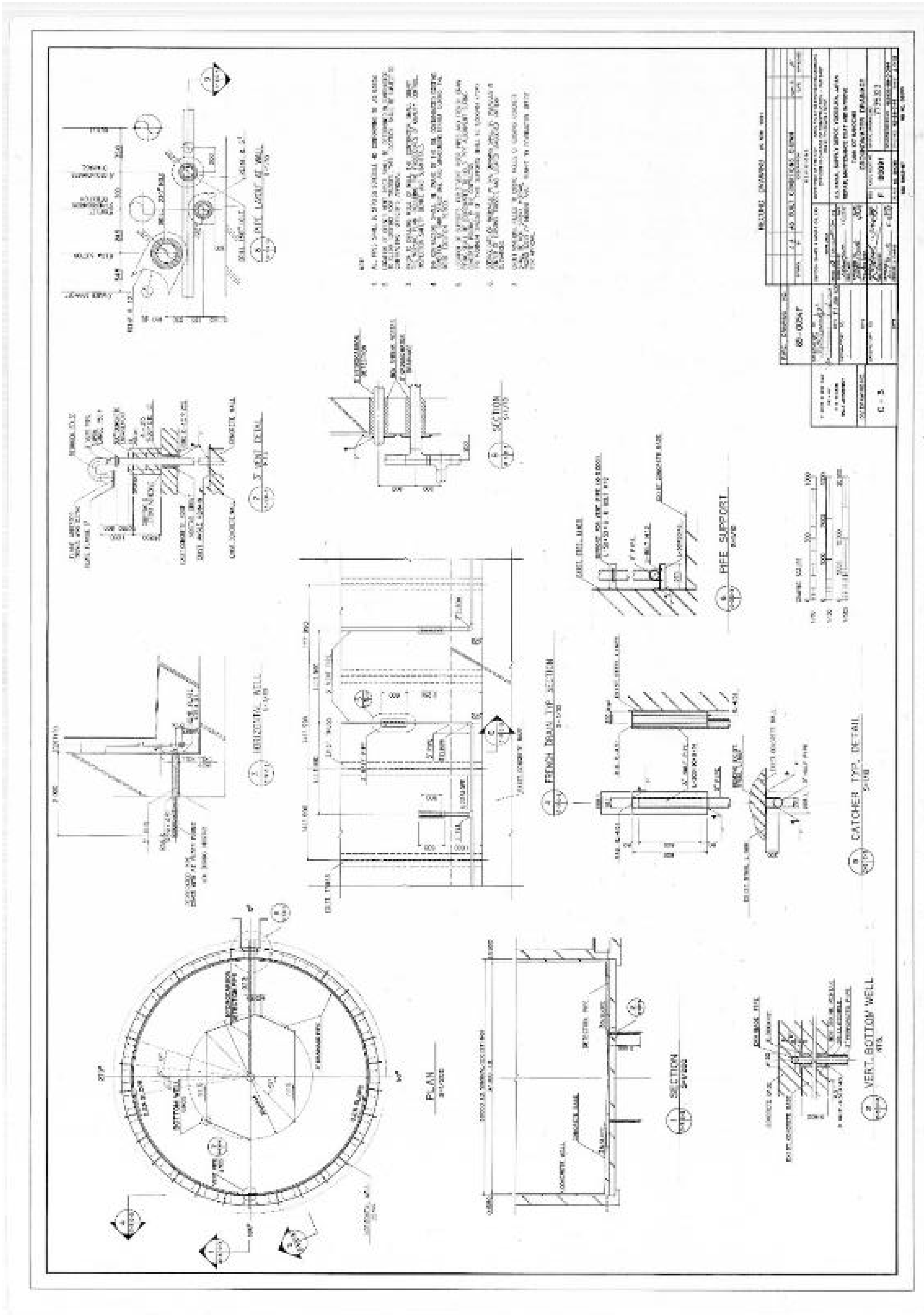
1. DEACTIVATE, VAPOR FREE AND CLEAN TANK INTERIOR AND BRANCH TUNNEL PIPING.
2. REMOVE CONCRETE NOZZLE AND WINCH BASE, INTERNAL VERTICAL LADDER, AND ROOF APPURTENANCES INCLUDING MANHOLES, ACCESS HATCHES.
3. REFORM EXISTING BULGED STEEL LINER.
4. PROVIDE GROUNDWATER DRAINAGE SYSTEM FOR WALL AND BOTTOM.
5. PROVIDE HYDROCARBON DETECTION SYSTEM.
6. PROVIDE REINFORCED CONCRETE BOTTOM AND STEEL BOTTOM LINER.
7. PROVIDE REINFORCED CONCRETE WALL AND STEEL WALL LINER.
8. PROVIDE INTERNAL VERTICAL LADDER WITH SAFETY CAGES AND MOVABLE EXTENSION LADDER.
9. PROVIDE INTERNAL SAFETY VALVES WITH STEM EXTENSIONS FOR INLET, OUTLET AND LOW SUCTION NOZZLE.
10. PROVIDE ROOF APPURTENANCES INCLUDING MANHOLES, ACCESS HATCHES, NOZZLES AND OPERATION BOX FOR INTERNAL SAFETY VALVES.
11. MODIFY AND PROVIDE TANK NOZZLES, PIPING, VALVES AND ACCESSORIES FOR TANK INLET, OUTLET, LOW SUCTION, WATER DRAW-OFF, GROUNDWATER DRAINAGE AND HYDROCARBON DETECTION LINE.
12. PROVIDE TANK LEVEL INDICATOR AND TEMPERATURE SENSING TUBE.
13. PROVIDE HI – HI, HIGH AND LOW LEVEL ALARMING SYSTEM.
14. CONNECT THE ALARM AND LEVEL INDICATOR TO LOCAL PANEL IN BLDG 6600352, WITH UNDERGROUND WIRING.
15. PROVIDE GROUNDING SYSTEM TO ROOF APPURTENANCES, AND PROVIDE BONDING SYSTEM TO FLANGE JOINTS OF FUEL LINES AND P/V VENTS.
16. APPLY FLUOROPOLYURETHANE COATING SYSTEM OVER TANK INTERIOR INCLUDING TANK WALL LINER, BOTTOM LINER AND STRUCTURES FIXED TO WALL AND BOTTOM LINER SUCH AS LADDER, INTERIOR PIPING, AND ETC.
17. APPLY POLYURETHANE COATING SYSTEM FOR ROOF PLATE, ROOF TRUSSES, BRANCH TUNNEL PIPING, SUPPORTS AND ROOF APPURTENANCES.
18. APPLY SYNTHETIC RESIN EMULSION PAINT TO CONCRETE WALL OF BRANCH TUNNEL.
19. REGRADE AND SEED ROOF GROUND SURFACE AND PROVIDE U-GUTTER AS SHOWN.
20. PERFORM ALL SPECIFIED TEST AND INSPECTION INCLUDING PNEUMATIC PRESSURE TEST OF PIPELINE SYSTEM AND LEAK TEST OF THE TANK WHEN FILLED WITH FUEL OIL.
21. PERFORM VARIOUS OTHER RELATED INCIDENTAL REPAIRS AND IMPROVEMENT.
22. RESTRAP THE TANK.

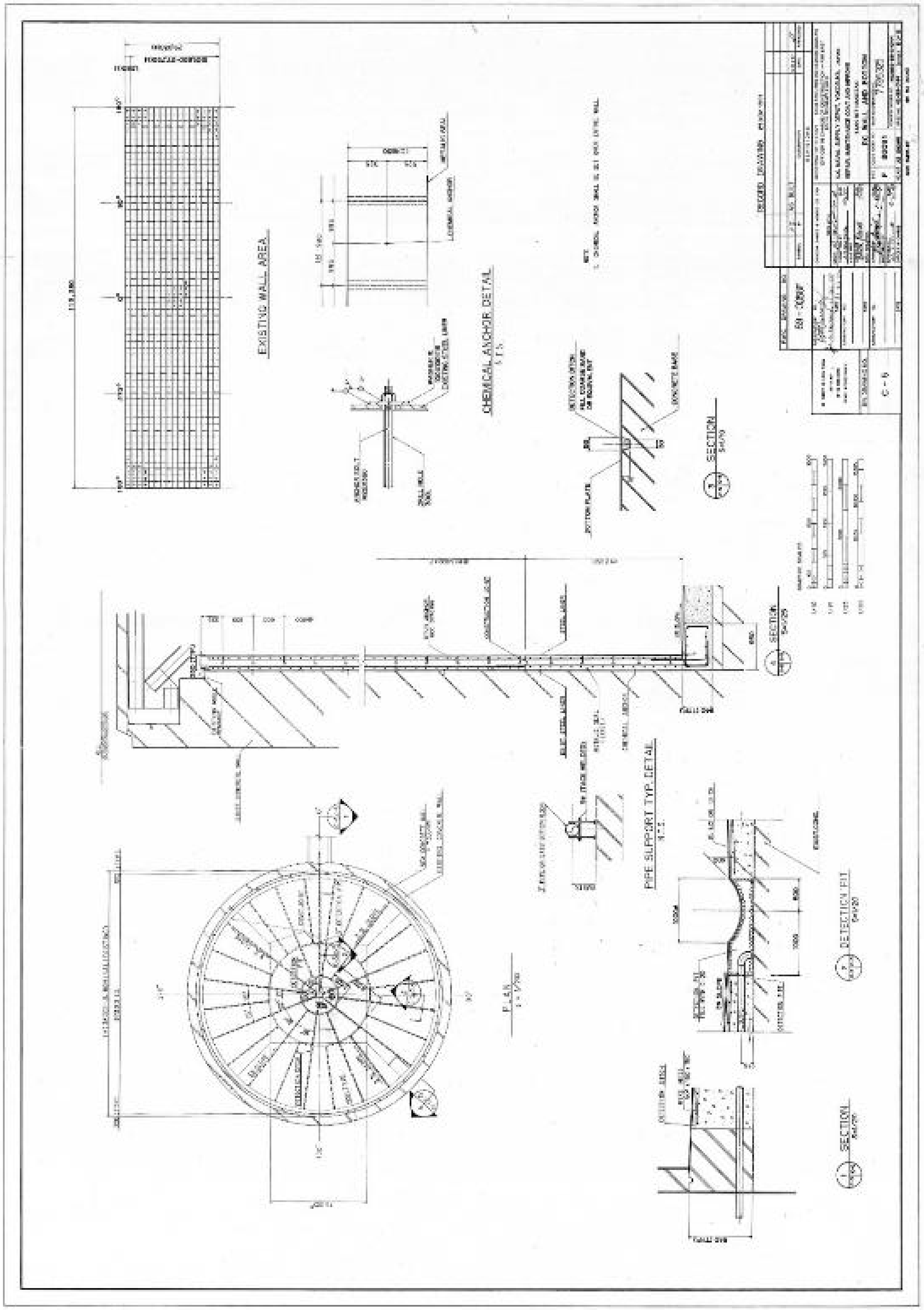

REPAIR, MAINTENANCE COAT AND IMPROVE TANK 107 HAKOZAKI
U.S.NAVAL SUPPLY DEPOT, YOKOSUKA, JAPAN
DRAWING LIST
ABBREVIATIONS
DESCRIPTION OF WORK
LEGEND
GENERAL NOTES
VICINITY MAP
LOCATION PLAN
T-1

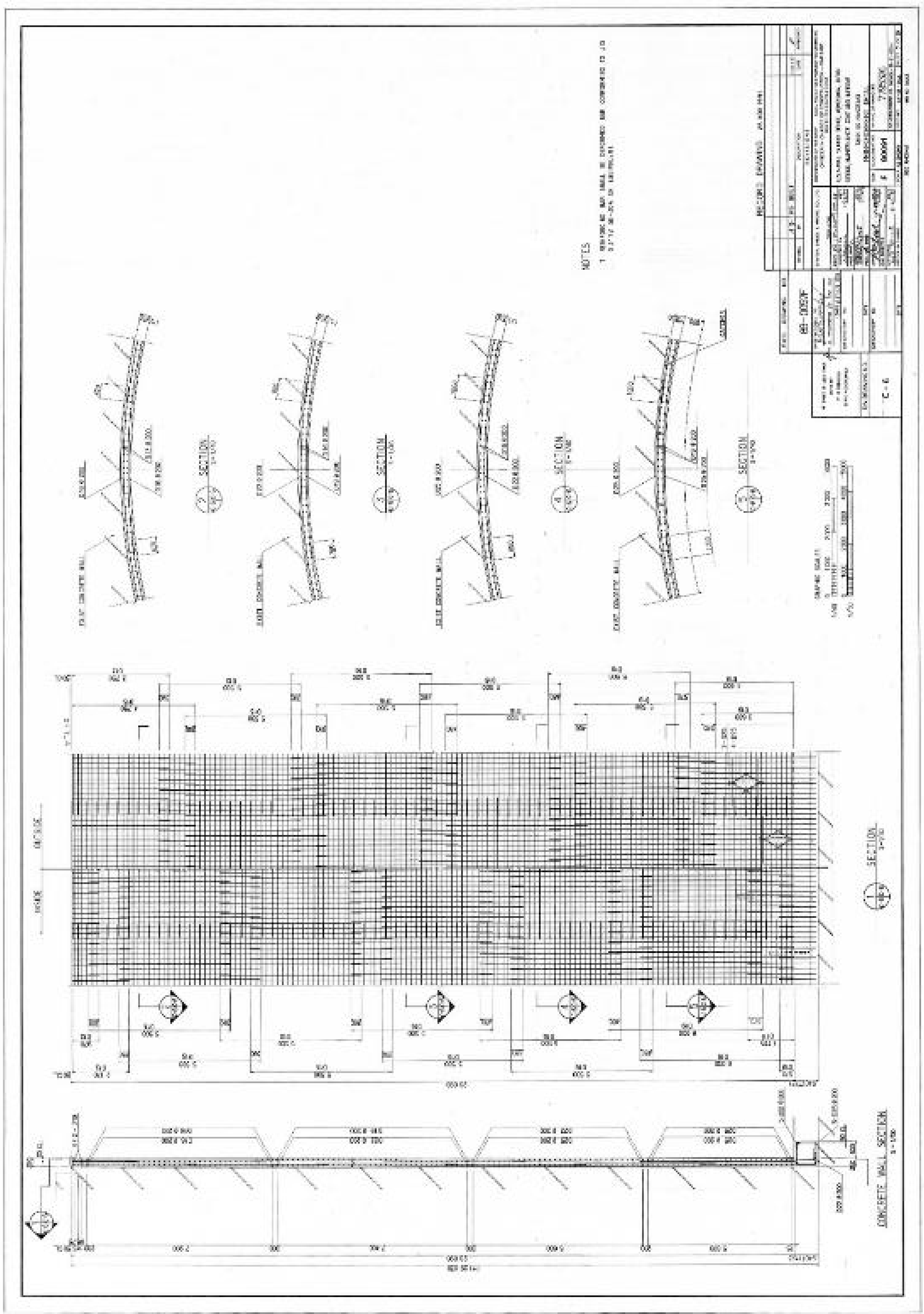



107
JET FUEL (JP-5)
FACILITY
NO.
TANK IDENTIFICATION SIGN
BOTTOM PLAN
JOINT DETAIL
DRAIN SUMP DETAIL
DETAIL OF POST
SECTION
STEEL BOTTOM LINER






EXISTING WALL AREA
CHEMICAL ANCHOR DETAIL
PIPE SUPPORT TYP. DETAIL
DETECTION PIT
SECTION
PLAN
C-6



4.7. Tank 108

Modification to Tank 108 occurred during the mid to late 1980's upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of the existing tank shell and bottom with an interstitial space filled with sand and concrete. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.

