GENERAL DESTRUCTIVE TESTING STATEMENT OF WORK

23 December 2016

1.0 BACKGROUND

On December 9, 2013, the Navy placed one of the tanks (Tank No. 5) at the Red Hill Bulk Fuel Storage Facility back into service after it had undergone routine scheduled maintenance. The maintenance work consisted of cleaning, inspecting, repairing the tank, and certifying, by an API inspector, that it was suitable for service. Upon placing Tank No. 5 back into service, the Navy commenced filling the tank with JP-8 fuel. On January 13, 2014, Navy discovered a loss of fuel from Tank No. 5, immediately notified the State of Hawaii Department of Health (DOH) and the United States Environmental Protection Agency (EPA), and defueled the tank.

In response to the fuel release reported by the Navy, an Administrative Order on Consent (AOC) between the Navy, Defense Logistics Agency (DLA), EPA, and the DOH provides for the performance by the Navy and DLA of a release assessment, response(s) to release(s), and actions to minimize the threat of future releases in connection with the field-constructed bulk fuel underground storage tanks (USTs), at the Red Hill Bulk Fuel Storage Facility located near Pearl Harbor, on the island of Oahu in the State of Hawaii.

2.0 PURPOSE AND SCOPE

The purpose of the deliverables to be developed and work to be performed in accordance with AOC-SOW Section 5.3 is to verify the findings of the Corrosion and Metal Fatigue Practices Report through the use of destructive testing on at least one tank at the Facility.

2.1 AOC-SOW REQUIREMENT

Within ninety (90) days from the final Destructive Testing Scoping Meeting, Navy and DLA shall submit a Destructive Testing Scope of Work, including a plan for implementation and a proposed schedule, to the Regulatory Agencies for approval. The Scope of Work shall detail planned destructive testing to be conducted on at least one (1) tank at the Facility. Once approved by the Regulatory Agencies, Navy and DLA shall implement the Scope of Work in accordance with the approved schedule.

Within twenty-four (24) months from the Regulatory Agencies' approval of the Destructive Testing Scope of Work, Navy and DLA shall submit the Destructive Testing Results Report to the Regulatory Agencies for approval.

2.2 Goals and Desired Outcomes

The goals and desired outcomes of the efforts to be done under this section are to:

- Validate the results of Non-destructive examination (NDE) inspection technologies
- Characterize steel material
- Record observations/chemical characteristics of the concrete behind the liner
- Analyze corrosion rate calculation procedures and recommend improvements as warranted
- Evaluate results against current corrosion mitigation practices and recommendations for modifications/improvements to tank inspection, repair, and maintenance (TIRM) procedures and tank upgrade alternatives (TUA).

3.0 DESTRUCTIVE TESTING DISCUSSION

NDE is a variety of industry methods used to evaluate the condition of fuel storage tanks and pipelines. Technologies are used to scan plate steel and welds for indications as well as to quantify the size of indications and amount of metal loss. The intent of this section is to validate the results of NDE technologies used to scan Red Hill storage tanks. Assessing the reliability of the NDE technologies may eliminate the need for destructive testing on other tanks scheduled for TIRM.

The Navy desires to meet the requirements of the AOC and minimize the amount of destructive testing on operational fuel storage tanks. Each coupon removal and repair must be carefully considered. To this end there are several key decision points in determining the destructive testing process.

3.1 Tank Selection Rationale

As all parties desire this effort to be completed as soon as practicable, selection of the tank(s) to be tested is an important consideration. Different tanks will be out of service at different times, and tank selection must also consider the ability to complete the destructive testing and complete the Destructive Testing Report within the AOC specified timeframe. Navy and DLA operational requirements must also be considered. Figure 1 (flow chart superimposed on AOC timeline) presents tank selection options within the AOC timeline.

Tank 17 is proposed for the following reasons:

Pros:

- Tank 17 is out of service and NDE is scheduled to commence in early 2017. This presents the best alternative to comply with the AOC timeline with minimal impact to Navy and DLA operations.
- Tank 17 has previous NDE scan data. With planned scanning in near future, there will be two sets of scan data to work with.

Cons:

- None at this time for the purposes of this ACO-SOW Section 5.3 effort.

