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

Section 5.4
EXECUTION PLAN
Decision on Need for and Scope of Modified Corrosion and Metal Fatigue Practices

Prepared by:
NAVFAC EXWC

DATE: 4 December 2020

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EXECUTIVE SUMMARY

The purpose of AOC Section 5.4 is to improve the current inspection process as stated in the AOC SOW Section 2.4 Tank, Inspection, Repair and Maintenance (TIRM) Decision Document, dated 24 April 2017. The agreed upon goal, by the Regulatory Agencies (RAs) and Navy/DLA (Defense Logistics Agency) for an improved TIRM process, is to achieve no release during the service interval between Clean, Inspect, and Repair (CIR) events. Improvements will focus on significant and practicable opportunities to increase confidence in achieving TIRM performance goal.

This report provides the execution plan for the Navy/DLA for the preparation of documents to respond to RAs letters regarding previous work and deliverables under AOC Section 5.3. The Navy will provide documents that will consist of additional research, studies, data, information, investigations, and recommendations. The intent of the documents is to clarify, explain, amplify, and present new information both in furtherance of responses related to AOC Section 5.3 as well as implementation of AOC Section 5.4.

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ACRONYMS AND ABBREVIATIONS

ACI	American Concrete Institute
AOC	Administrative Order on Consent
BFET	Balanced-Field Electromagnetic Technology
DLA	Defense Logistics Agency
DTRR	Destructive Testing Results Report
HCL	Hawaii Corrosion Laboratory
MFE	Magnetic Flux Examination
NDE	Non-Destructive Examination
PAUT	Phase Array Ultrasonic Testing
PLCA	Preliminary Liner Corrosion Assessment Report
RAs	Regulatory Agencies
RHBFSF	Red Hill Bulk Fuel Storage Facility
SOW	Scope of Work
TIRM	Tank, Inspection, Repair and Maintenance
UH	University of Hawaii
UST	Underground Storage Tank
UT	Ultrasonic Testing

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1.0 INTRODUCTION

1.1 Background

The Navy/DLA submitted the *Corrosion and Metal Fatigue Practices, Destructive Testing Results Report* (DTRR) to the RAs on July 7, 2019 to satisfy the requirements in section 5.3.3 of the Red Hill Administrative Order on Consent ("AOC"). On March 16, 2020, the RAs provided their response to this report, in which they stated that they "do not concur that the "NDE results are validated, both by Destructive Testing and thorough, case-by-case analysis." The RAs stated in their letter that additional work should include both 1) future effort to improve the non-destructive testing protocol as generally envisioned in Section 5.4 of the AOC SOW, and 2) further destructive testing to address deficiencies to evaluate proposed improvements to the non-destructive testing protocol.

Following the RAs' letter disapproving the DTRR, discussions between the Navy/DLA and the RAs resolved many of the differences in interpretation. The Navy/DLA submitted a letter on June 2, 2020 to the RAs that agreed with the RAs that additional information to substantiate the DTRR conclusions is warranted. RAs conditionally approved the DTRR on July 7, 2020 under an agreement that the Navy/DLA will work to "identify and implement practicable improvements to the NDE process with the specific goal of defining performance objectives that are protective of human health and the environment." Thus, the requirements to implement the AOC SOW Section 5.4 were met.

1.2 Section 5.4 Scoping Meetings

Three scoping meetings were held between the Navy/DLA and the RAs: (1) July 13, 2020, (2) August 11, 2020, and (3) September 1, 2020. Attachment A is the final Scope of Work outline presented to the RAs on 1 September 2020.

1.3 Execution Plan

The Navy/DLA has incorporated the Scope of Work outline (Attachment A) into ten (10) distinct Work Products. The development of the Work Products will include additional research, studies, data, information, investigations, and recommendations.

The numbers in parenthesis in each below Work Product correlate to the Scope of Work outline (Attachment A). The Navy/DLA is unable to provide specific planned contract documents that will be performed by Contractors, as this is Source-Selection privileged information.

1.4 Content

In addition, the work products' content will address the following broad categories.