Tank 108 – Tank Top

Tank 108 Valves

DESCRIPTION OF WORK

THE FOLLOWING ITEMS SHALL BE PERFORMED AS INDICATED ON THE DRAWINGS AND SPECIFICATIONS:

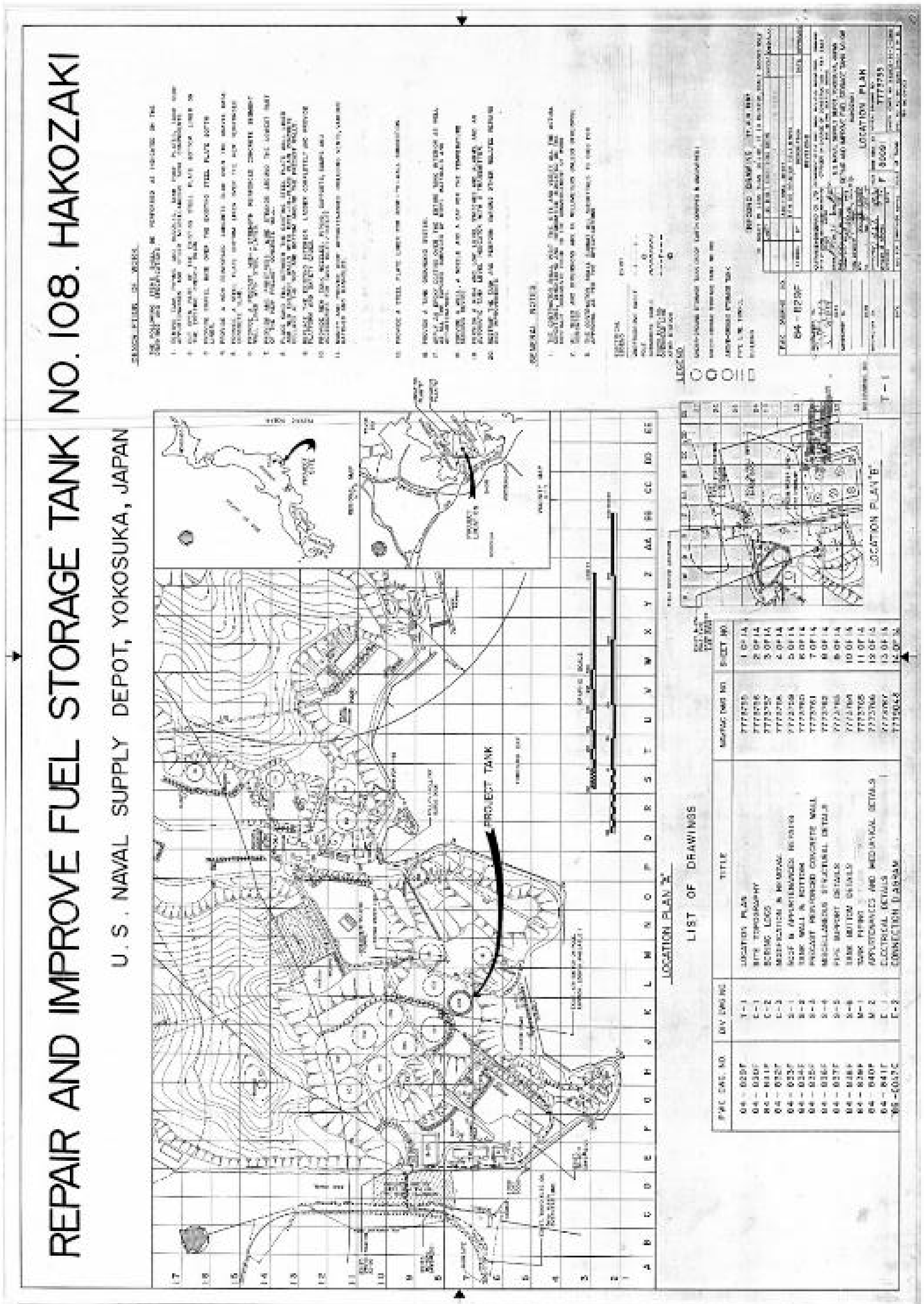
1. REMOVE TANK PIPING AND NOZZLES, TANK ROOF PLATES, TANK ROOF APPURTENANCES AND OTHER MISCELLANEOUS TANK COMPONENTS.
2. CUT OPEN PART OF THE EXISTING STEEL PLATE BOTTOM LINER ON THE EXISTING FRENCH DRAIN.
3. PROVIDE GRAVEL BASE OVER THE EXISTING STEEL PLATE BOTTM LINER.
4. PROVIDE A NEW REINFORCED CONCRETE SLAB OVER THE GRAVEL BASE.
5. PROVIDE A STEEL PLATE BOTTOM LINER OVER THE NEW REINFORCED CONCRETE SLAB.
6. PROVIDE A PRECAST HIGH-STRENGTH REINFORCED CONCRETE SEGMENT WALL LINED WITH STEEL PLATES.
7. PROVIDE AND PRESTRESS WIRE STRANDS AROUND THE LOWEST PART OF THE NEW PRECAST CONCRETE WALL.
8. PLACE SAND FILL BETWEEN THE EXISTING STEEL PLATE WALL LINER AND NEW PRECAST WALLS WITH CAST-IN-PLACE PLAIN CONCRETE COLLARS AT THE TOP AND BOTTOM AROUND THE PRECAST WALLS.
9. REPLACE THE EXISTING INTERIOR LADDER COMPLETELY AND PROVIDE PLATFORM AND SAFETY CAGES.
10. PROVIDE NEW TANK NOZZLES. PIPING, SUPPORTS, SUMPS AND ACCESSORIES FOR TANK INLET/OUTLET.
11. MODIFY AND PROVIDE ROOF APPURTENANCES INCLUDING VENTS, VARIOUS HATCHES AND MANHOLES.

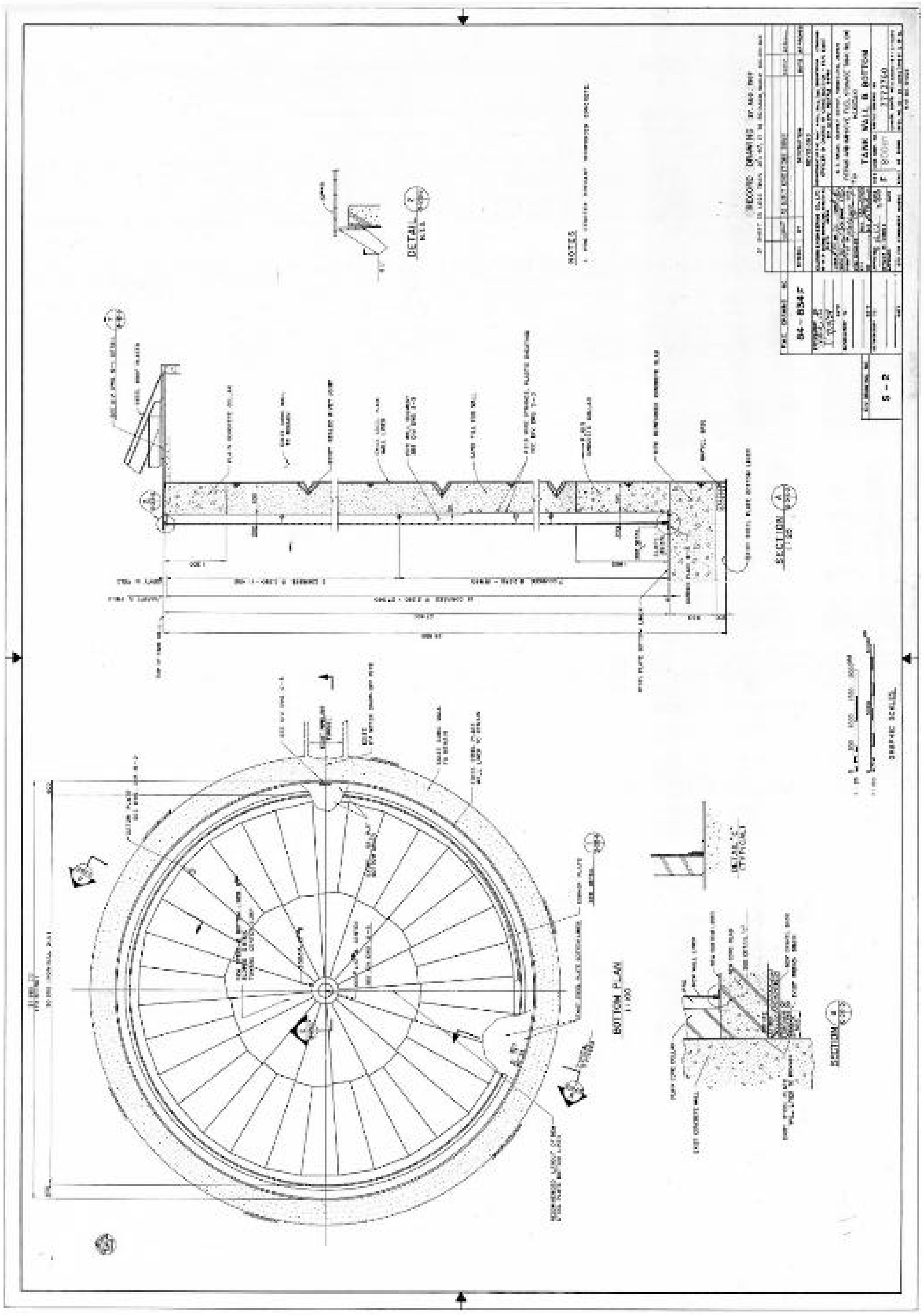
[illegible]

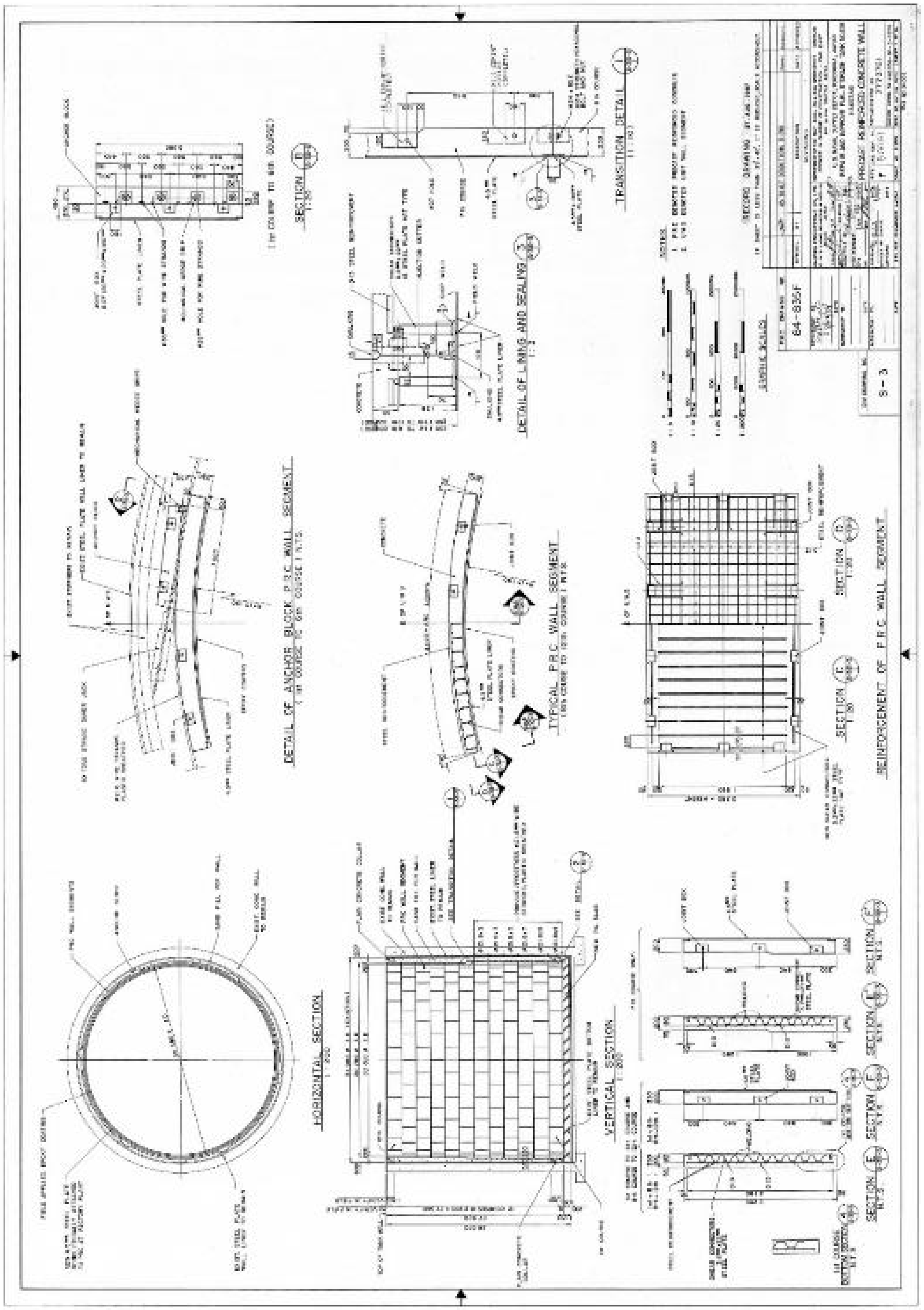
[illegible]

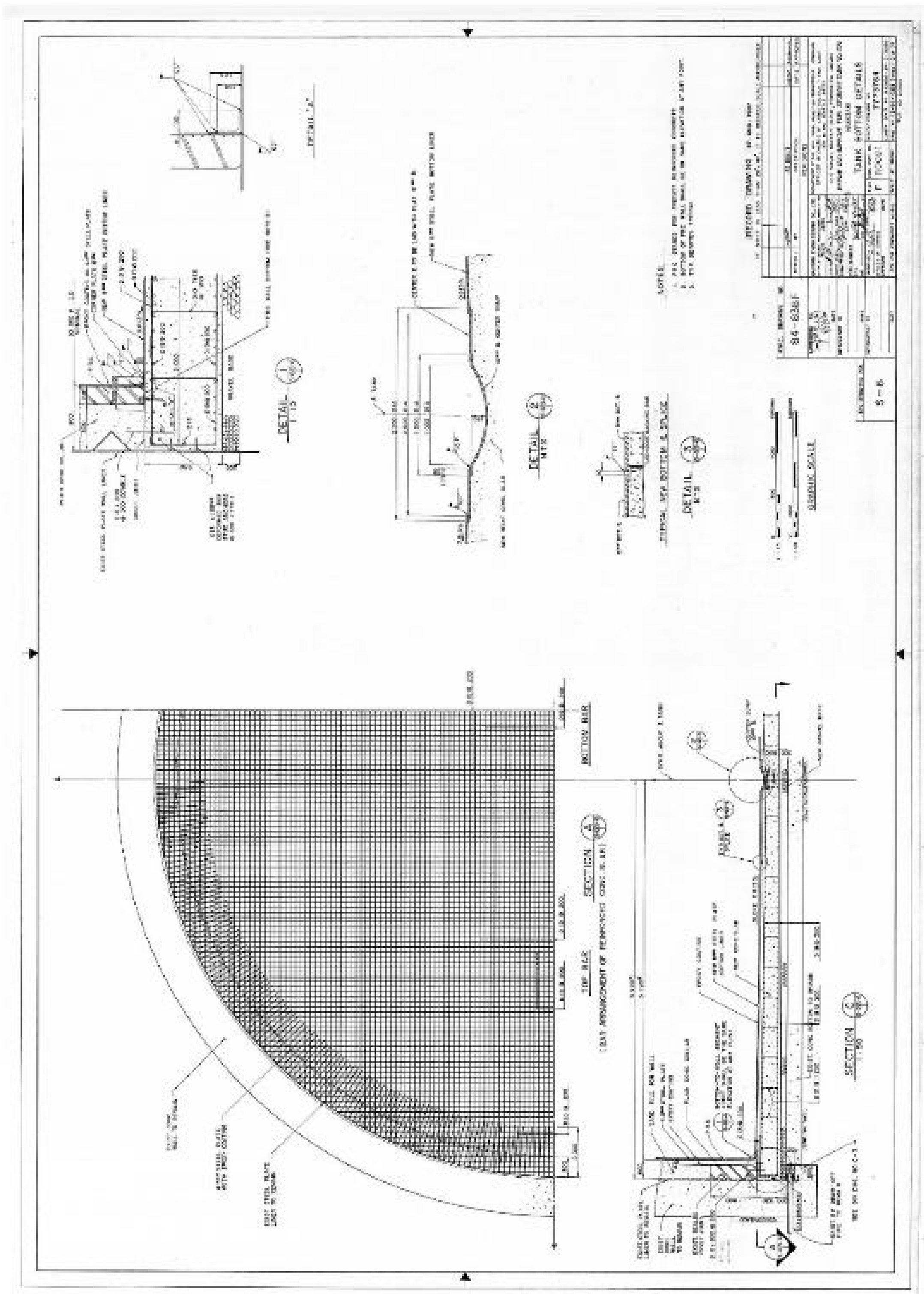
[illegible]

15. PROVIDE A STEEL PLATE LINER FOR ROOF-TO-WALL CONNECTION.
16. PROVIDE A TANK GROUNDING SYSTEM.
17. APPLY AN EPOXY COATING OVER THE ENTIRE TANK INTERIOR AS WELL AS ALL THE EXPOSED SURFACES OF STEEL MATERIALS AND APPURTENANCES.
18. PROVIDE A WELL, A NOZZLE AND A CAP FOR THE TEMPERATURE SENSING DEVICE.
19. FURNISH A HIGH AND LOW LEVEL SWITCHES AND ALARMS, AND AN AUTOMATIC TANK LEVEL INDICATOR WITH A TRANSMITTER.
20. RESTRAP THE TANK AND PERFORM VARIOUS OTHER RELATED REPAIRS AND IMPROVEMENTS.


REPAIR AND IMPROVE FUEL STORAGE TANK NO. 108. HAKOZAKI
U.S. NAVAL SUPPLY DEPOT, YOKOSUKA, JAPAN
PROJECT TANK
LOCATION PLAN "A"
LIST OF DRAWINGS
LOCATION PLAN "B"
GENERAL NOTES
LEGEND
LOCATION PLAN


BOTTOM PLAN
SECTION
DETAIL
NOTES
GRAPHIC SCALES
TANK WALL & BOTTOM
S-2

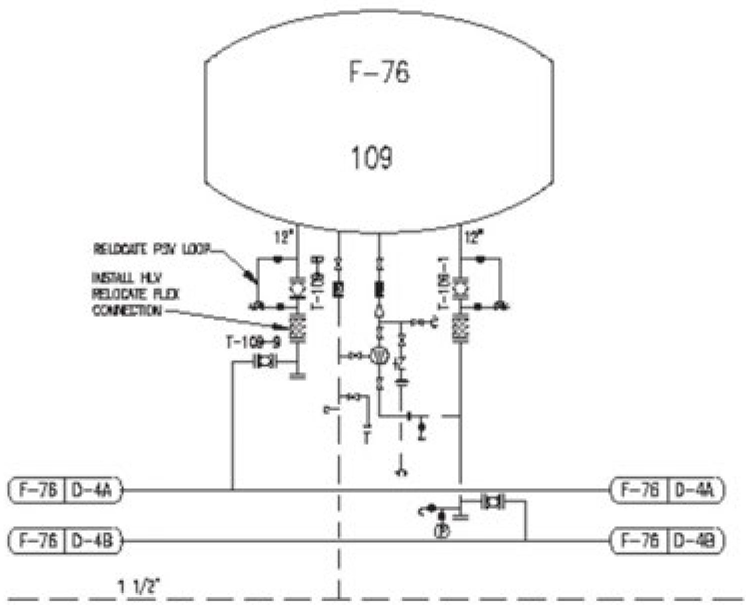

HORIZONTAL SECTION
VERTICAL SECTION
DETAIL OF ANCHOR BLOCK P.R.C. WALL SEGMENT
TYPICAL P.R.C. WALL SEGMENT
DETAIL OF LINING AND SEALING
TRANSITION DETAIL
REINFORCEMENT OF P.R.C. WALL SEGMENT
RECORD DRAWING
64-835F
S-3



4.8. Tank 109

Modification to Tank 109 occurred during the mid to late 1980's upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of the existing tank shell and bottom with an interstitial space filled with sand and concrete. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.