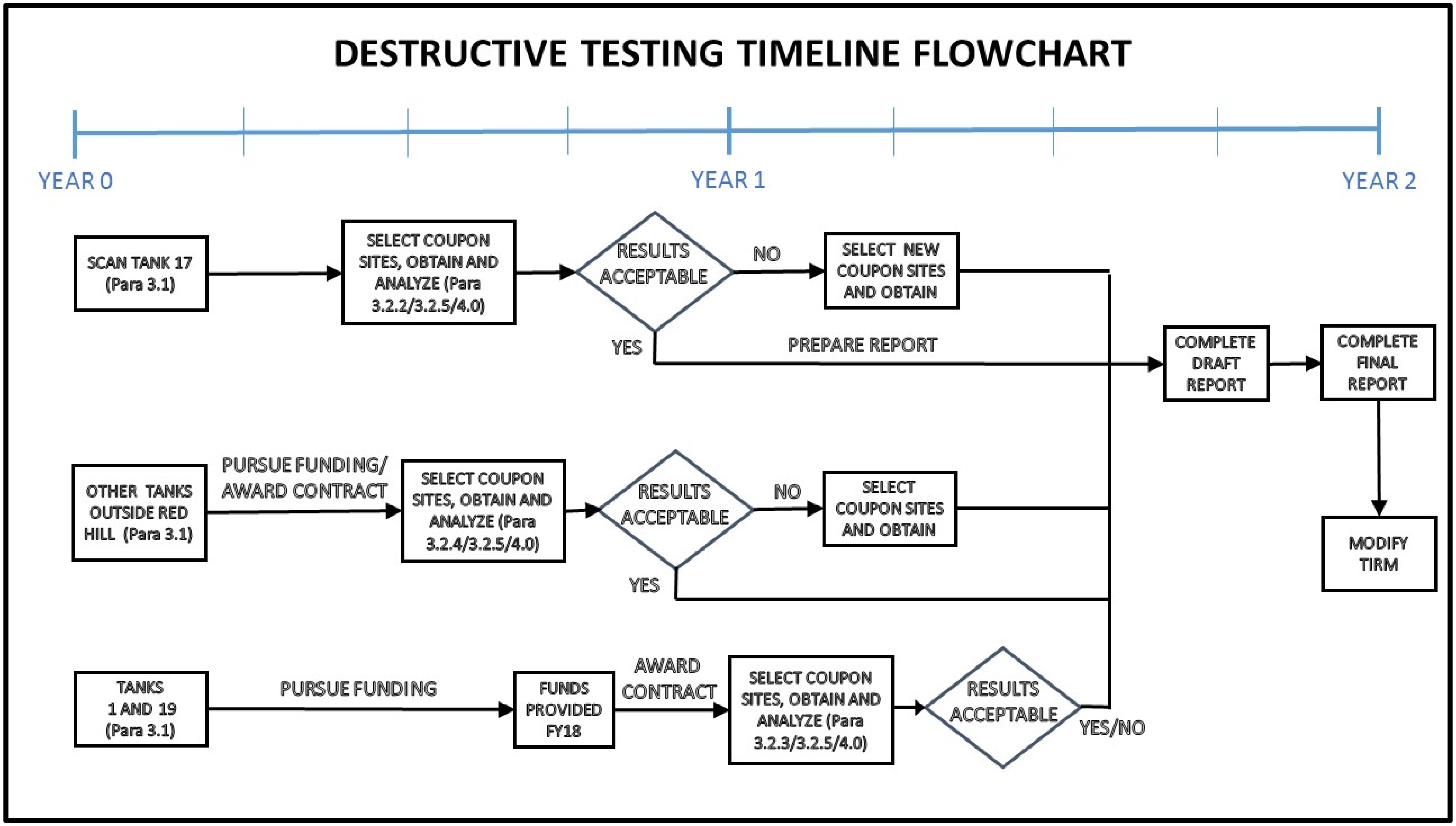

Figure 1. Destructive testing timeline and flowchart

If additional destructive testing is necessary based on the results of destructive testing in Tank 17, the current TIRM schedule identifies three other tanks which will be taken out of service shortly with a targeted return to service timeframe 2019. These tanks can be considered if the destructive testing can be completed in time to complete the Destructive Testing Report. Due to the size of these tanks as well as operational requirements, the process to empty, clean and prepare a tank for safe entry can take several months.

It has been suggested that destructive testing be conducted in Tank 5. While Tank 5 has been scanned and repaired and would also be favorable to meet the AOC timeline, further delays in placing this tank back into service would detrimentally impair the ability to take the next tank out of service for inspection and repair. In addition, any modifications to the tank will void warranties on the repairs done on this tank and the contractor's API inspector certification that the tank can be returned to service.