1) Technology – including Non-Destructive Examination (NDE) technology such as specific technologies and equipment to get optimal data within practicable limitations.
2) Human Factors (implementation of technology) – the overall Tank Inspection, Repair, and Maintenance (TIRM) process related to corrosion control is reliant on human performance. What can be done to limit or mitigate human factor errors?
3) Repair Threshold / Process / Criteria – Re-evaluate adequacy of current practice to determine if adjustments are needed to account for new information such as the destructive testing study and analysis on NDE limitations.
4) Slowing / Stopping Corrosion – Given lessons learned from NDE data, destructive testing, and others studies, what can be done (if anything) to slow or stop corrosion that is occurring?
5) NDE Comparison – How does Balanced-Field Electromagnetic Technology (BFET) NDE testing compare with other non-electronic NDE (such as vacuum testing or Magnetic Flux Examination (MFE)) methods to verify weld joint integrity?

1.5 Schedule

The approximate schedule for the completion of the work is provided for each document. This schedule is based on Navy/DLA resources and realistic timeframes. However, these schedules are very dependent on COVID-19 work and travel restraints, therefore these schedules may be extended by several months. An overall estimated schedule for this entire effort is provided in Appendix B. A significant amount of additional content has been requested by the RAs during the Section 5.4 Scoping meeting. The development of some of the documents are based on results of antecedent reports and analysis. Other information will require original publication-grade research. Therefore, there will be multiple documents for the RAs to review. It is anticipated that limited preliminary document(s) may be available as within six (6) months of approval of this plan. Due to the amount of testing, research, and dependencies between the documents, the overall plan will require 1-1/2 to two (2) years to provide all of the documents.

2.0 DOCUMENT #1 – NAVY/DLA INTERPRETATION OF THE COUPON RESULTS

2.1 Purpose

- The RAs' interpretation of the Destructive Testing Report was that there were two (2) False Positives and two (2) False Negatives.
- The RAs stated that Navy's laboratory analysis did not or was unable to identify the thinnest portion of each plate which made the destructive testing exercise and its analysis incomplete.
- The RAs stated there is insufficient correlation between NDE and the laboratory measurements.
- The RAs stated a need for more discussion of the significance of field NDE results vs. laboratory results.
- This report will address the following topics in response to the RAs interpretation and statements submitted in their letter dated March 16, 2020.

2.2 Outline

1. [redacted]

2.3 Schedule

- November 2021 (refer to paragraph 1.5 above)

NOTE: Items in parenthesis () refer to sections in Appendix A –
AOC Section 5.4 Scope of Work Outline (1 September 2020).

3.0 DOCUMENT #2 – PRELIMINARY LINER CORROSION ASSESSMENT REPORT (PLCA)

3.1 Purpose

- The RAs stated a belief the Navy is underestimating corrosion rates for Tank 14 and should reassess corrosion rates used in calculating minimum remaining thickness under TIRM.
- Also, it was stated the potential cause for increasing corrosion rates creates concern for potential corrosion of embedded reinforcement in the concrete.
- The Navy/DLA will address the following topics in response to the RAs' statement.

3.2 Outline

1. Potential for Increased Rates of Corrosion
   - 1.1. Method by which Corrosion Rate is calculated (4.1)
   - 1.2. Using extreme value rates to establish Minimum Remaining Thickness (4.2)
   - 1.3. Environmental and chemical conditions affecting rates (4.4)
   - 1.4. Potential causes for corrosion (4.6)
   - 1.5. Potential corrosion impact from use of old verses new carbon steel Patch Plates (4.9)
     - 1.5.1. Potential Galvanic corrosion between new patch plate and old carbon steel liner (4.9.1)

2. Potential for weld stress due to crevice corrosion in the gap between the steel liner and a new patch plate. (4.9.2)
   - 2.1 Address crevice corrosion in fillet-welded patch plates on ASTs and how this is applicable for Red Hill and USTs in general.

3. Rainfall effects on Red Hill metal liners (4.7)

4. Factor of Safety (5.2)
   - Comparison with other industries (API, ASME, ASCE, etc.)

5. Corrosion Rates (5.3)
   - Address extreme value (e.g., timber lodged behind plate) vs uniform rate
   - Comparison of corrosion rate model used at Red Hill with API standards
   - Reevaluate the repair threshold and associated factor of safety to account for inaccuracies in NDE, corrosion rates, and possible delays in repair cycles.