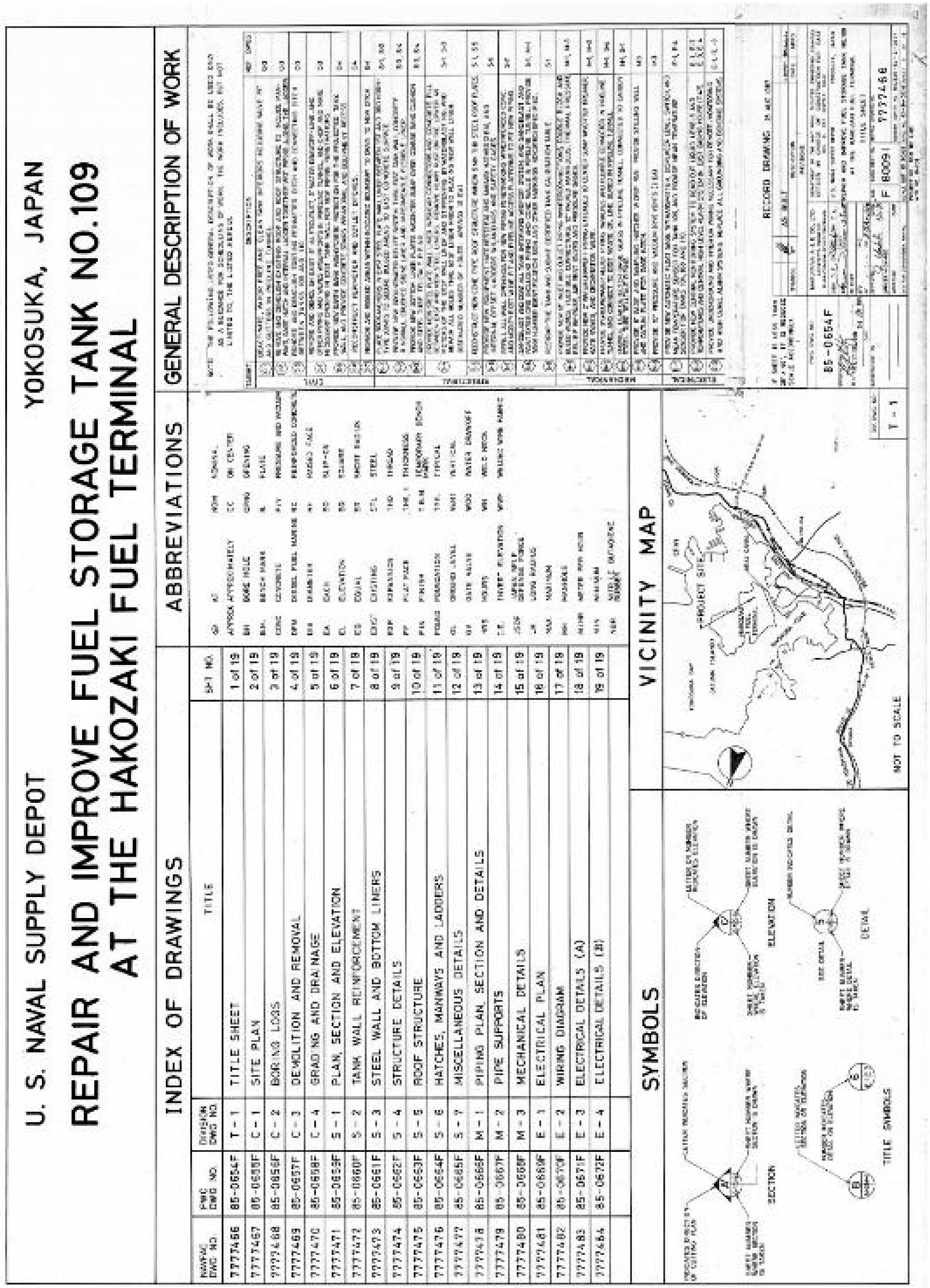
Tank 109

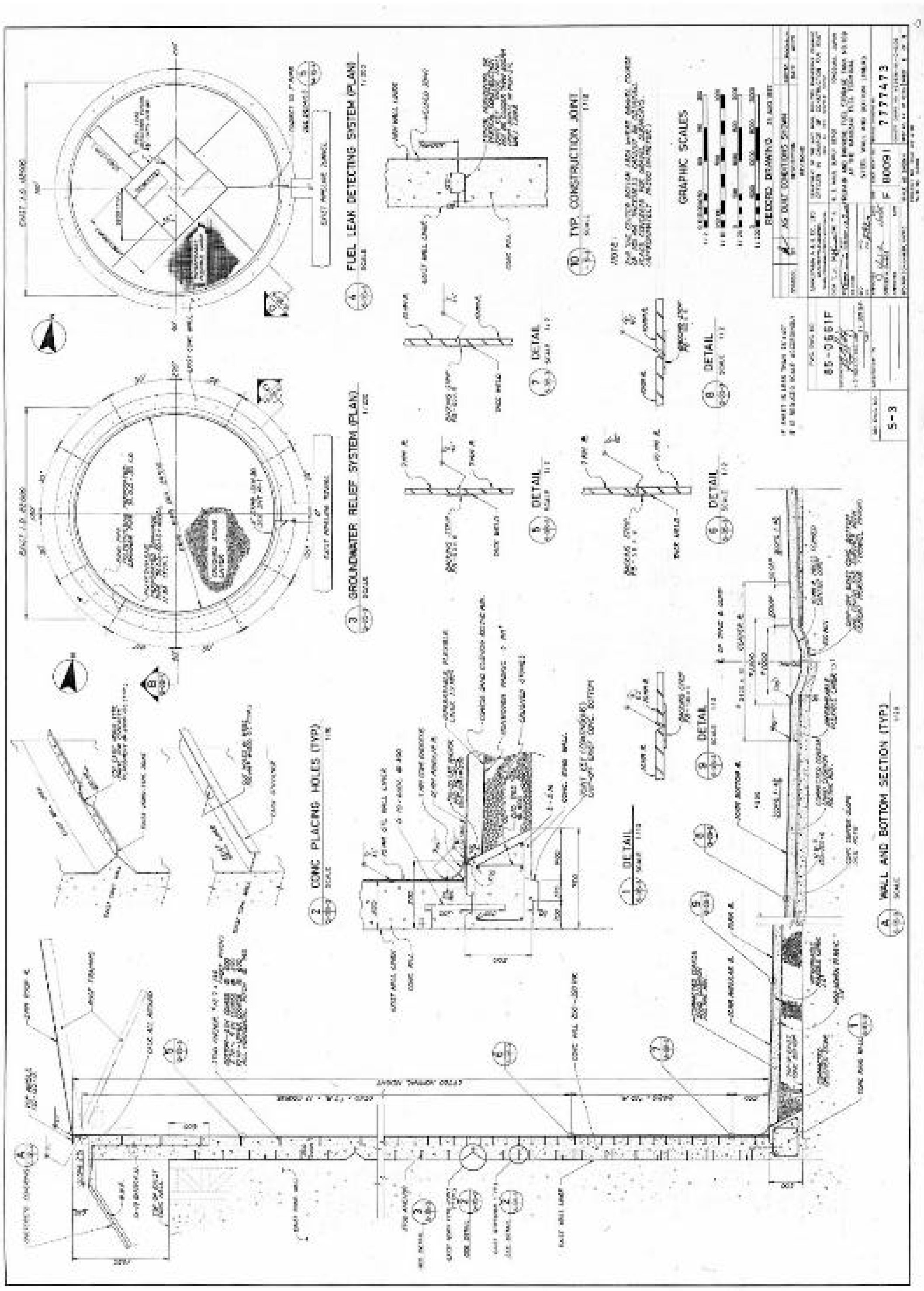
Tank 109 – Tank Top

GENERAL DESCRIPTION OF WORK

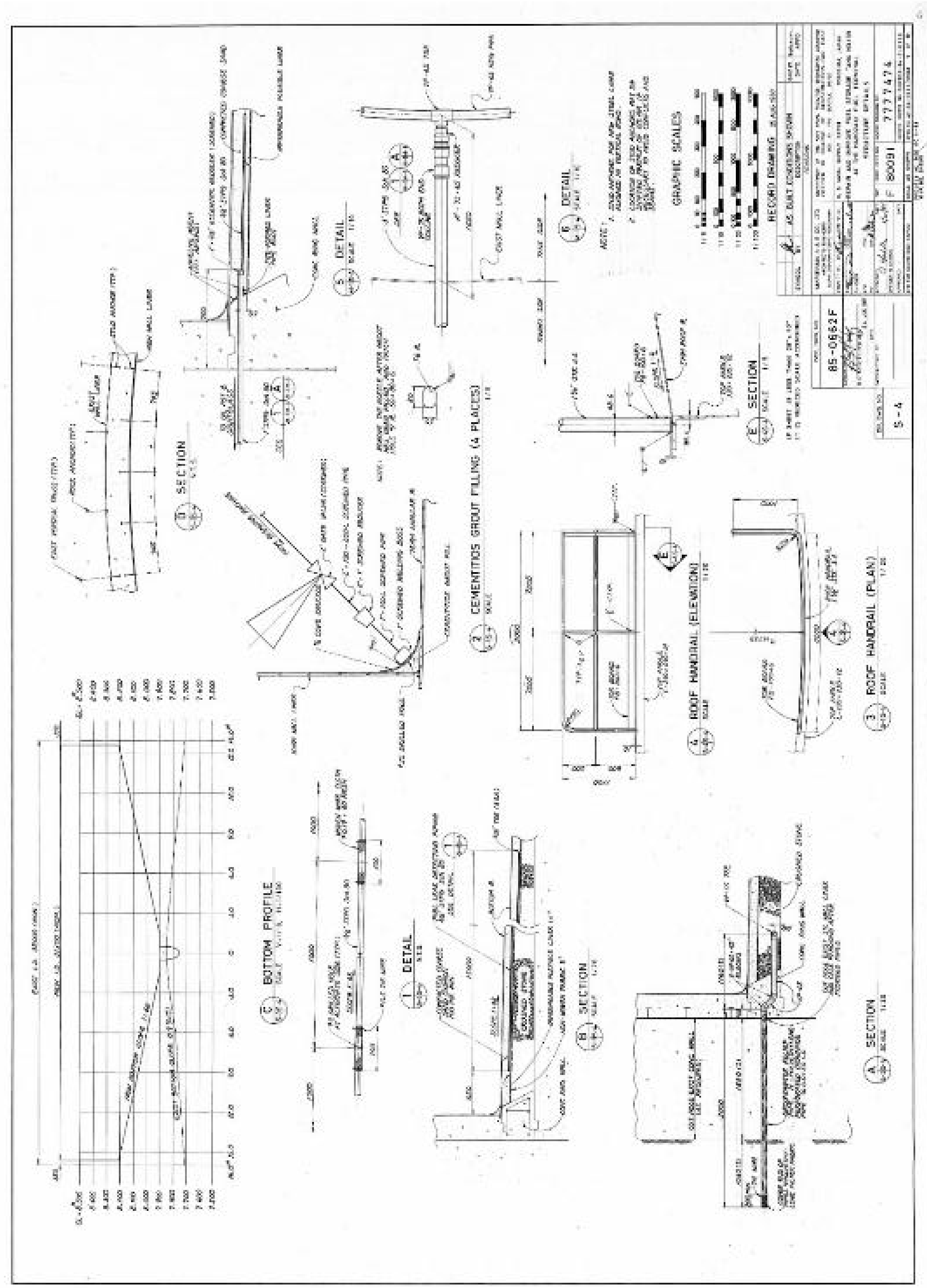
NOTE: THE FOLLOWING LISTED GENERAL DESCRIPTION OF WORK SHALL BE USED ONLY AS A GUIDANCE FOR SCHEDULING OF WORK. THE WORK INCLUDES, BUT NOT LIMITED TO, THE LISTED HEREIN.

TARGET		DESCRIPTION	REF DWGS
CIVIL	C-1	DEACTIVATE, VAPOR FREE AND CLEAN TANK INTERIORS INCLUDING VALVE PIT AND GUTTERS IN PIPELINE TUNNEL.	C-3
	C-2	REMOVE AND DEMOLISH EXISTING ROOF AND ROOF STRUCTURE TO INCLUDE MAN-WAYS, GAGE HATCH AND INTERNAL LADDER TOGETHER W/3" PIPING ALONG THE LADDER.	C-3
	C-3	REMOVE AND DEMOLISH EXISTING PERIMETER DITCH AND CONNECTING DITCH BETWEEN TANKS 109 AND 110.	C-3
	C-4	REMOVE AND DEMOLISH EXIST 8" INLET/OUTLET, 3" WATER DRAWOFF-LINE, AND OTHER PIPING AND VALVES W/SUPPORTS IN PIPELINE TUNNEL, AND CHOP AND MAKE NECESSARY OPENING IN EXST TANK WALL FOR NEW PIPING PENETRATIONS.	C-3
	C-5	PROVIDE NEW EARTH BANK W/SHOTCRETE PROTECTION FOR THE PROJECTED TANK WALL, AND PROVIDE CONCRETE STAIRS W/HANDRAIL AND EQUIPMENT RECESS.	C-4
	C-6	RECONSTRUCT PERIMETER AND OUTLET DITCHES.	C-4
	C-7	REGRADE AND RESEED AREAS WITHIN INDICATED BOUNDARY TO DRAIN TO NEW DITCH.	C-4
STRUCTURAL	S-1	PLACE ROCK ANCHORS IN EXST STEEL PLATE WALL LINER BETWEEN 1ST AND 3RD HORN-TYPE JOINTS TO SECURE BULGED AREAS TO EXST CONCRETE SURFACE.	S-1, S-2
	S-2	PROVIDE NEW GROUNDWATER RELIEF SYSTEM THRU EXST TANK WALL, CONCRETE RINGWALL, CRUSHED STONE LAYER AND IMPERMEABLE FLEXIBLE LINER.	S-3, S-4
	S-3	PROVIDE NEW BOTTOM LINER PLATES W/CENTER SUMP OVER COARSE SAND CUSHION AND STEEL TUBE TELLTALE PIPING.	S-3, S-4
	S-4	PROVIDE NEW STEEL PLATE WALL LINER W/SHEAR CONNECTORS AND CONCRETE FILL BETWEEN EXST AND NEW STEEL LINERS. REMOVE HEAVY RUST ON THE LOWER 45 METERS OF THE EXST WALL LINER AND STIFFENING BY WATERBLASTING, AND REPAIR ALL HOLES THRU EXST LINER PRIOR TO PLACING NEW WALL LINER. (ESTIMATED NUMBER OF HOLES: APPROX 10 EA)	S-1, S-3
	S-5	RECONSTRUCT NEW CONE TYPE ROOF STRUCTURE W/NEW 5-MM THK STEEL ROOF PLATES	S-1, S-5
	S-6	PROVIDE NEW EQUIPMENT HATCHES (2 EA) AND MANWAY HATHES (2 EA), AND INTERNAL OFFSET LADDERS W/LANDINGS AND SAFETY CAGES.	S-6
	S-7	REFILL ALL WALL OPENINGS FOR NEW PIPING PENETRATIONS W/REINFORCED CONC, AND MODIFY EXST VALVE PIT AND PIPELINE ACCESS PLATFORMS TO FIT NEW PIPING.	S-7
	S-8	SANDBLAST AND COAT ALL TANK INTERIORS W/EPOXY SYSTEM, AND SANDBLAST AND PAINT EXTERIORS INCLUDING PIPING AND CONC WALLS IN PIPELINE TUNNEL. PROVIDE TANK NUMBER IDENTIFICATION SIGN AND OTHER MARKINGS INDICATED/SPECIFIED.	S-1, M-1
	S-9	RESTRAP THE TANK AND SUBMIT CERTIFIED TANK CALIBRATION TABLE.	S-1
MECHANICAL	M-1	PROVIDE NEW 12" INLET AND OUTLET PIPING W/INTERCONNECTIONS, DOUBLE BLOCK AND BLEED VALVES, FLEXIBLE CONNECTORS, 12" VALVED MANIFOLDS, THERMAL PRESSURE RELIEF BY-PASS, AIR VENT VALVES AND PRESSURE GAGES.	M-1, M-3
	M-2	PROVIDE NEW 2" WATER-DRAWOFF PIPING EXTENDED TO CENTER SUMP W/VORTEX BREAKER, GATE VALVES, AND DECANTATION VALVE.	M-1, M-3
	M-3	PROVIDE 3" GROUNDWATER RELIEF PIPING W/VALVES AND FLEXIBLE CONNECTOR IN PIPELINE TUNNEL, AND CONNECT TO EXST WASTE OIL LINE BURIED IN PIPELINE TUNNEL.	M-1, S-4
	M-4	PROVIDE LEAK DETECTOR GAGE GLASS IN PIPELINE TUNNEL, CONNECTED TO CARBON STEEL TUBE TELLTALE PIPING.	M-1, S-4
	M-5	PROVIDE 6" GAGE AND SAMPLING HATCHES W DRIP PAN. PROVIDE STILLING WELL AND DATUM PLATE FOR GAGE HATCH.	M-3
	M-6	PROVIDE 10" PRESSURE AND VACUUM (P/V) VENTS (2 EA).	M-3
ELECTRICAL	E-1	PROVIDE NEW AUTOMATIC FLOAT GAGE W/TRANSMITTER, DISPLACER LEVEL SWITCH, AND MEAN TEMPERATURE SENSOR FOR TANK 109, AND PROVIDE MEAN TEMERATURE SENSOR FOR TANKS 104, 108 AND 110.	E-1, E-4
	E-2	PROVIDE NEW CENTRAL MONITORING SYSTEM TO READ OUT LIQUID LEVELS AND TEMPERATURES AND CENTRAL HIGH LEVEL ALARM SYSTEM IN EXST GAGING HOUSE (T-42).	E-1, E-2 E-3, E-4
	E-3	PROVIDE UNDERGROUND AND INTERIOR WIRING NECESSARY FOR REMOTE MONITORING AND HIGH LEVEL ALARM SYSTEMS. REPLACE ALL GROUNDING AND BONDING SYSTEMS.	E-1, -2, -3