Tanks 1 and 19 are available for testing considerations with some caveats:

Pros:

- Tanks are permanently out of service.
- Very little impact to Navy and DLA operations.
- Do not need to scan the entire tank. Can conduct NDE scans on small sections then remove coupons to validate the NDE scans.

Cons:

- Because the tanks are permanently out of service, there is no operational budget for these tanks, and special funding will need to be requested to conduct the testing on these tanks. The process to obtain the funding will take time, and it may not be possible to complete testing within the timeframe required to be able to complete the Destructive Testing Report.
- The timeframe to enter, establish safe shell access, and conduct work in Tank 1 will be very lengthy. Refer to the ventilation, degassing, and confined space requirements in the TIRM Report.
- The conditions of the lattice tower inside Tank 1 are unknown, and there are no ventilation and lights.
- The timeframe to establish safe shell access in Tank 19 will be lengthy. Refer to the ventilation, degassing, and confined space requirements in the TIRM Report.

Consideration of Tanks 1 and 19 must be done in parallel with testing in Tank 17 in the event that the government budgeting process will not permit accomplishment within the AOC timeline.

In addition, other tanks in the Navy inventory are being considered. Tank bottoms of aboveground storage tanks are representative candidates to assess NDE reliability and can increase the size of the dataset.

3.2 Coupons for Testing

As previously indicated, the Navy desires to minimize the amount of destructive testing on operational fuel storage tanks required to meet the requirements of the AOC. To this end there are several key decision points in determining the destructive testing process. The quantity and size of coupons is somewhat dependent upon tank selection.

3.2.1 Coupon size

- Coupons need not all be the same size, and the size may be dependent upon the location and the NDE scans
- Navy desires to limit the size – minimize length of repair welds
- If a coupon is too large, the replacement plate must be rolled to match the curvature of the existing steel and handled with specialized rigging.
- TIRM report identifies a coupon size of 8 inches by 4 inches. Based upon initial findings, adjustment of the coupon quantities or sizes may be necessary.
- If repairs to any of the tanks are occurring during the timeline of the report, and the nature of the repair requires removal of the plate section, the removed section may be documented as a coupon. As indicated in the TIRM, some flaws deemed necessary to be repaired will typically be repaired by welding a patch plate over the area.

3.2.2 Quantity of coupons

Due to the huge surface area presented by the steel tank liner, acquiring sufficient number of samples for worthwhile statistical analysis of a particular tank's status and behavior with respect to corrosion (and fatigue) would be an inordinate task.

From a statistical standpoint, a sampling percentage of 1 – 10% of the total surface area of tankage has been suggested. With tankage surface areas of over 80,000 SF, one percent of the total area is about 800 SF which would be the equivalent of 50 coupons of size 4 feet by 4 feet. This large quantity and size of coupons suggested would require significant amounts of additional time beyond the typical TIRM schedule that would detrimentally impact the mission of the facility and the overall Navy/DLA desired timeline to inspect the rest of the Red Hill tanks and determine their condition. The TIRM Report describes, in detail, the numerous operational, physical, contractual, and tank inspection frequency constraints.

Clearly for the Red Hill Tanks, determination of the number and size of coupons must include good engineering judgement in combination with statistical methods to provide sufficient data for the planned statistical analysis. Rules of thumb are important because they promote discussion that facilitates the selection of an optimal sample size. Also, assumptions and many other considerations affect sample-size selection. These considerations include: sampling cost, purpose, approach, method, capturing a reasonable amount of data variation, the type of model being developed, the underlying data distribution—such as normal or exponential—and the type of statistical tools being used.

The Navy already does some amount of validation. Based on initial NDE scan results, prove-ups such as ultrasonic testing to verify/validate the scans is conducted before selecting defects for repair. This process also provides good confidence in the scanning process for defects. Therefore, examination and testing of a smaller number of samples of the shell from specific locations presenting the highest risk to corrosion is proposed.