3.3 Schedule

- July 2021
- Refer to paragraph 1.5 above

4.0 DOCUMENT #3 – PRELIMINARY CONCRETE ASSESSMENT REPORT

4.1 Purpose

Empirical evidence and a preliminary assessment of the Red Hill Bulk Fuel Storage Facility (RHBFSF) demonstrate the concrete is in good condition. Further information about the quality and durability of the RHBFSF concrete, and the potential for corrosion in the reinforcement is needed. The basis for this information is an analysis of mechanical, physical, and material properties. Due to characteristics of the facility and the potential for deleterious consequences of ad hoc destructive testing, a deliberate approach that will mitigate damage to the infrastructure is necessary.

4.2 Outline

1. Conduct additional analyses on the condition of the concrete structure and embedded reinforcing steel. (5.4)
    - Study existing concrete pursuant to principles of American Concrete Institute (ACI) 364-1R- 19 Guide for Assessment of Concrete Structures Before Rehabilitation
    - Cores might include embedded reinforcing steel
    - Physical, chemical, and mechanical properties of the concrete will be studied

4.3 Schedule

- July 2021
- Refer to paragraph 1.5 above

NOTE: Items in parenthesis () refer to sections in Appendix A –
AOC Section 5.4 Scope of Work Outline (1 September 2020).

5.0 DOCUMENT #4 – INSPECT AND REPAIR PROTOCOLS PROJECT FOR RED HILL UNDERGROUND STORAGE TANKS

5.1 Purpose

The RAs stated a belief the Navy is underestimating corrosion rates for Tank 14 and should reassess corrosion rates used in calculating minimum remaining thickness under TIRM.

5.2 Outline

1. University of Hawaii (UH) Study - The Hawaii Corrosion Laboratory (HCL), Department of Mechanical Engineering proposes to 1) elucidate the limits of nondestructive evaluation on severely corroded steel panels with adherent corrosion products, 2) develop protocol to measure in situ corrosion rates of steel panels that can be used for the Red Hill USTs, and 3) evaluate repair and patch protocols to prevent premature failures. (4.3)

2. Peer Review of Report (Corrosion Consultant)

5.3 Schedule

- November 2021
- Based on current UH schedule
- Refer to paragraph 1.5 above

6.0 DOCUMENT #5 – CONCRETE TANK DEGRADATION INSPECTION AND RETROFIT

6.1 Purpose

The RAs stated a belief that the potential cause for increasing corrosion rates creates concern for potential corrosion of embedded reinforcement in the concrete.

6.2 Outline

1. UH Study - The objectives of this portion (secondary containment-corrosion in concrete) of the project are to 1) identify the locations and extent of cracking/degradation of the concrete and steel structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete and steel degradation based on chemical and mineralogical analysis, and 3) propose appropriate retrofitting technologies and strategies. (4.5)

2. Peer review of report – Concrete Consultant

6.3 Schedule

- November 2021
- Based on current UH schedule
- Refer to paragraph 1.5 above

7.0 DOCUMENT #6 – ELEMENT, PHASE, AND OXIDATION STATE MAPPING OF RED HILL UST CORROSION BY ADVANCED MICROSCOPY METHODS

7.1 Purpose

Assess the possibility of distinguishing historic from contemporary corrosion episodes via "tracer" element and oxidation state distributions that may reveal episodic corrosion history and allow exclusion of one or more sources from consideration in water pathway.

7.2 Outline

1. UH Study - Laboratory study to attempt to distinguish between recent and historic corrosion. The Advanced Electron Microscopy Center at UH will perform element, phase, and oxidation state mapping and analysis of coupons extracted from out-of-service Red Hill USTs, and in close collaboration with Task 2, laboratory-generated corrosion samples, as they are produced. These analyses will be carried out in a focused-ion-beam scanning electron microscope and a scanning transmission electron microscope using electron imaging, energy dispersive X-ray spectroscopy and electron energy loss spectroscopy to visualize structure, morphology, and corrosion product phases and distributions. (5.3.5)