U. S. NAVAL SUPPLY DEPOT
YOKOSUKA, JAPAN
REPAIR AND IMPROVE FUEL STORAGE TANK NO.109 AT THE HAKOZAKI FUEL TERMINAL
INDEX OF DRAWINGS
NAVFAC DWG NO.
PWC DWG NO.
DIVISION DWG NO.
TITLE
SHT NO.
7777466 85-0654F T-1 TITLE SHEET 1 of 19
7777467 85-0655F C-1 SITE PLAN 2 of 19
7777468 85-0656F C-2 BORING LOGS 3 of 19
7777469 85-0657F C-3 DEMOLITION AND REMOVAL 4 of 19
7777470 85-0658F C-4 GRADING AND DRAINAGE 5 of 19
7777471 85-0659F S-1 PLAN, SECTION AND ELEVATION 6 of 19
7777472 85-0660F S-2 TANK WALL REINFORCEMENT 7 of 19
7777473 85-0661F S-3 STEEL WALL AND BOTTOM LINERS 8 of 19
7777474 85-0662F S-4 STRUCTURE DETAILS 9 of 19
7777475 85-0663F S-5 ROOF STRUCTURE 10 of 19
7777476 85-0664F S-6 HATCHES, MANWAYS AND LADDERS 11 of 19
7777477 85-0665F S-7 MISCELLANEOUS DETAILS 12 of 19
7777478 85-0666F M-1 PIPING PLAN, SECTION AND DETAILS 13 of 19
7777479 85-0667F M-2 PIPE SUPPORTS 14 of 19
7777480 85-0668F M-3 MECHANICAL DETAILS 15 of 19
7777481 85-0669F E-1 ELECTRICAL PLAN 16 of 19
7777482 85-0670F E-2 WIRING DIAGRAM 17 of 19
7777483 85-0671F E-3 ELECTRICAL DETAILS (A) 18 of 19
7777484 85-0672F E-4 ELECTRICAL DETAILS (B) 19 of 19
ABBREVIATIONS
GENERAL DESCRIPTION OF WORK
SYMBOLS
SECTION
ELEVATION
DETAIL
TITLE SYMBOLS
VICINITY MAP
PROJECT SITE
NOT TO SCALE
RECORD DRAWING
85-0654F
T-1
7777466



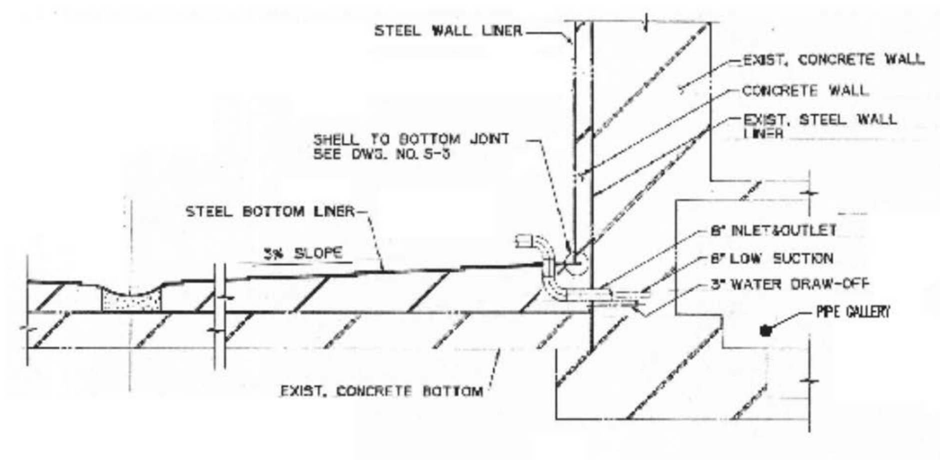
WALL AND BOTTOM SECTION (TYP)
CONC PLACING HOLES (TYP)
GROUNDWATER RELIEF SYSTEM (PLAN)
FUEL LEAK DETECTING SYSTEM (PLAN)
TYP. CONSTRUCTION JOINT
DETAIL
GRAPHIC SCALES
RECORD DRAWING
AS BUILT CONDITIONS SHOWN
85-0551F
7777473
5-3


BOTTOM PROFILE
CEMENTITIOS GROUT FILLING (4 PLACES)
ROOF HANDRAIL (ELEVATION)
ROOF HANDRAIL (PLAN)
SECTION
DETAIL
GRAPHIC SCALES
85-0662F

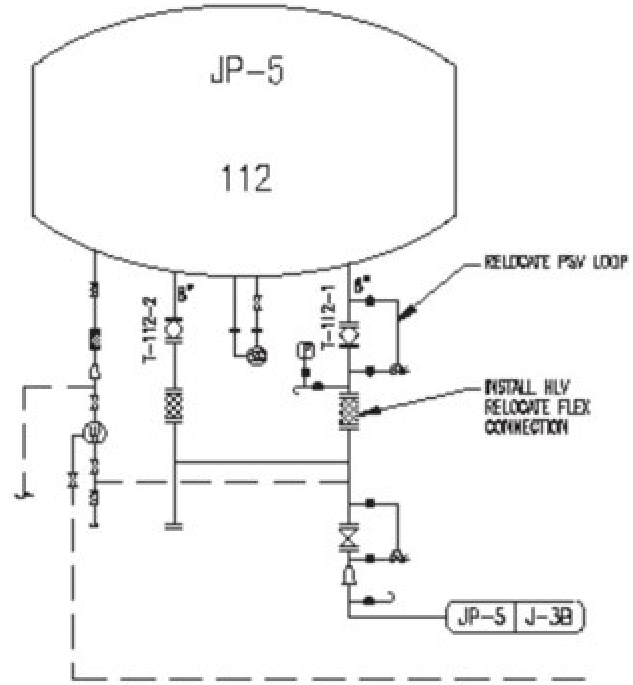
4.9. Tanks 112 and 113

Modification to Tanks 112 and 113 occurred during the late 1980's to early 1990's upgrade project. The hydraulic integrity improvements included the construction of multiple enhanced features including systems for containment, ground water drainage, leak detection, and epoxy coatings.

The containment system consists of lower sections of the existing tank shell and the entire bottom with an interstitial space filled with sand, concrete and/or a flexible liner. The containment area, drain valves, and drainage structures were designed to impound any escaping fuel. The containment area is sufficient to contain the stored product. The leak detection system utilizes a French drain around the tank perimeter to monitor the interstitial space between the new and existing tank shells / bottoms when drained into a pump-out collection pit in the piping tunnel.

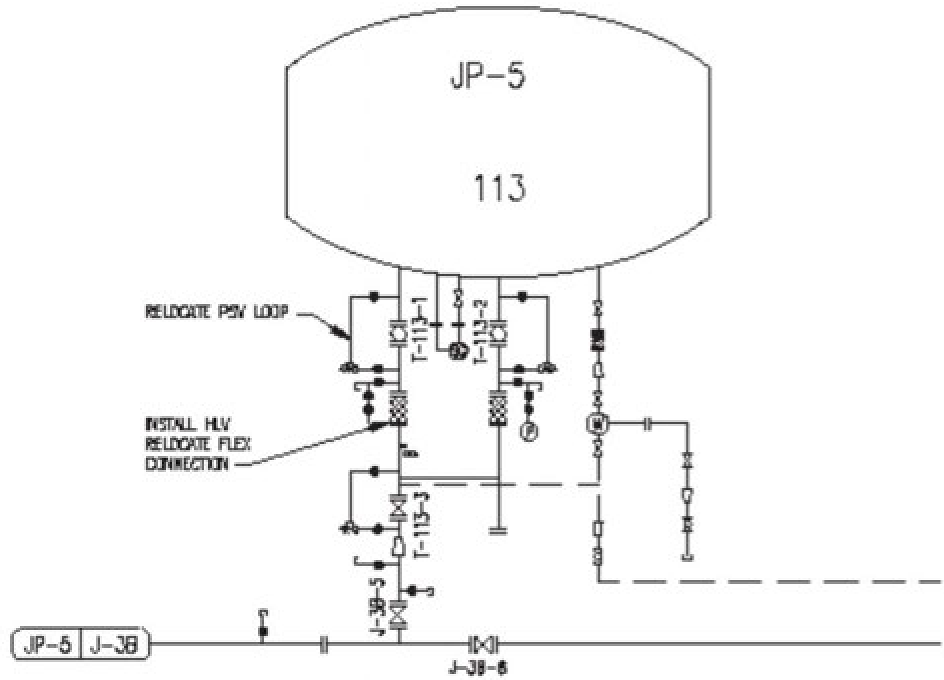


NOTES
1. NEW WELDED FLOOR & SHELL LINER ADDED IN 1991.
2. ORIGINAL TANK PIPING MODIFIED TO REFLECT NEW FLOOR PROFILE.


JP-5
112
RELOCATE PSV LOOP
T-112-2
T-112-1
INSTALL HLV
RELOCATE FLEX
CONNECTION
JP-5
J-3B

Tank 112 – Tank Top

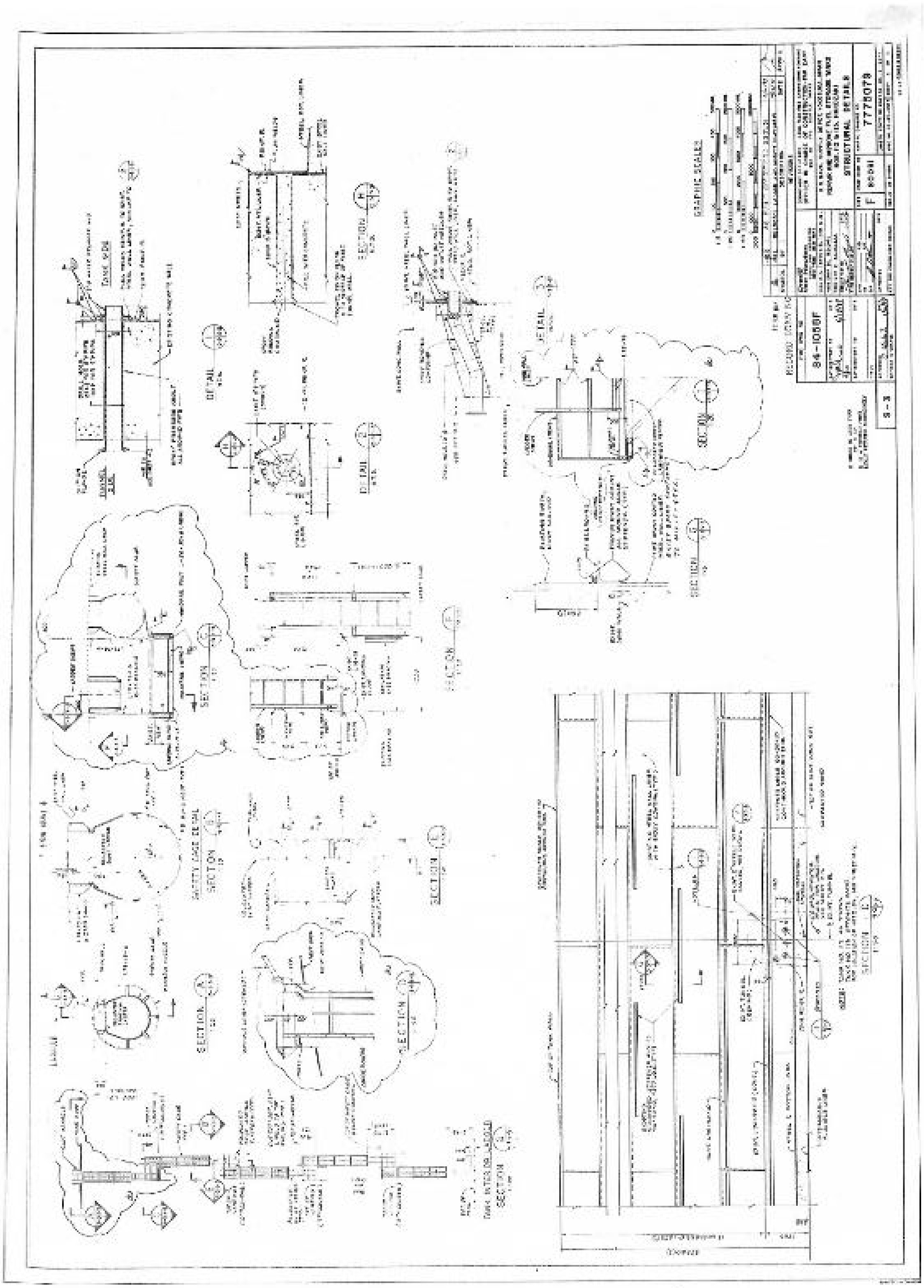
Tank 112 Valves

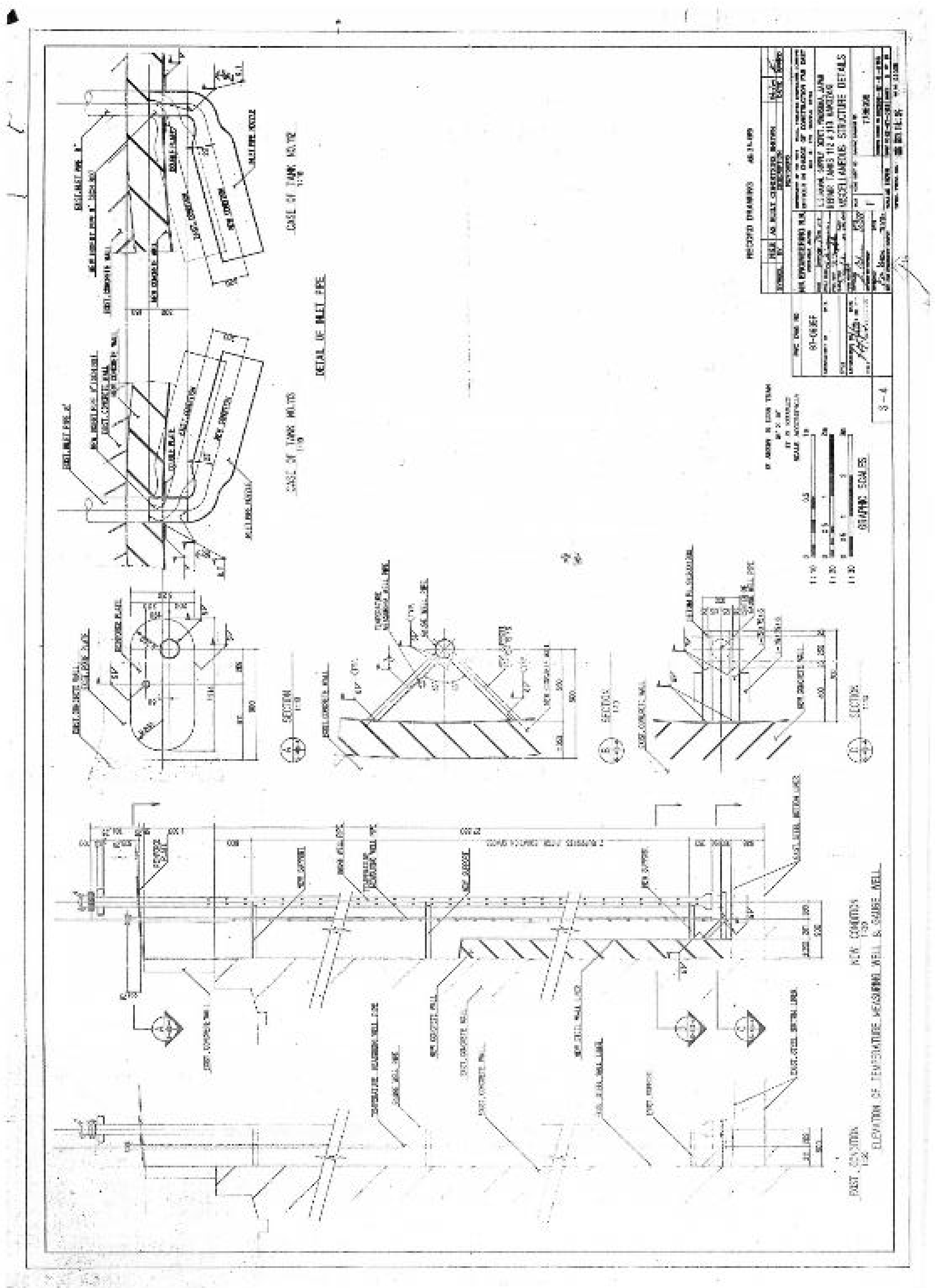

JP-5
113
RELOCATE PSV LOOP
INSTALL HLV
RELOCATE FLEX
CONNECTION
T-113-1
T-113-2
T-113-3
J-38-5
JP-5
J-38
J-38-6


161

Tank 113 – Tank Top

Tank 113 Valves




DETAIL OF INLET PIPE
GRAPHIC SCALES
NEW CONDITION
EXIST. CONDITION
ELEVATION OF TEMPERATURE MEASURING WELL & GAUGE WELL

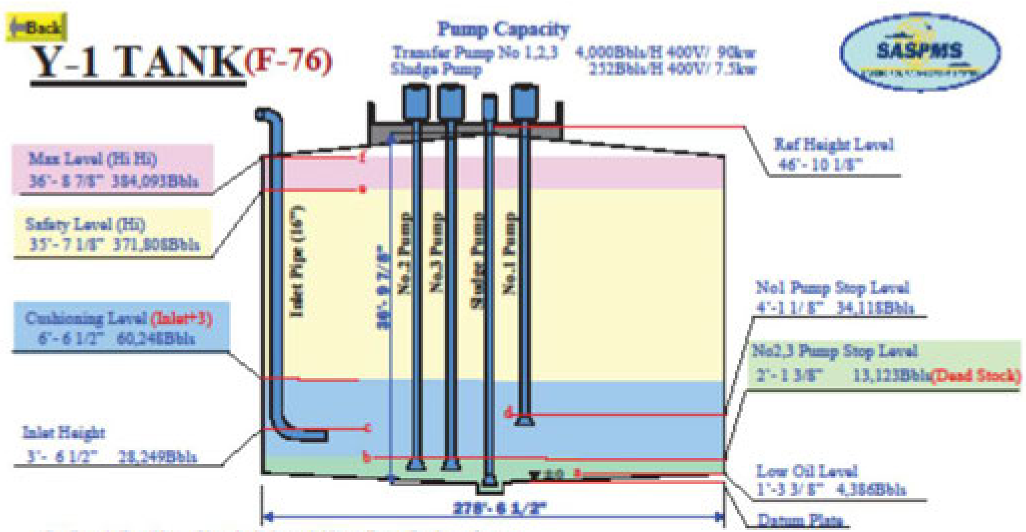
5.0 YOKOSE – TANK WITHIN A TANK

Data for each of the Yokose Y-Series tanks is detailed in their respective sections below. Availability of data varies for each tank; all applicable specifics readily available are included.