Reliability sampling using the Bayes Success-Run Theorem (based on the binomial distribution) is one useful method that can be used to determine an appropriate risk-based sample size for process validations. The Bayes Success-Run Theorem is as follows:

$$R = (1-C)\ e^{(1/n)}$$

where: R = Reliability (margin of error or probability of success)
C = confidence level
n = sample size for "0" failures allowed on test

Transposed the formula becomes:

$$n = \ln(1-C)/\ln(R)$$

Most process validation studies allow for a 5 - 10% margin of error with a confidence level of 95%. For this Red Hill effort, use a margin of error of 5% and a confidence level of 95% and the minimum number of samples, n, will be:

$$\begin{aligned} n &= \ln(1-0.95)/\ln(0.95) \\ &= \ln(0.05)/\ln(0.95) \\ &= (-2.9957)/(-0.0513) \\ &= 59 \text{ say } 60 \text{ samples} \end{aligned}$$

What this means is assuming the incorrect NDE scan detection rate is actually 5%, and we take 60 samples, we will see at least one incorrect scan detection per each 60 sample set 95% of the time. Alternatively, if the samples taken indicate zero incorrect scan detections, this means we will incorrectly accept an incorrect scan detection less than 5% of the time.

The initial proposed location is Tank 17 which is anticipated to be out of service at the time required to comply with the AOC. Removal of at least five but no more than 12 coupons is planned. The size of the coupons will be 2 feet by 2 feet and will include a variety of characteristics (i.e. steel plate with internal/backside flaws, steel plate without flaws, and welded areas). Each coupon will be marked to 16 smaller 6-inch by 6-inch samples, each identified as to its location, to compare against the NDE scans. This will help remove any possible operator issues with the scan results being more a function of the equipment. Each set of five coupons would then be equivalent to 80 samples and would provide a slightly higher reliability of 96.3%. Twelve coupons would be equivalent to 192 samples and would provide a higher reliability of nearly 98.5%.

Locations for selection of coupons for testing will be based on data from previous/current visual and NDE inspections of the tank for selection of target areas based on reported reductions in wall thickness, corrosion, and cracking. Minimal amount of sampling is planned for the upper dome. Although the upper dome is scanned, repaired and pressure tested, current Navy operational procedure is to not fill the tanks into the upper dome.

The following is the planned process for selecting and testing coupons and samples:

- Review data from all previous inspections of the tanks for selection of target areas based on reported reductions in wall thickness, and corrosion. Consider locations of tank shell penetrations such as those of a tell-tale system piping and shell attachments to underlying ribbing deemed potential sites of localized corrosion (and fatigue). Also consider locations of surface irregularities, such as weldments which present metallurgical variants that can serve as sources of corrosion cells (and fatigue). Present coupon locations along with rationale for selection will be presented to the regulators for review and comment prior to actual sampling.
- Cut-out one coupon from the upper dome just above spring line.
- Cut-out two to four coupons from the barrel. Coupons will be from opposite sides of the Barrel, with at least one taken from the upper part of the Barrel and one from the lower part. The lower coupon shall be taken from just above a horizontal butt welded joint between the 19.6’ x 5.0’ shell plates.
- Cut-out one or two coupons from the lower dome. Coupons are to be taken from the sloping plate in the second course up from the flat bottom plate just above a horizontal butt welded joint.
- Cut-out one coupon from the lower dome (½” bottom plate.)
- Cut-out four additional coupons at random locations based upon NDE evaluations that include welds.
- Conduct prove-up testing at coupon/sample sites. Prove-up testing includes: Ultrasonic Testing and visual confirmation by American Society for Nondestructive Testing (ASNT) SNT-TC-1A Level II inspectors.
- Regulators have suggested that they should be invited to witness the testing. Safety is a top priority for the Navy with a goal of ZERO accidents/incidents. All observers must meet Navy security requirements and comply with Navy and contractor safety requirements (personal protective, safety training, etc.). In addition, due to the limited personnel baskets in the tanks, observers will only be able to witness the testing from the catwalk, not the basket.
- Coupons will be preserved in accordance with ASTM G1 when sending for laboratory analysis.
- If coupon analysis agrees with current NDE scans, end coupon sampling. Agreement between past and current NDE scans of areas not repaired after the past scans will demonstrate the repeatability of the NDE process and further confirm its accuracy and credibility. Future coupon sampling will be as indicated in the TIRM.
- If more than five samples exhibit significant difference to the findings of the

NDE, take five additional coupons from another tank (either Red Hill or a similar AST of approximately the same vintage) scheduled for inspection and repair.