2. Peer review of report by corrosion consultant

7.3 Schedule

- August 2021
- Refer to paragraph 1.5 above

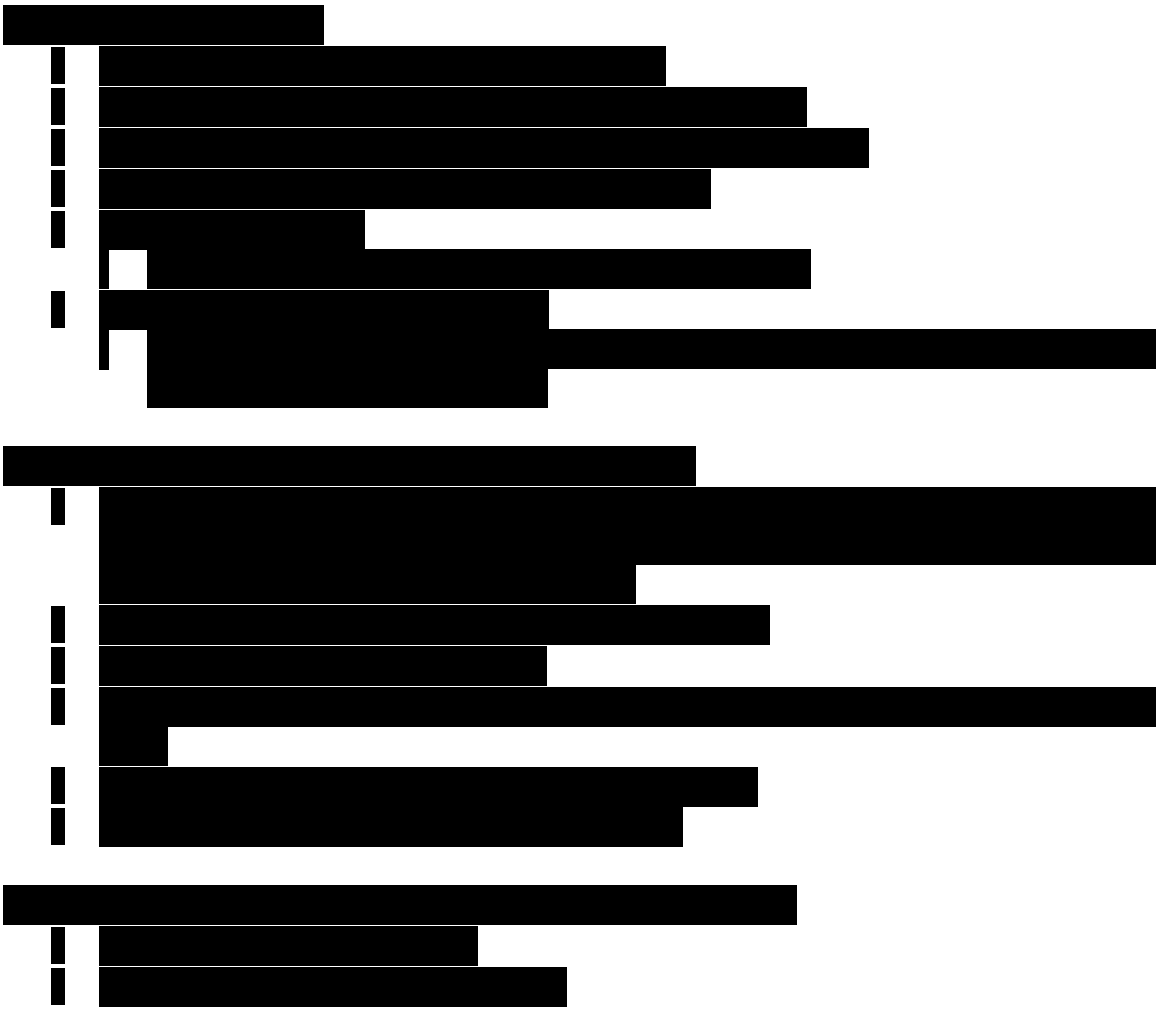
8.0 DOCUMENT #7 – INSPECTION DATA, LFET, AND STEP 2 ANALYSIS REPORT

8.1 Purpose

The following topics were developed during discussions with the RAs during previous Scoping meetings from 4 June 2020 to 11 August 2020. These topics will be addressed, analyzed, and discussed thoroughly by Navy/DLA. The Navy/DLA will provide this information and documentation to the RAs as they are developed.

8.2 Outline

1. [redacted]



NOTE: Items in parenthesis () refer to sections in Appendix A –
AOC Section 5.4 Scope of Work Outline (1 September 2020).

8.3 Schedule

- May 2022??
- Delayed 6 – 12 months due to COVID-19. We are not allowed in the Lab to create the corrosion on the test plates.
- Refer to paragraph 1.5 above

9.0 DOCUMENT #8 – ROBOTIC INSPECTION REPORT

9.1 Purpose

Analyze the technology of robotic inspections and compare to a previously performed inspection using manual inspections.