5.1. Tank Y-1

Tank Y-1 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1984 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The tank is 278'-6" in diameter and 36'-9" high and is of welded construction with butt-welded shell plates and lap-welded floor plates. The nominal shell capacity is 372,000 BBLS. The tank is currently in F-76 service.

Tank Y-1 Elevation View – West Side

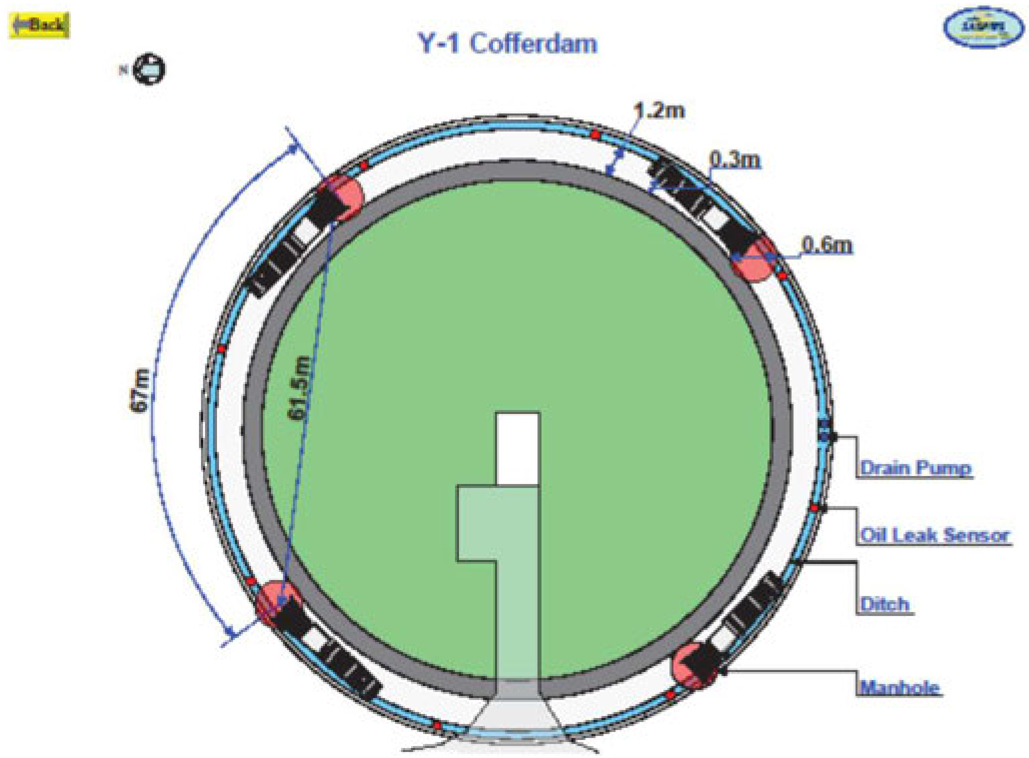


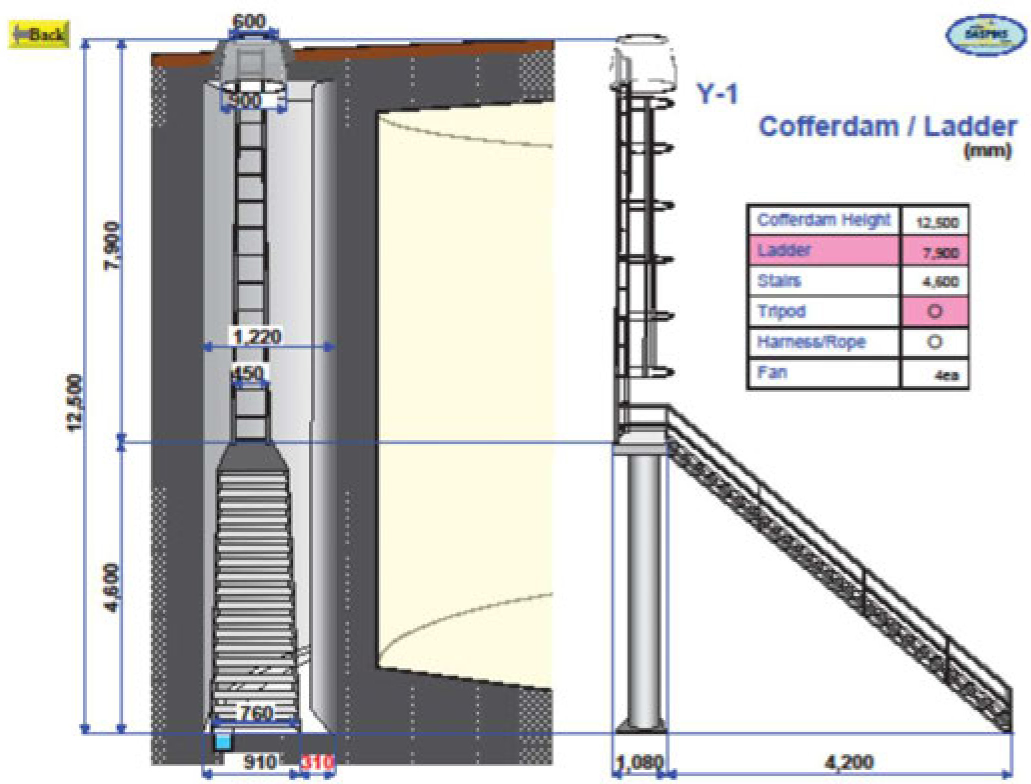
Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 3 3/8"		1'-6 3/4"	1'- 8 3/8"	
b	No2,3 Pump Stop Level	2'- 1 3/8"		2'- 1 3/4"	2'- 2 1/16"	
c	Inlet Pipe Level	3'- 6 1/2"		3'- 5 1/2"	3'- 2 3/4"	
d	No1 Pump Stop Level	4'- 1 1/8"		4'- 6 1/2"	4'- 2 11/16"	
e	High Level	35'- 7 1/8"	35'- 6 1/2"			34'-11 3/4"
f	High High Level	36'- 8 7/8"	36'- 8 1/4"			36'- 1 7/8"

For cushioning
60,248Bbls ÷ 2,685Bbls/H = 22.5Hrs

For Emptying
13,123Bbls ÷ 252Bbls/H = 52Hrs


Back
Y-1 Cofferdam
1.2m
0.3m
0.6m
67m
61.5m
Drain Pump
Oil Leak Sensor
Ditch
Manhole


Back
600
900
7,900
12,500
1,220
450
4,600
760
910
310
Y-1
Cofferdam / Ladder
(mm)
Cofferdam Height 12,500
Ladder 7,900
Stairs 4,600
Tripod O
Harness/Rope O
Fan 4ea
1,080
4,200

Exterior of Tank Y-1 – Tank Top

Tank Y-1 Elevation View – East Side

Exhaust Fan Serving to Ventilate the Gallery (Typical of 8)

Access Manway to Gallery (Typical of 4)

Ladder and Stair Access into Gallery Space (Typical of 4)
(Note: Original tank barrel is on the left side; tank shell is on right)

Gallery Space: Tank Barrel on Right; Gallery Exterior Wall (Cofferdam) on Left; Ceiling Above

Gallery Space
Note: Tank shell is on the left side; original tank barrel is on the right; floor on the bottom

Gallery Space Sump Pump (Typical of 8)
Note: This location is the gallery low point and main sump pump; original tank barrel is on the right

5.2. Tank Y-2

Tank Y-2 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1985 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The tank is 278'-6" in diameter and 36'-9" high and is of welded construction with butt-welded shell plates and lap-welded floor plates. The nominal shell capacity is 372,000 BBLS. The tank is currently in F-76 service.

Much of the data provided in this section was extracted from an EEI project in 2005 titled Tank Y-2 Leak Location and API 653 Inspection, Yokose Terminal, Sasebo, Japan, EEI Project No. 05-3941.30. The Final Report was dated December 2005. The primary goal of this project was to locate a reported release and identify the repair method. An additional goal was to evaluate the leak and determine if the leak was related to the design or the tank or other cause. The project also included a baseline API 653 inspections and evaluation of the entire tank.

Tank Y-2 Elevation View – Tank Top

Back

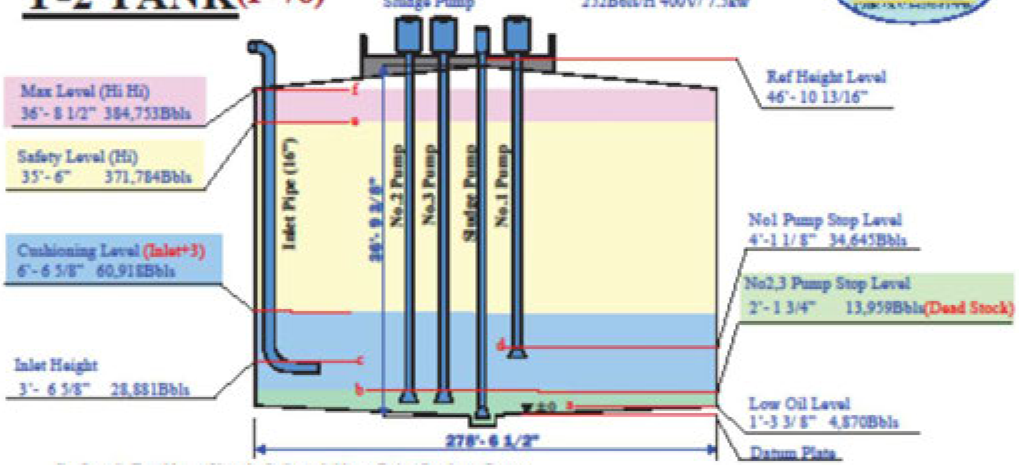
Y-2 F-76

Shell Capacity: 402,963Bbls
Safety Capacity: 371,784Bbls
Date Built: Apr'85
Type of Tank: Under Ground Conc. &Steel Lining
History of Tank Cleaning: Oct'05
History of API Inspection: Nov'05
History of Tank Tightness Test: Sep;10

Back

Y-2 TANK (F-76)

Pump Capacity
Transfer Pump No 1,2,3 4,000Bbls/H 400V/ 90kw
Sludge Pump 252Bbls/H 400V/ 7.5kw

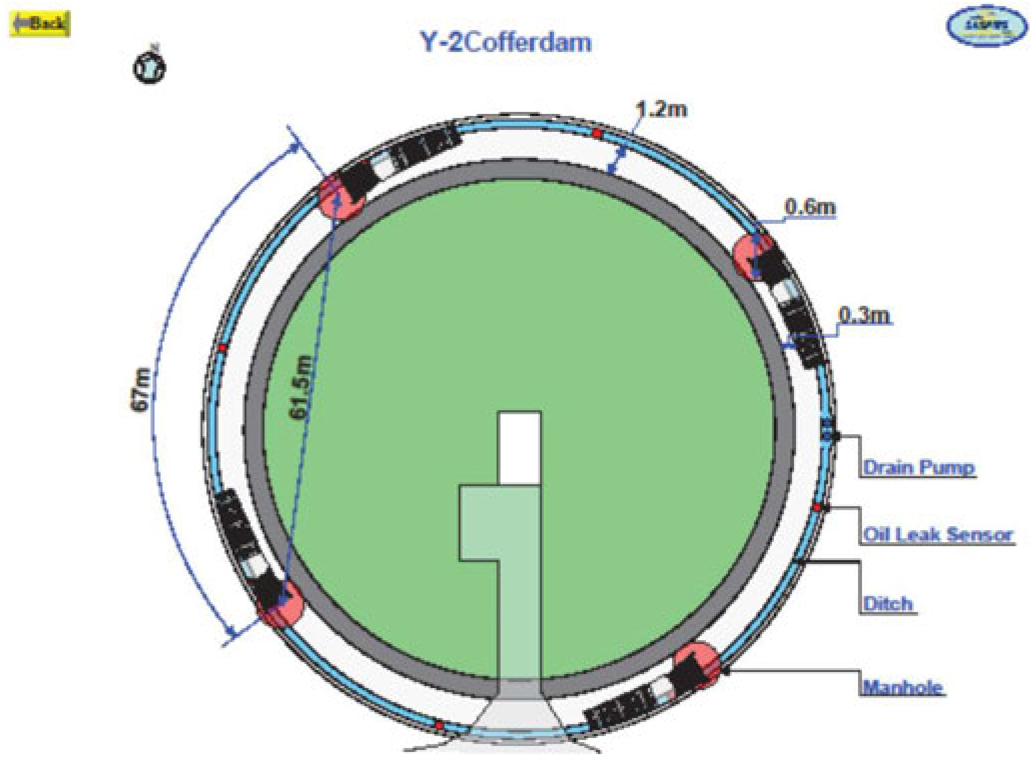


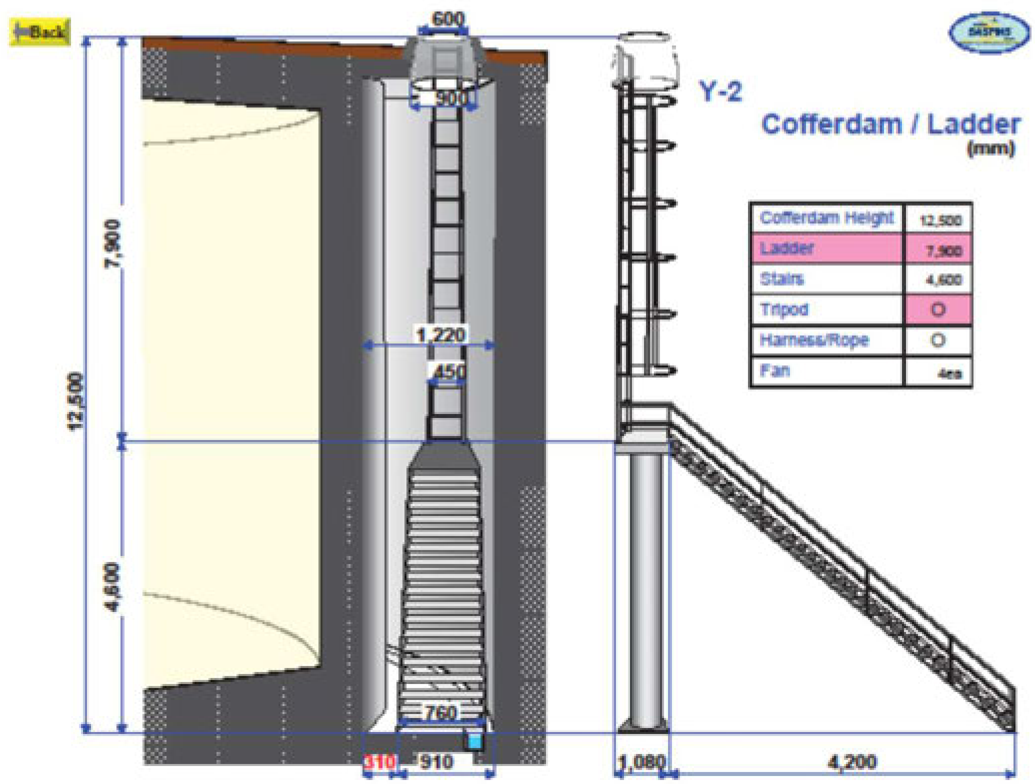
Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 3 3/8"		2'- 4 3/8"	1'- 5 1/4"	
b	No2,3 Pump Stop Level	2'- 1 3/4"		3'- 3 1/4"	2'- 5 1/16"	
c	Inlet Pipe Level	3'- 6 5/8"		3'- 7"	2'- 5 1/16"	
d	No1 Pump Stop Level	4'- 1 1/8"		5'- 2 1/4"	4'- 3 3/4"	
e	High Level	35'- 6"	35'- 6 5/8"			34'-9 3/4"
f	High High Level	36'- 8 1/2"	36'- 8 1/2"			36'- 1"