3.2.3 Tanks 1 and 19

Concurrent with the testing of tank 17, the Navy will pursue funding and a contracting process to conduct testing and coupon sampling in Tanks 1 and 19. The entire tank need not be scanned, just large enough sections to allow removal of coupon of sufficient size to validate the NDE results. Identify five to ten sites and coupon sizes. This option is dependent upon the special funding being obtained in time to complete the testing within the AOC timeline of the Destructive Testing Report. In addition, due to its age and condition, establishing safe shell access, tower inspection and repairs, lighting, and ventilation, in Tank 1 may not be practicable, and testing may only be practicably done on the lower part of the lower dome. If this work can be executed within the AOC timeline, Regulators will be invited to review coupon site selection rationale, and witness the testing (must comply with all security and safety requirements). Except for maybe in the lower dome area, observers will only be able to witness the testing from the catwalk, not the basket.

3.2.4 Other Tanks Outside Red Hill

A highly recommended and more practicable option to Tanks 1 and 19, the Navy will pursue funding and a contracting process to conduct testing and coupon sampling in other tanks not located at Red Hill concurrent with the testing of Tank 17. The purpose of this alternative testing is to validate the results of the NDE per the goals of this AOC-SOW section, although the plates will not be representative of the condition of the Red Hill tanks. The intention is to validate the technology and calibration of the equipment is good not just for Red Hill tanks but other types of tanks constructed of different type of steels, further increasing confidence in the validity of the scanning process. This will also provide additional samples to those obtained from Tank 17 to add to the statistical analysis of the validity of the scanning process and its independence on a particular site. Regulators will be invited to witness the testing (must comply with all security and safety requirements).

3.2.5 Summary of Coupon Quantity, Size and Decision Process

The following bullets summarize the coupon sampling process. Figure 1 is a flow chart of the process.

- Tank 17
    - Conduct NDE (first quarter calendar year 2017). Invite Regulators to observe at agreed upon time.
    - Analyze data and select coupon sites (seek feedback from Regulators)
    - Obtain coupon samples. Invite Regulators to observe at agreed upon time. Conduct visual examinations and on-site testing.
    - Laboratory testing
    - Determination of additional coupons necessary in other tanks or

modifications required to the TIRM. Utilize Tanks 1 and 19 if special funding is obtained in time.

- Tanks 1 and 19
  - o Pursue special funding upon approval of the SOW.
  - o Conduct NDE (fourth quarter calendar year 2017 or first quarter calendar year 2018). Invite Regulators to observe at agreed upon time.
  - o Analyze data and select coupon sites (seek feedback from Regulators)
  - o Obtain coupon samples. Invite Regulators to observe at agreed upon time. Conduct examinations and testing to validate the NDE.
  - o Determination if additional sites/coupons necessary.

- Other Tanks Outside Red Hill
  - o Conduct NDE (second or third quarter calendar year 2017). Invite Regulators to observe at agreed upon time.
  - o Conduct examinations and testing to validate the NDE.

4.0 PROCEDURES AND TESTS

4.1 On-site investigations.

4.1.1 Characterization of the Exterior and Interior Steel Coupon

Table 1 is in the form of a field inspection data sheet that indicates the tests and observations required of the steel coupon. In addition, the Navy may pursue positive material identification by Optical Emission Spectroscopy as described in the TIRM Report.

4.1.2 Exterior Concrete Containment

Conduct the following procedures for evaluating the concrete containment immediately upon removal of coupon. Note the condition of the concrete.

- Observe/measure the void space between the concrete and the liner in the area surrounding the coupon site. Check to determine if the material behind the coupons taken from the lower dome is grout or concrete.

- Measure the temperature at the concrete/liner interface. Note the presence of moisture. Also measure pH of exposed medium (if wet).

- Measure the structure-to-electrolyte potential of the steel liner-to-concrete/exposed medium at several locations around the circumference of the coupon site.

Table 1. Characterization of Steel Coupon

COUPON SPECIFICS		
Coupon ID #		
Coupon Location		
Coupon Dimensions		
Coupon Thickness		
Locations of Welds (If Any)		
VISUAL EXAMINATION		
Checks	**Observations**	
	Exterior	Interior
Deposits, Coatings, Debris		
Scale		
Biological Materials		
Wet or Dry		
Smell		
Presence of Petroleum Product Between Steel and Concrete Surface, and on or Above the Leg of the Angle Backer Bar Embedded in the Concrete.		
Presence of Corrosion		
Isolated pitting		
Isolated pitting within areas of general corrosion		
Linked pitting within areas of general corrosion		
General metal loss with some deeper pits		
General metal loss with no pitting		
Selective attack at welds		
Pit surface and cross section morphology		
Severity of Corrosion		
Maximum wall loss		
Profile of wall loss		
Maximum/average pit depth		
Maximum/average pit diameter		
Pit length vs pit width		
Depth to diameter ratio		
Provide a photo of the coupon		
Provide a sketch of the coupon showing the size and any indications. Provide ID#s for all indications on coupon		