For cushioning
60,918Bbls ÷ 2,685Bbls/H = 22.5Hrs

For Emptying
13,959Bbls ÷ 252Bbls/H = 55.5Hrs

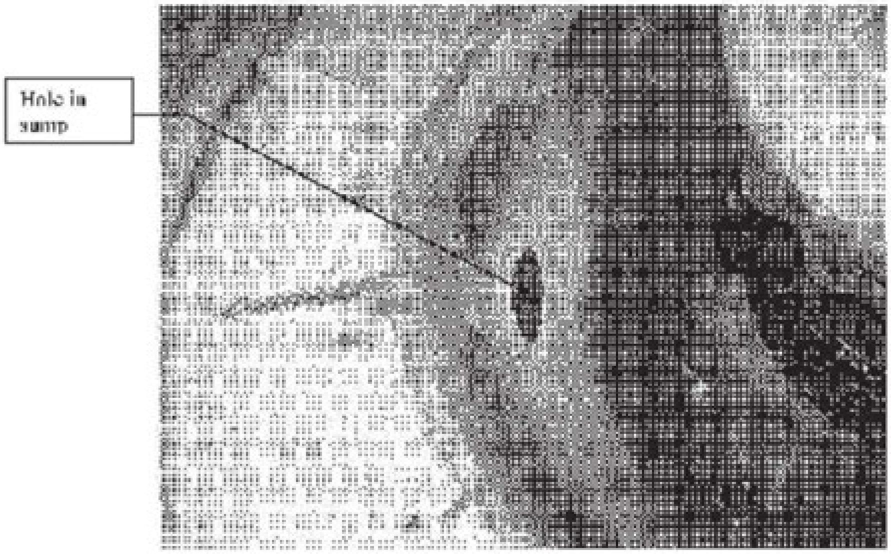




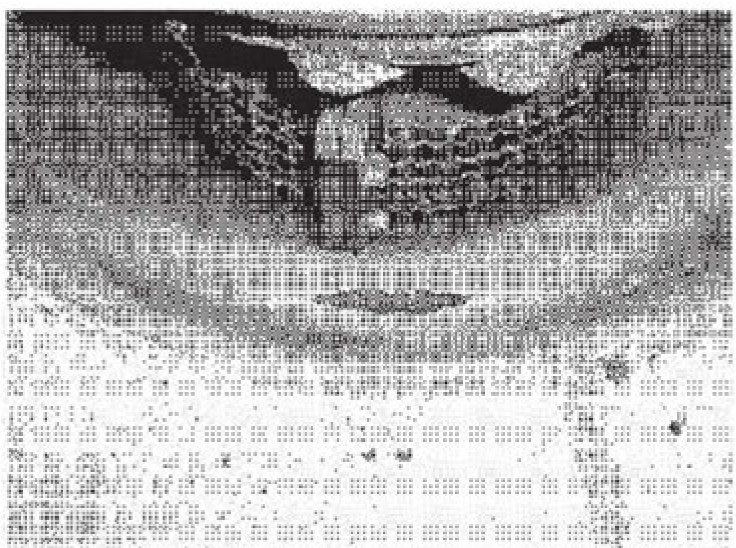
Cofferdam Height	12,500
Ladder	7,900
Stairs	4,600
Tripod	O
Harness/Rope	O
Fan	4ea

Exterior of Tank Y-2 – East Side

Exterior of Tank Y-2 – North Side



Wear Area and Hole in Sump



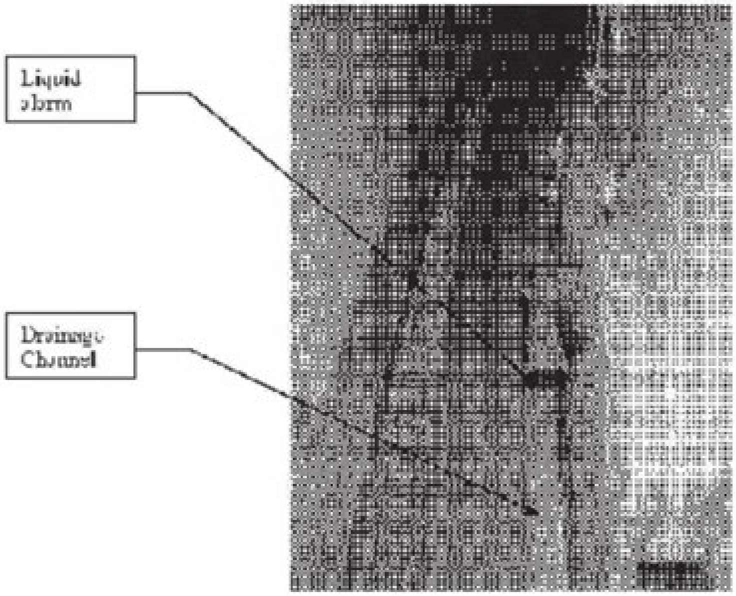
Wear Area in Sump

Sump Pump

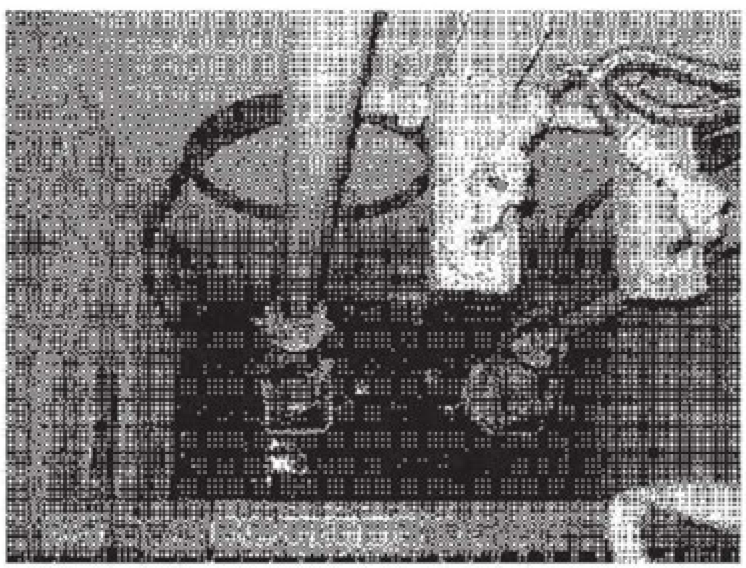
Wear Hole in Sump

Closeup of Hole in Sump

Hole in Sump



Drainage Channel and Liquid Alarm

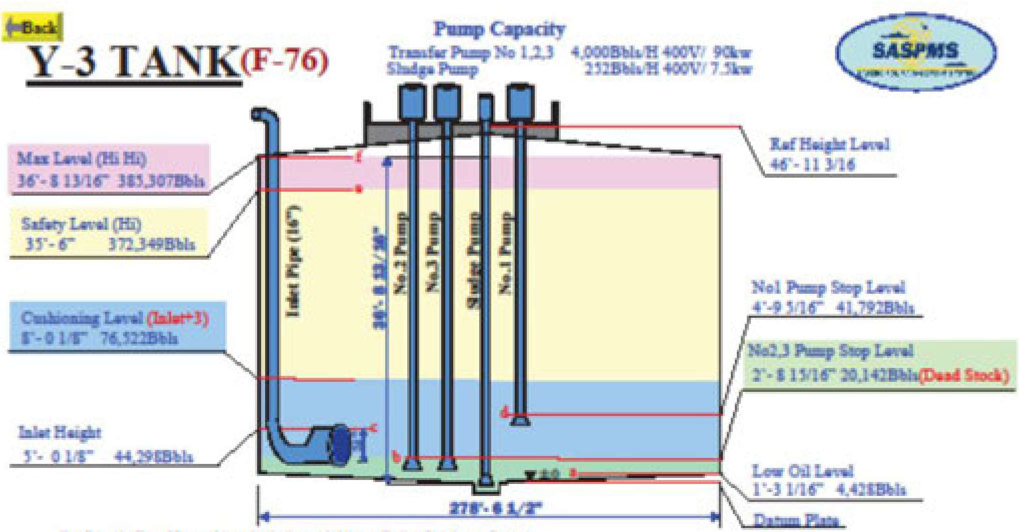


Cofferdam Sump and Sump Pumps

5.3. Tank Y-3

Tank Y-3 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1988 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The tank is 278'-6" in diameter and 36'-9" high and is of welded construction with butt-welded shell plates and lap-welded floor plates. The nominal shell capacity is 372,500 BBLS. The tank is currently in F-76 service.

Exterior of Tank Y-3 – South Side

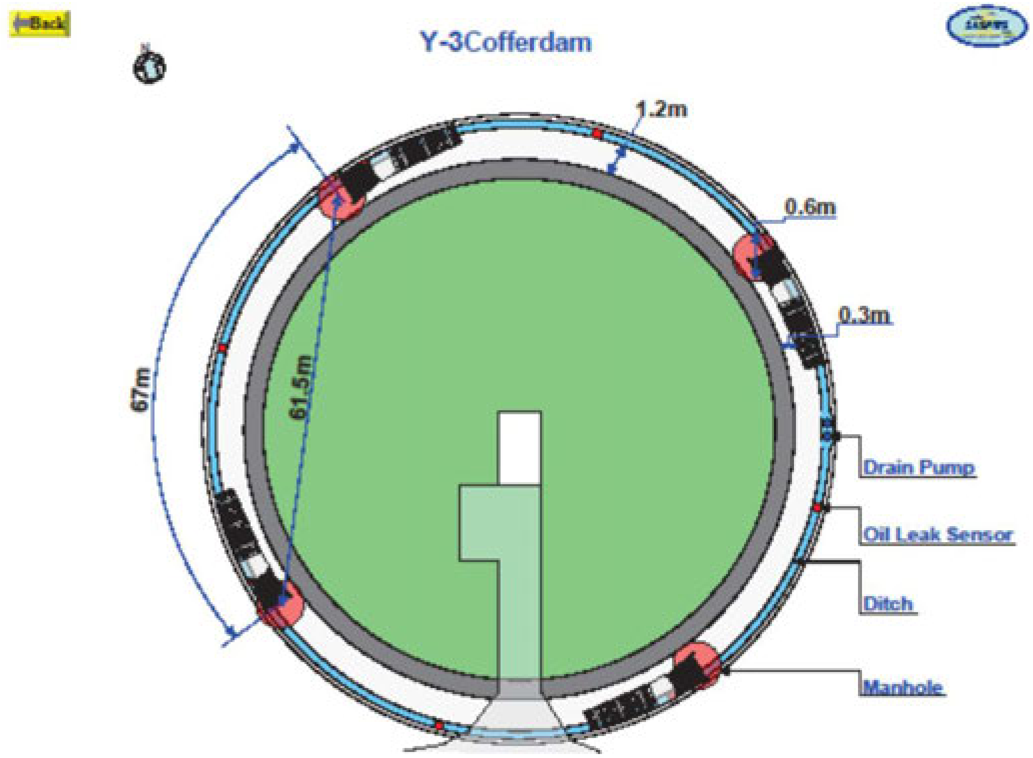


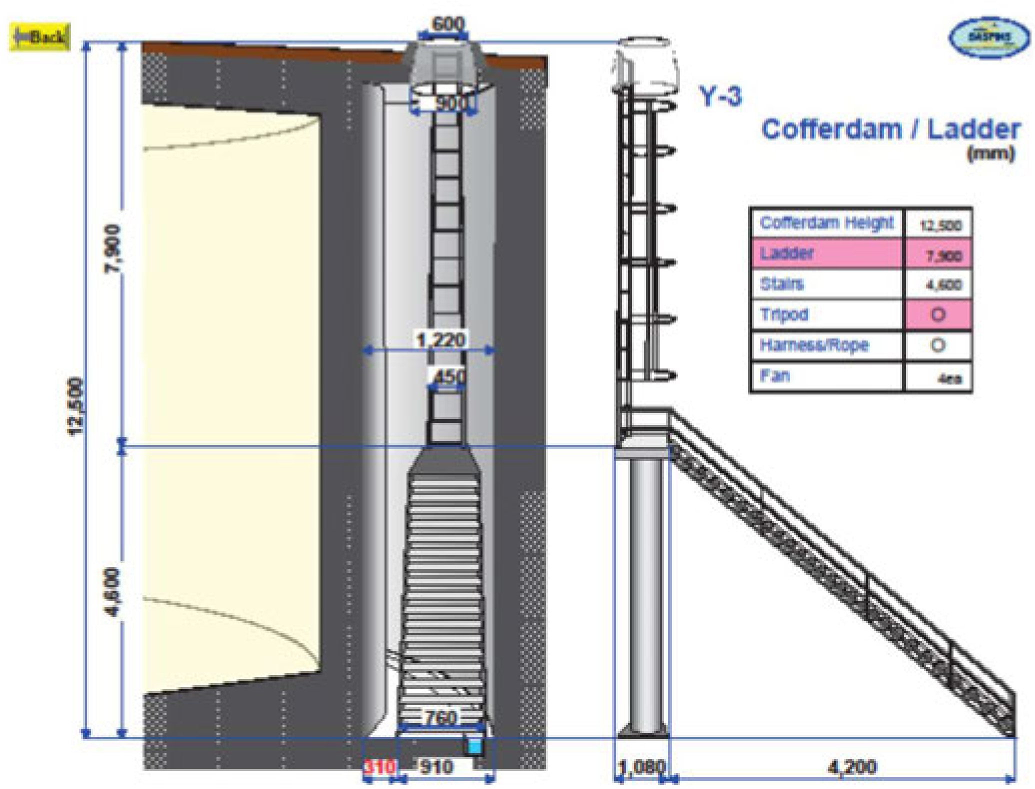
Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 3 1/16"		2'- 5 1/8"	1'- 4 1/4"	
b	No2,3 Pump Stop Level	2'- 8 15/16"		3'- 5 1/2"	2'- 10 3/16"	
c	Inlet Pipe Level	4'- 4 1/8"		4'- 3 5/8"	3'- 4 7/8"	
d	No1 Pump Stop Level	4'- 9 5/16"		5'- 10 15/16"	4'- 7 7/8"	
e	High Level	35'- 6"	35'- 9 1/16"			35'-2"
f	High High Level	36'- 8 13/16"	36'- 8 1/2"			36'- 2"

For cushioning
76,522Bbls ÷ 6,042Bbls/H = 12.5Hrs

For Emptying
20,142Bbls ÷ 252Bbls/H = 80Hrs


Back
Y-3Cofferdam
1.2m
0.6m
0.3m
67m
61.5m
Drain Pump
Oil Leak Sensor
Ditch
Manhole


Back
Y-3
Cofferdam / Ladder
(mm)
600
900
1,220
450
760
310
910
7,900
12,500
4,600
1,080
4,200
Cofferdam Height 12,500
Ladder 7,900
Stairs 4,600
Tripod O
Harness/Rope O
Fan 4ea

Exterior of Tank Y-3 – East Side

Exhaust Fan Serving to Ventilate the Gallery (Typical of 8)

Access Manway to Gallery (Typical of 4)

Ladder and Stair Access in Gallery Space (Typical of 4)
Note: Original tank barrel is on the right side; tank shell is on left.

Gallery Ventilation Ductwork - Tank Barrel on Right, Gallery Exterior Wall (Cofferdam) on Left

Oil Leak Detection Alarm in Gallery Space

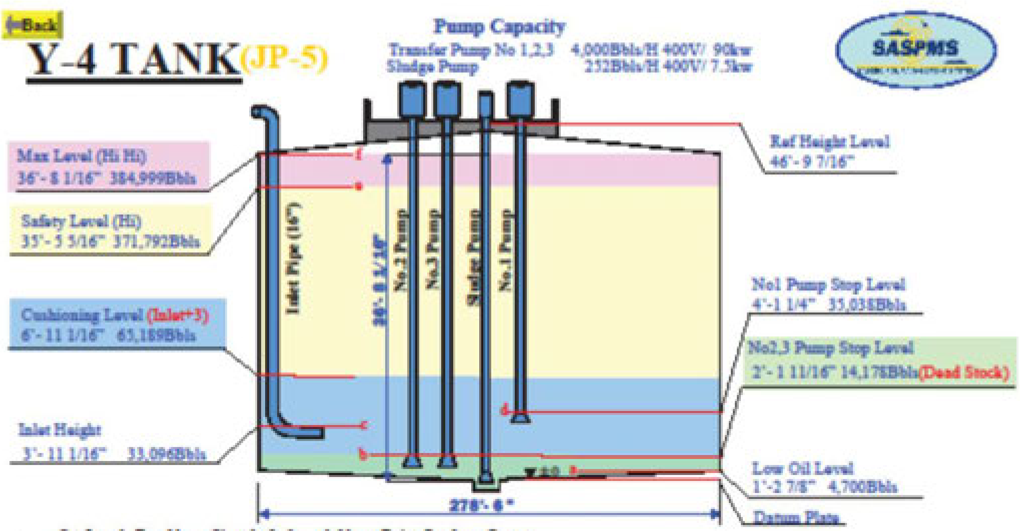
Drainage Slots Below Tank Floor
Note: Slots exit to gallery trough

Gallery Space Sump Pump
Note: This location is the gallery low point and main sump pump

5.4. Tank Y-4

Tank Y-4 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1986 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The nominal tank diameter is 278'-6" and the height is 36'-8". It is of concrete construction with a steel liner made of butt-welded shell plates and lap-welded floor plates. The underside of the roof is exposed concrete. The tank floor is cone down with a center sump. The tank is not equipped with an internal floating pan (IFP). The nominal shell capacity is 372,000 Bbls. The tank is currently in JP-5 service.