- Measure concrete bulk resistivity (or conductivity), pH, and moisture content at the liner/concrete interface. Table 2 is in the form of a field inspection data sheet that indicates the tests and observations required of the concrete. Take 2-inch diameter by 3-inches deep cores of concrete at three locations to aid in measurement of these characteristics. Anticipated sites are one each from opposite sides of the barrel, and one from the lower dome. If rebar is encountered at depths less than three inches, do not continue coring. It is not necessary to obtain the core in one intact piece, as long as the depth of the core sections are known. The intent is to obtain powder samples for conducting the chemical tests of the concrete at different depths. The Navy has considered the suggestion of obtaining 4-inch diameter cores to the rock behind the concrete, but does not plan to include this effort as it could damage the extensive reinforcing steel and weaken the concrete structure as well as introduce moisture that could initiate corrosion. In addition, this deep coring effort provides no additional relative information towards verifying the findings of the Corrosion and Metal Fatigue Practices Report per the AOC-SOW Section 5.3.

- Test any contaminants at the coupon site, chlorides, sulfates/sulfides, biological materials. Note evidence of hydrocarbons.

Table 2. On-site Visual Inspection and Testing of Concrete

CONCRETE/CORE SPECIFICS		
Core ID #		
Core Location		
Core Dimensions		
ON-SITE TESTS/VISUAL EXAMINATION		
Checks	**Observations**	
	Exterior	Interior
Void space between concrete and liner (if any)		
Biological Materials		
Wet or Dry		
Smell		
Temperature		
Surface pH		
General condition		
Provide a photo of the concrete and core (if taken)		

4.2 Laboratory Analysis

Laboratory testing will include

- Metallurgical/chemical analysis of the coupons. Determine the physical and mechanical characteristics of the liner steel and weldments.
  - Chemical analysis of corrosion products and coatings.
  - Chemical analysis to evaluate for conformance with any specification.
  - Microscopic examination of surfaces, before and after cleaning. Examination and analysis of metallographic sections, determine microstructure.
  - Hardness measurements, bulk and cross-sectional.
  - Tensile testing, establish yield strength, ultimate tensile strength, and ductility.
  - Fatigue testing - establish endurance limit.
  - Evaluate results for validation of conformance with any material specification(s).

- Characterization of the exterior and interior of the steel coupon.

- Chemical analysis of concrete cores taken as indicated in 4.1.2.

5.0 REPAIR OF COUPON SITES

Coupon sites will be repaired in accordance with current TIRM procedures and other applicable repair requirements identified in the contract Statement of Work (SOW) for repairs.

6.0 IMPLEMENTATION PLAN

6.1 Method of Accomplishment

It is intended that the destructive testing work under this section will be conducted primarily by the tank Inspection/Repair contractor. A new contract must be awarded after funding for the effort is received.

NAVFAC EXWC will provide quality assurance and will be involved with some of the on-site testing and examination.

6.2 Proposed Schedule

The inspection/repair contract for Tank 17 was awarded on 31 August 2016. The contract will need to be modified in order to remove these coupons, test them, and then repair the tank where the coupons were removed.

Tank 17 NDE: Early 2017

Coupon removal and examination: Determination of destructive testing coupon sites upon completion of analysis of NDE test data.

Laboratory Analysis: Upon removal of the metal or concrete sample.

Destructive Testing Report: 2 years from approval of the SOW

7.0 REPORT CONTENT

The Destructive Testing Report will provide detailed discussions of the destructive testing examination effort including discussions of test processes and rationale, tabulation of test data, identification of appropriate reference criteria or standards, and narrative explanation of the results including

- Correlation of destructive testing data/observation with NDE test data
- Records of on-site visual examinations and tests
- Analysis of corrosion rate calculation procedures and recommendations for improvement
- Evaluation of results against current corrosion mitigation practices and recommendations for modifications/improvements to TIRM and TUA.
- Recommendations for additional destructive testing