Exterior of Tank Y-4 – Tank Top



Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 2 7/8"		3'- 1"	1'- 11 13/16"	
b	No2,3 Pump Stop Level	2'- 1 11/16"		3'- 10 3/16"	3'- 0 9/16"	
c	Inlet Pipe Level	3'- 11 1/16"		2'- 7"	1'- 11"	
d	No1 Pump Stop Level	4'- 1 1/4"		6'- 3 7/8"	4'- 11 5/8"	
e	High Level	35'- 5 5/16"	35'- 2 3/8"			34'-6 5/8"
f	High High Level	36'- 8 1/16"	36'- 5 7/8"			35'- 8"

For cushioning
65,189Bbls ÷ 2,685Bbls/H = 24.5Hrs

For Emptying
14,178Bbls ÷ 252Bbls/H = 56Hrs

5.5. Tank Y-5

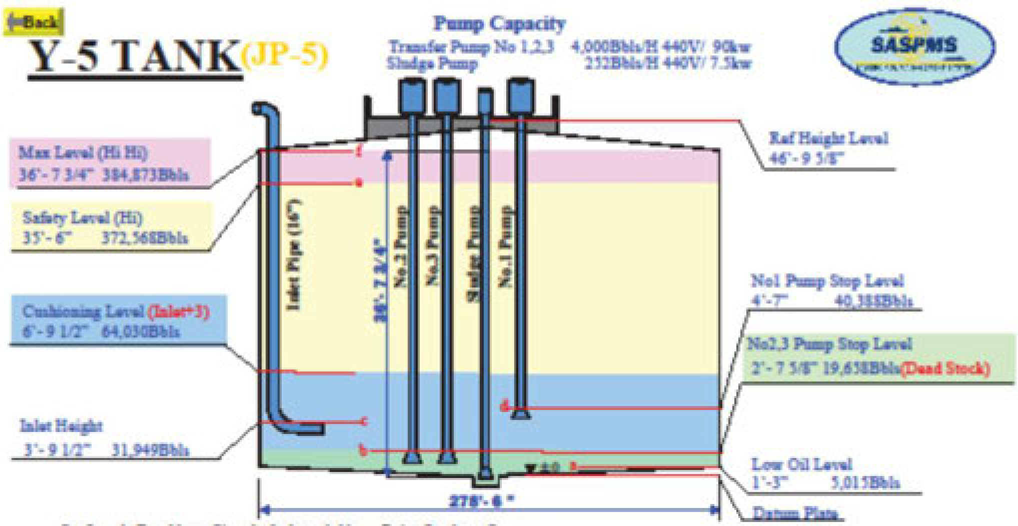
Tank Y-5 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1989 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The nominal tank diameter is 278'-6" and the height is 36'-8". It is of concrete construction with a steel liner made of butt-welded shell plates and lap-welded floor plates. The underside of the roof is exposed concrete. The tank floor is cone down with a center sump. The tank is not equipped with an internal floating pan (IFP). The nominal shell capacity is 373,000 Bbls. The tank is currently in JP-5 service.

Exterior of Tank Y-5 – Tank Top

Back

Y-5 JP-5

Shell Capacity: 402,963Bbls
Safety Capacity: 372,568Bbls
Date Built: May'89
Type of Tank: Under Ground Conc. &Steel Lining
History of Tank Cleaning: Aug'00
History of API Inspection:
History of Tank Tightness Test: Jul'10

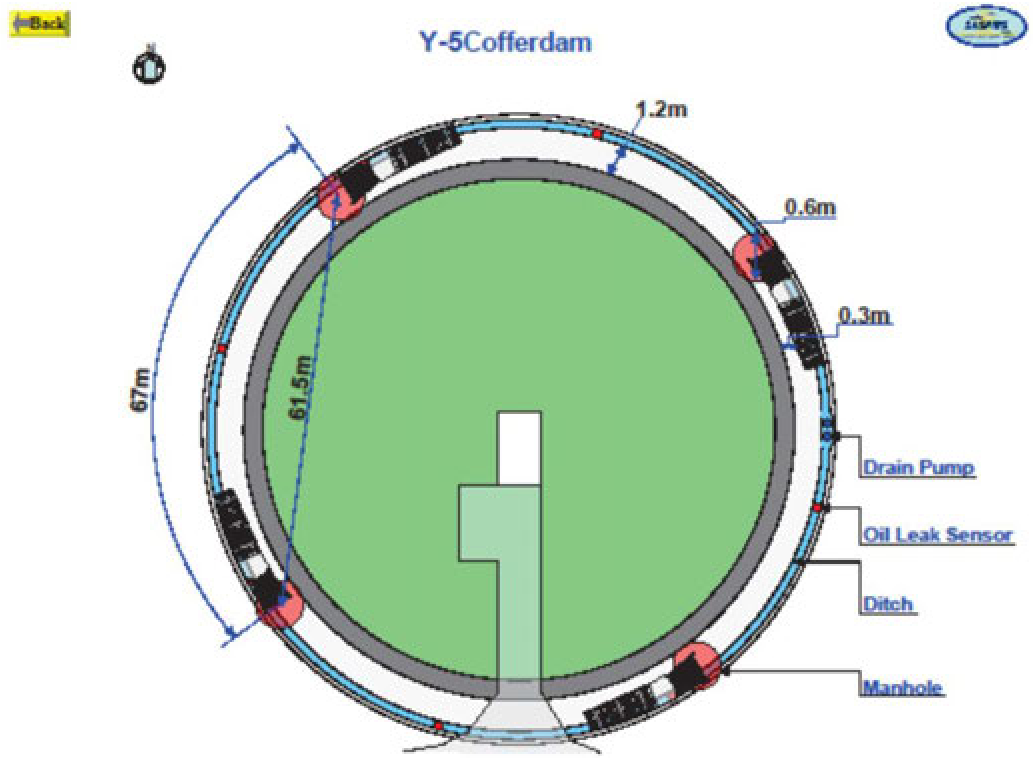


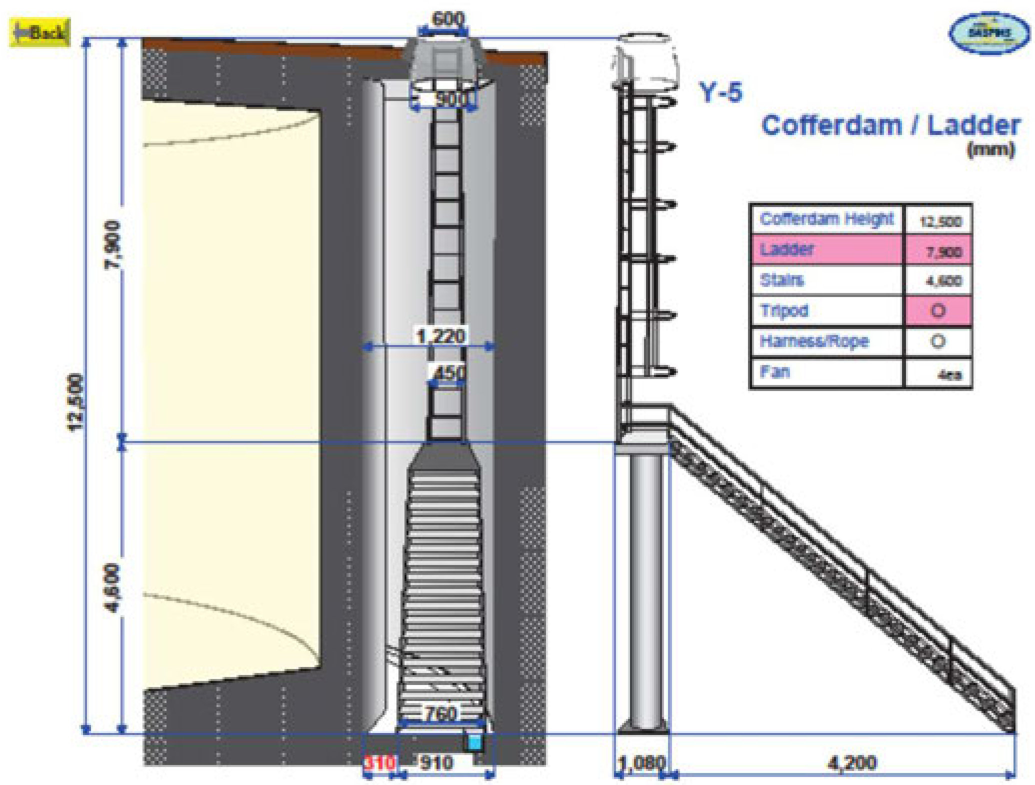
Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 3"		2'- 5 1/2"		
b	No2,3 Pump Stop Level	2'- 7 5/8"		3'- 7 7/8"	2'- 7 3/8"	
c	Inlet Pipe Level	3'- 9 1/2"		2'- 11 5/8"		
d	No1 Pump Stop Level	4'- 7"		6'- 1 1/4"	4'- 9 1/2"	
e	High Level	35'- 6"	34'- 10"			34'-2 1/2"
f	High High Level	36'- 7 3/4"	36'- 7 1/2"			35'- 11 7/8"

For cushioning
64,030Bbls ÷ 2,685Bbls/H = 24Hrs

For Emptying
19,658Bbls ÷ 252Bbls/H = 78Hrs

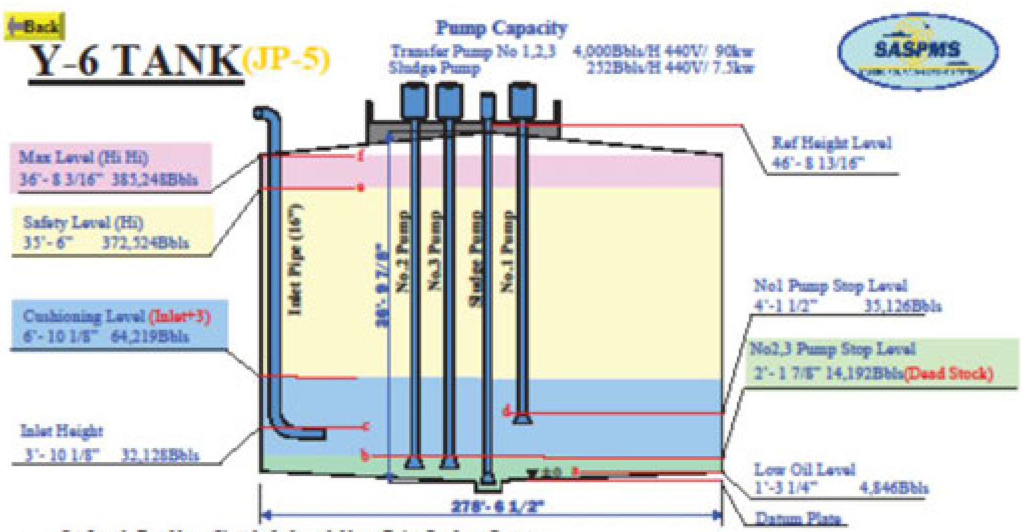

Back
Y-5Cofferdam
1.2m
0.6m
0.3m
67m
61.5m
Drain Pump
Oil Leak Sensor
Ditch
Manhole


Back
Y-5
Cofferdam / Ladder
(mm)
Cofferdam Height 12,500
Ladder 7,900
Stairs 4,600
Tripod O
Harness/Rope O
Fan 4ea
600
900
7,900
12,500
4,600
1,220
450
760
310
910
1,080
4,200

5.6. Tank Y-6

Tank Y-6 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1990 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The nominal tank diameter is 278'-6" and the height is 36'-10". It is of concrete construction with a steel liner made of butt-welded shell plates and lap-welded floor plates. The underside of the roof is exposed concrete. The tank floor is cone down with a center sump. The tank is not equipped with an internal floating pan (IFP). The nominal shell capacity is 373,000 Bbls. The tank is currently in JP-5 service.

Exterior of Tank Y-6 – Tank Top

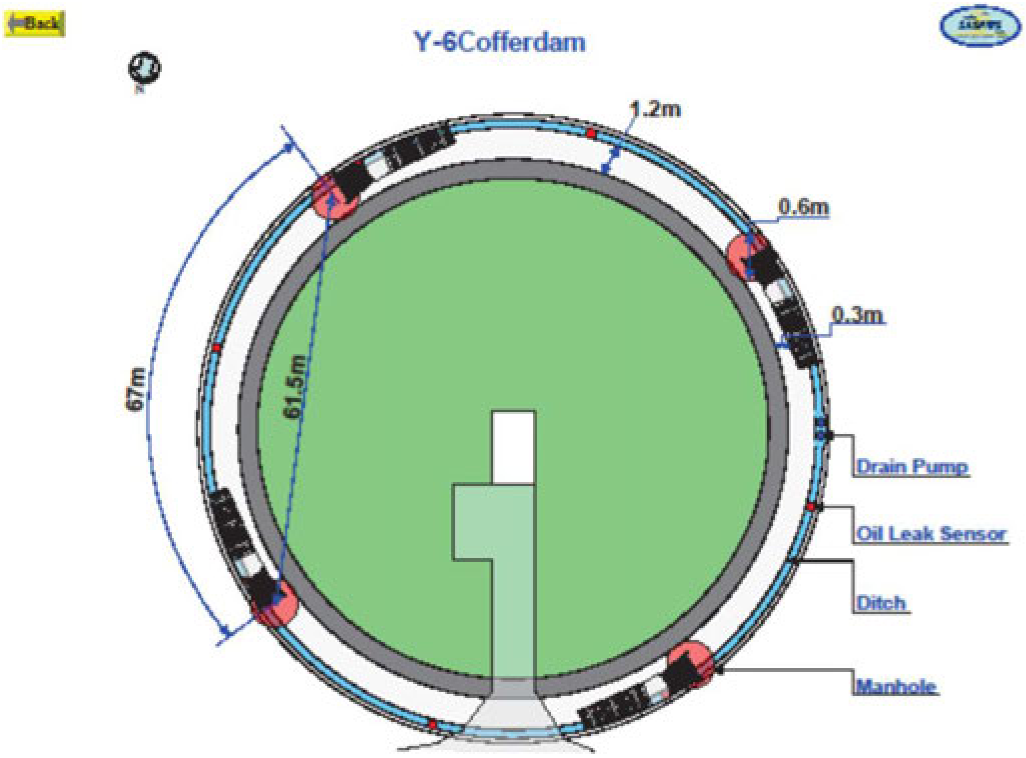


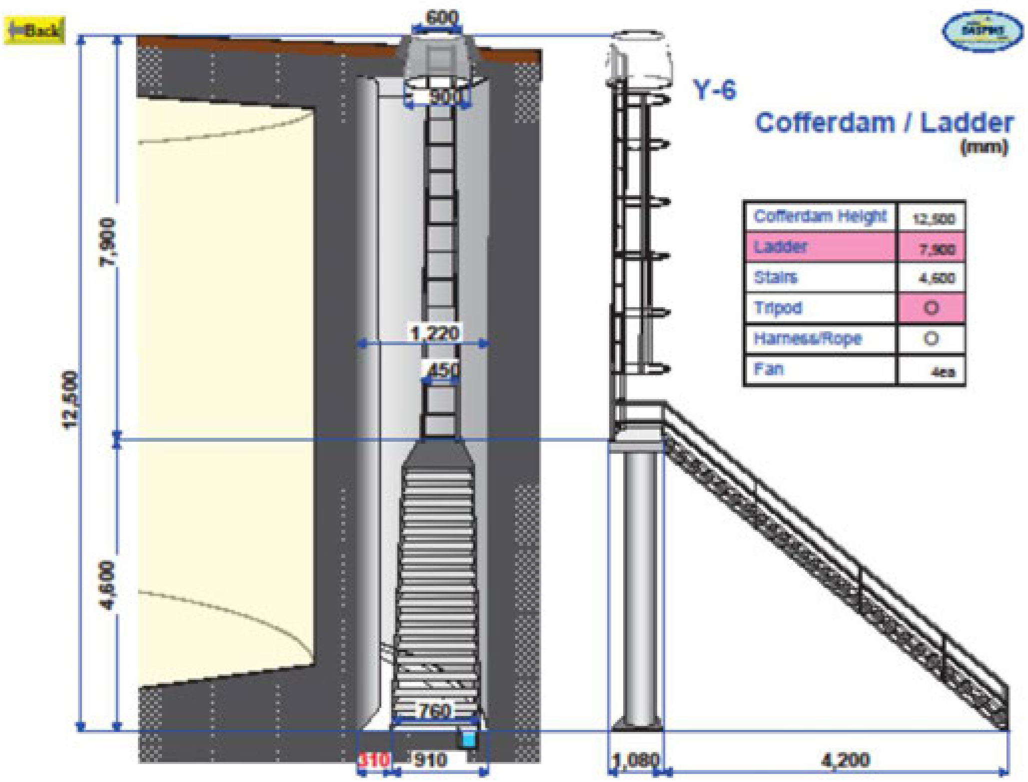
Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 3 1/4"		2'- 6"	1'- 3 1/8"	
b	No2,3 Pump Stop Level	2'- 1 7/8"		3'- 7 1/16"	2'- 5 1/8"	
c	Inlet Pipe Level	3'- 10 1/8"		4'- 1"	3'- 0"	
d	No1 Pump Stop Level	4'- 1 1/2"		5'- 5 5/16"	4'- 1 3/4"	
e	High Level	35'- 6"	35'- 5"			34'-9 3/4"
f	High High Level	36'- 8 3/16"	36'- 8 5/8"			36'- 2 3/8"

For cushioning
64,219Bbls ÷ 2,685Bbls/H = 24Hrs

For Emptying
14,192Bbls ÷ 252Bbls/H = 56Hrs

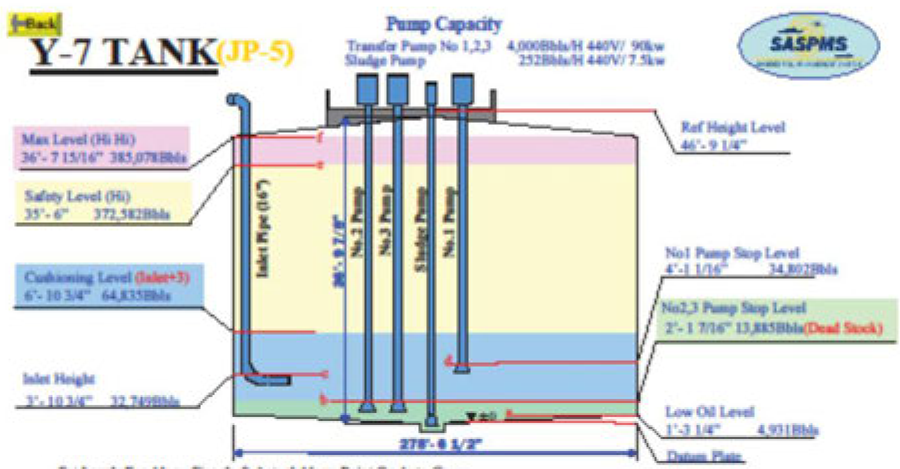

Back
Y-6Cofferdam
1.2m
0.6m
0.3m
67m
61.5m
Drain Pump
Oil Leak Sensor
Ditch
Manhole


Back
Y-6
Cofferdam / Ladder
(mm)
600
900
7,900
12,500
4,600
1,220
450
760
310
910
1,080
4,200
Cofferdam Height 12,500
Ladder 7,900
Stairs 4,600
Tripod O
Harness/Rope O
Fan 4ea

5.7. Tank Y-7

Tank Y-7 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in the 1920's by mining out the tank from the rock and placing reinforced concrete. The new reinforced concrete tank with steel lining was added inside the existing tank in 1991 by the Government of Japan. There is an accessible "gallery" space between the original tank shell and the new shell. The nominal tank diameter is 278'-6" and the height is 36'-10". It is of concrete construction with a steel liner made of butt-welded shell plates and lap-welded floor plates. The underside of the roof is exposed concrete. The tank floor is cone down with a center sump. The tank is not equipped with an internal floating pan (IFP). The nominal shell capacity is 373,000 Bbls. The tank is currently in JP-5 service.