APPENDIX A

GLOSSARY

ACRONYMS

A-E or A/E	Architect-Engineer
ANSI	American National Standards Institute
AOC	Administrative Order on Consent
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
CSE	Copper-copper sulfate (reference) electrode
DLA	Defense Logistics Agency
DoD	Department of Defense
DOH	(State of Hawaii) Department of Health
EPA	Environmental Protection Agency
NACE International	National Association Corrosion Engineers International
NAVFAC	Naval Facilities Engineering Command (NAVFACENGCOM)
NAVFAC EXWC	NAVFAC Engineering and Expeditionary Warfare Center
NDE	Non Destructive Evaluation
O&M	Operation and Maintenance
pH	A measure of hydrogen ion activity
POL	Petroleum, Oil and Lubricants
RFP	Request for Proposal
SCE	Silver-silver chloride (reference) electrode
S/E	Structure-to Electrolyte
SOW	Statement of Work
TIRM	Tank Inspection Repair and Maintenance
TUA	Tank Upgrade Alternatives

UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guides Specifications.
U.S.	United States
UST	Underground Storage Tank

DEFINITION OF TERMS

Anode: The electrode of an electrochemical cell at which oxidation occurs. (The anode is usually the electrode where corrosion occurs and metal ions enter the solution).

Bimetallic corrosion: (See galvanic corrosion).

Cathode: The electrode of an electrochemical cell at which reduction occurs.

Coating: A dielectric material applied to a structure to separate it from its environment.[1]

Conductivity: The measurement of a material's ability to conduct electrical current.

Corrosion: The deterioration of a material or its properties due to a reaction of that material with its chemical environment.

Corrosion potential: The potential of a corroding metal surface relative to a reference electrode under specific conditions in an electrolyte.

Corrosion rate: The rate at which corrosion proceeds.[1]

Crevice Corrosion: Localized corrosion resulting from a concentration cell formed between two metal surfaces or between a metal and non-metallic surface.

Defect: Flaw whose characteristics or properties do not meet acceptance criteria and is rejectable.

Electrode: A conductor used to establish electrical contact with an electrolyte and through which current is transferred to or from an electrolyte.[1]

Electrolyte: A chemical substance or mixture containing ions that migrate in an electric field. Examples are soil and seawater.

Evaluation: Determination whether a relevant indication is cause to accept or reject (the repair).

Flaw: Imperfection or discontinuity detectable by nondestructive testing; not necessarily rejectable.

Galvanic cell: A corrosion cell in which anode and cathode are dissimilar conductors, producing corrosion because of their innate difference in potential.

Galvanic corrosion: Corrosion resulting from the coupling of dissimilar metals in an electrolyte.

Holiday: A discontinuity in a coating that exposes the metal surface to the environment.

Imperfection: Departure of a quality characteristic from its intended condition.

Indication: Results of a non-destructive examination.

Interpretation: Determination whether an indication is relevant, non-relevant, or false.

Optical Emission Spectroscopy: An analytical technique used to determine the elemental composition of a broad range of metals. An OES analyzer works by emitting an electric arc onto a sample, whose atoms transmit an elemental signature of light to the analyzer. The analyzer then processes the incoming light signals to determine the elemental composition of the sample.

pH: A measure of hydrogen ion activity defined by: $pH = \log_{10} (1/aH^+)$ where aH^+ = hydrogen ion activity = molal concentration of hydrogen ions multiplied by the mean ion activity coefficient (= 1 for simplified calculations).

Pitting: Localized corrosion of a metal surface that is confined to a small area and takes the form of cavities called pits.

Reference electrode: A reversible electrode with a potential that may be considered constant under similar conditions of measurement.

Relevant Indication: An NDT indication that requires evaluation.

Resistivity: The measurement of a material's ability to oppose the flow of electric current.

Rust: A reddish-brown corrosion product of iron that is primarily hydrated iron oxide.

Safe Shell Access: Compliance with the ventilation, degassing, confined space, and other safety requirements when entering fuel storage tanks. Refer to the TIRM Report

Structure-to-electrolyte potential (also structure-to-soil potential): The potential difference between a buried metallic structure surface and electrolyte that is measured with reference to an electrode in contact with the electrolyte. See also pipe-to-soil potential.

Structure-to-structure voltage (also structure-to-structure potential): Difference in voltage between metallic structures in a common electrolyte.

Uniform corrosion: Corrosion attack of a metal that is essentially the same at all exposed areas of its surface.

Voltage: An electromotive force, or a difference in electrode potentials expressed in volts.