Exterior of Tank Y-7 – West Elevation

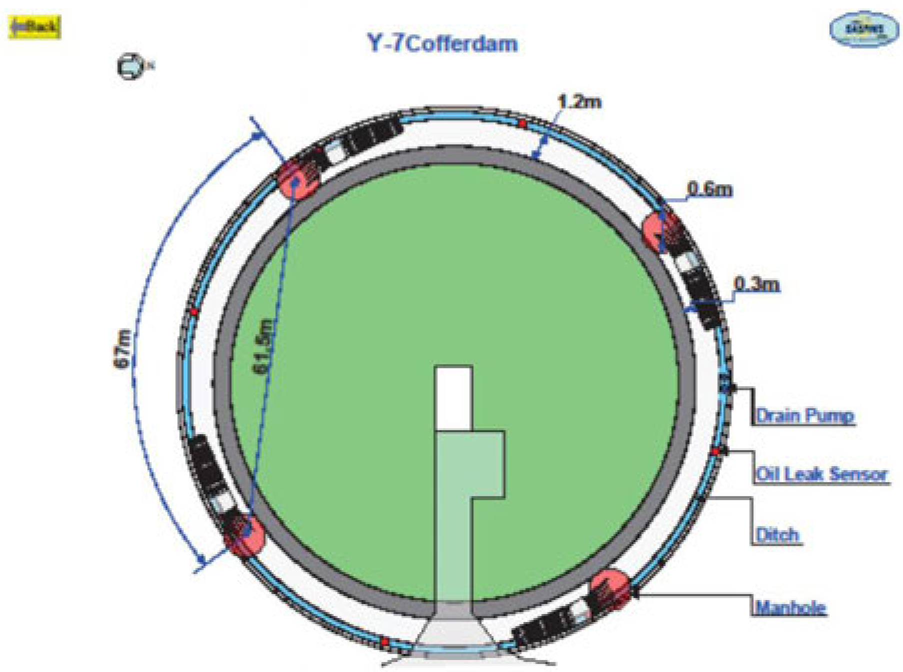


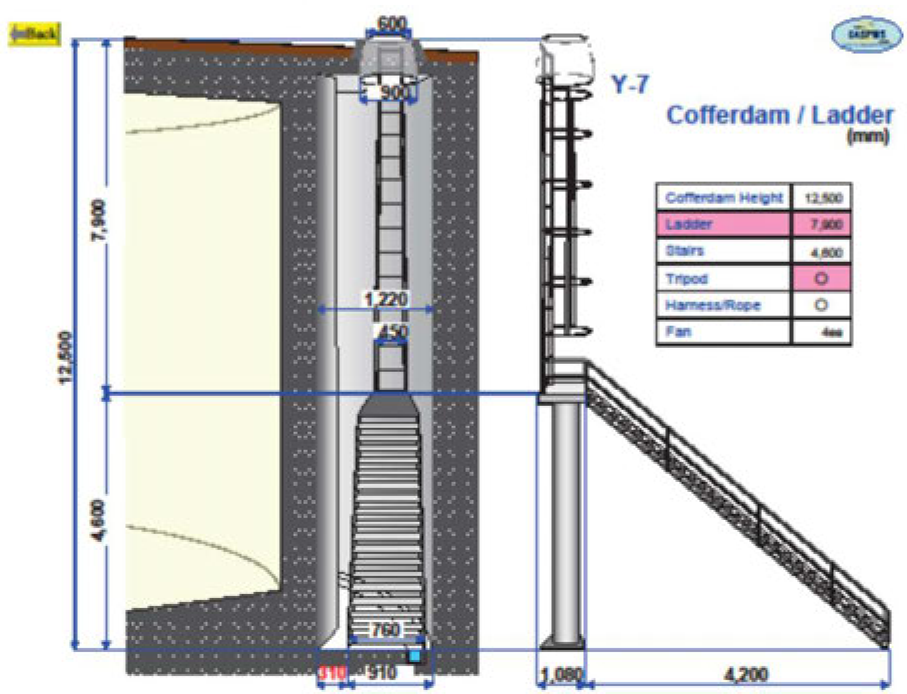
Set Levels For Alarm Signals & Actual Alarm Point On Auto Gauge

		Set Level	Filling		Discharging	
			Lamp On	Lamp Off	Lamp On	Lamp Off
a	Low Oil Level	1'- 3 1/4"		2'- 1 1/2"	1'- 3 1/8"	
b	No2,3 Pump Stop Level	2'- 1 7/16"		2'- 9 1/2"	2'- 1 3/4"	
c	Inlet Pipe Level	3'- 10 3/4"		3'- 10 9/16"	2'- 10 11/16"	
d	No1 Pump Stop Level	4'- 1 1/16"		5'- 2 1/8"	4'- 1 3/4"	
e	High Level (Safety)	35'- 6"				
f	High High Level (Maximum)	36'- 7 15/16"				36'- 0 3/4"

For cushioning
64,835Bbls ÷ 2,685Bbls/H = 24Hrs

For Emptying
13,885Bbls ÷ 252Bbls/H = 55Hrs

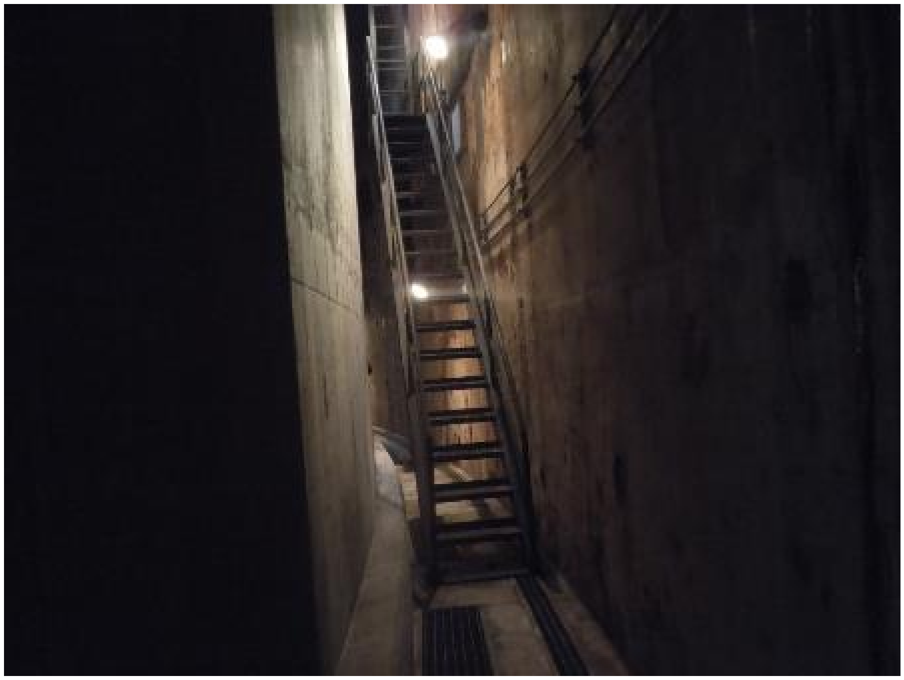




Cofferdam Height	12,500
Ladder	7,900
Stairs	4,600
Tripod	○
Harness/Rope	○
Fan	4ea

Exhaust Fan Serving to Ventilate Gallery (Typical of 8)

Access Manway to Gallery (Typical of 4)



Ladder and Stair Access in Gallery Space (Typical of 4)
Note: Original tank barrel is on the right side, tank shell is on left.

Gallery Space: Tank Barrel on Right, Gallery Exterior Wall (Cofferdam) on Left

Oil Leak Detection Alarm in Gallery Space, Drainage Slots Below Floor
Note: Floor grating removed for photo. Drainage slots exit to gallery trough.

Gallery Space Sump Pump
Note: This location is the gallery low point and main sump pump.

Gallery Ventilation Ductwork

Exterior of Tank Y-7 - East Elevation

Exterior of Tank Y-7 – South Elevation

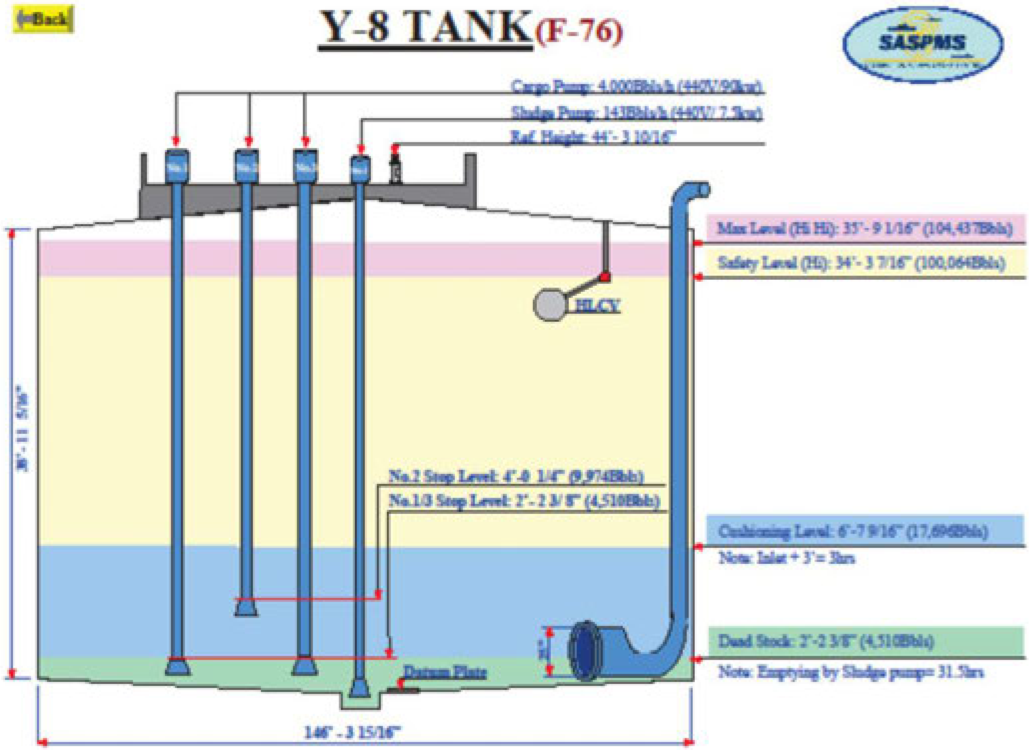
Exterior of Tank Y-7 – North Elevation

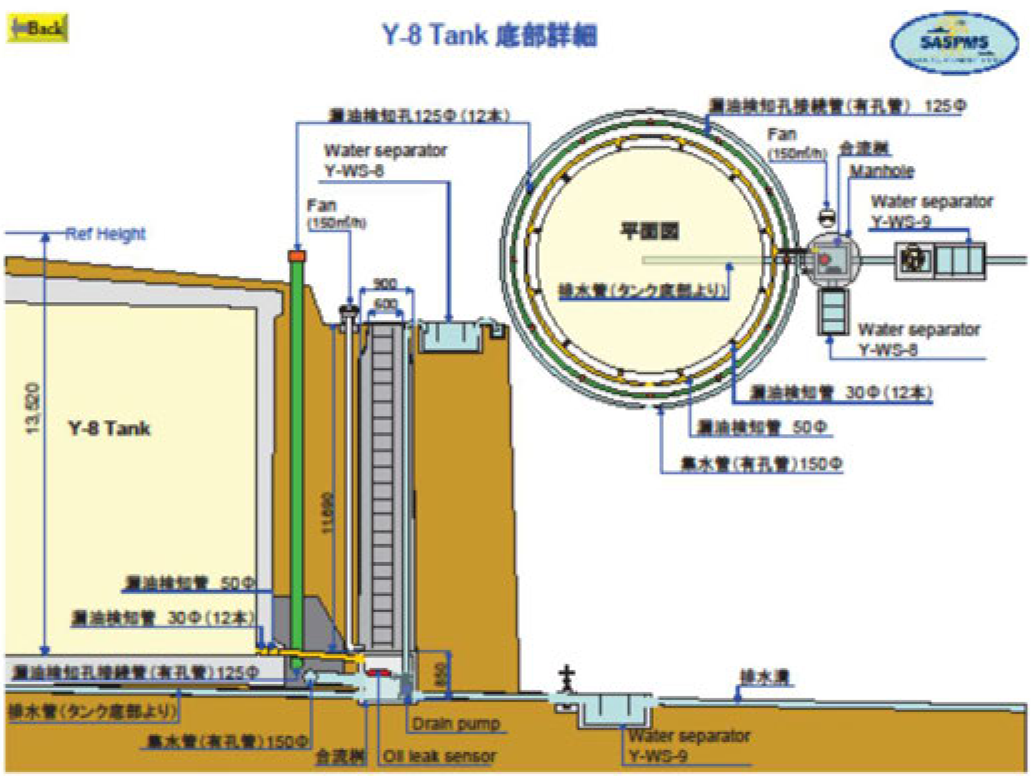
5.8. Tank Y-8

Tank Y-8 is an underground, steel-lined, concrete fuel storage tank. The tank was originally constructed in 1994. The inside diameter of the tank is 146’ and the height is 36’ high. The internal steel liner is of welded construction with butt-welded shell plates and butt-welded floor plates. There is no floating pan. The nominal shell capacity is 100,000 Bbls. and the tank is currently in F-76 service.

Exterior of Tank Y-8 – North Elevation


Back
Y-8 F-76
SASPMS
Shell Capacity: 121,811Bbls
Safety Capacity: 100,064Bbls
Date Built: May'94
Type of Tank: Under Ground Conc. &Steel Lining
History of Tank Cleaning: Jul'09
History of Tank Conversion: Nov'10(JP-5 to F-76)
History of API Inspection: Aug'09
History of Tank Tightness Test: Dec'07
TANK Y-8
F-76


Back
Y-8 TANK(F-76)
SASPMS
Cargo Pump: 4,000Bbls/h (440V/90kw)
Sludge Pump: 143Bbls/h (440V/ 7.5kw)
Ref. Height: 44'- 3 10/16"
Max Level (Hi Hi): 35'- 9 1/16" (104,437Bbls)
Safety Level (Hi): 34'- 3 7/16" (100,064Bbls)
HLCV
No.2 Stop Level: 4'-0 1/4" (9,974Bbls)
No.1/3 Stop Level: 2'- 2 3/8" (4,510Bbls)
Cushioning Level: 6'-7 9/16" (17,696Bbls)
Note: Inlet + 3'= 3hrs
Dead Stock: 2'-2 3/8" (4,510Bbls)
Note: Emptying by Sludge pump= 31.5hrs
Datum Plate
146' - 3 15/16"


Back
Y-8 Tank 底部詳細
SASPMS
漏油検知孔125Φ(12本)
Water separator
Y-WS-8
Fan
(150㎥/h)
Ref Height
900
600
13,520
Y-8 Tank
11,690
漏油検知管 50Φ
漏油検知管 30Φ(12本)
漏油検知孔接続管(有孔管)125Φ
排水管(タンク底部より)
集水管(有孔管)150Φ
合流桝
Oil leak sensor
Drain pump
650
Water separator
Y-WS-9
排水溝
漏油検知孔接続管(有孔管) 125Φ
Fan
(150㎥/h)
合流桝
Manhole
Water separator
Y-WS-9
平面図
排水管(タンク底部より)
Water separator
Y-WS-8
漏油検知管 30Φ(12本)
漏油検知管 50Φ
集水管(有孔管)150Φ

Exterior of Tank Y-8 – East Elevation

Exterior of Tank Y-8 – West Elevation

Exterior of Tank Y-8 – South Elevation

Fire (Foam) Injection Port (Typical of 4)