9.2 Outline

[redacted]

9.3 Schedule

- June 2022
- Dependent on schedule of tank availability.
- Refer to paragraph 1.5 above

10.0 DOCUMENT #9 – TIRM UPDATE REPORT

10.1 Purpose

The results of the above initiatives will be incorporated into an update to the TIRM Report.

10.2 Outline

1. Data Entry and Documentation (5.7)
   - Refine process to eliminate entry errors (5.7.1)
   - Eliminate intermediate steps in data handling (5.7.2)
   - Screening for outlier data (5.7.3)

2. Auditing of Quality Control Program (5.8)
   - Spot checks (metal loss) using Contractor NDE (5.8.1)
   - Spot checks (metal loss) using 3rd party NDE (5.8.2)
   - Spot checks (metal loss) using destructive means (5.8.3)
   - Spot checks of Quality Control documentation (5.8.4)
   - Negative Performance Incentives (rework, removal of personnel, rejection of work) (5.8.5)
   - Acceptance sampling plan (Develop after "Inspection Data, LFET, and Step 2 Analysis Report") (5.8.6)

3. Changes to Quality Assurance Procedures (6.3)

4. Tank Inspection Specification (6.2)
   - Specs, drawings, etc. (6.2.1)
   - Qualification of Inspectors (6.2.2)
   - Testing procedures (6.2.3)
   - Reporting procedures (6.2.4)
   - Audit coupons (6.2.5)

5. Tank Repair Specification (6.2)
   - Specs, drawings, etc. (6.2.1)
   - Qualification of Inspectors (6.2.2)
   - Testing procedures (6.2.3)
   - Reporting procedures (6.2.4)
   - Audit coupons (6.2.5)
6. Removal of telltales (4.8)

10.3 Schedule

- May 2022- Dependent on other studies and testing
- Refer to paragraph 1.5 above

11.0 DOCUMENT #10 - OVERALL CORROSION ASSESSMENT REPORT (OCA) (6.1)

11.1 Purpose

The Overall Corrosion Assessment Report will amalgamate the Preliminary Concrete Assessment Report (Document #3) and the Preliminary Liner Corrosion Assessment Report (PLCA) (Document #2) into a unified synopsis of corrosion in the Red Hill storage tanks. (6.1)

11.2 Outline

1. Report on results

11.3 Schedule

- March 2022
- Dependent on other studies and testing
- Refer to paragraph 1.5 above

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NOTE: Items in parenthesis () refer to sections in Appendix A –
AOC Section 5.4 Scope of Work Outline (1 September 2020).

APPENDIX A - AOC Section 5.4 Scope of Work Outline (1 September 2020)

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AOC SECTION 5.4 SCOPE OF WORK OUTLINE (1 September 2020)

1. Interpretation of the Coupon Results
   PURPOSE: The RAs interpretation of the Destructive Testing Report was that there were two (2) False Positives and two (2) False Negatives. The Navy/DLA will address the following topics in response to the RAs interpretation.

2. Deficiencies in Data Collected
   PURPOSE: The RAs stated that Navy's laboratory analysis did not or was unable to identify the thinnest portion of each plate which made the destructive testing exercise and its analysis incomplete. The Navy/DLA will address the following topics in response to the RAs statement.

3. Uncertainty Regarding NDE Accuracy
   PURPOSE: The RAs stated there is insufficient correlation between NDE and the laboratory measurements. The Navy/DLA will address the following topics in response to the RAs statement.

4. Potential for Increased Rates of Corrosion
   PURPOSE: The RAs stated a belief the Navy is underestimating corrosion rates for Tank 14 and should reassess corrosion rates used in calculating minimum remaining thickness under TIRM. Also, it was stated the potential cause for increasing corrosion rates creates concern for potential corrosion of embedded reinforcement in the concrete. The Navy/DLA will address the following topics in response to the RAs statement.
   - 4.1. Method by which Corrosion Rate is calculated
     - 4.1.1. Evaluate potential causes for corrosion and possible actions to reduce corrosion rates, if possible.
   - 4.2. Using extreme value vs uniform to establish Minimum Remaining Thickness
   - 4.3. [redacted] theory concerning metal liner
   - 4.4. Environmental and chemical conditions affecting rates

4.5. [redacted] theory concerning reinforced concrete
4.6. Potential causes for corrosion
4.7. Rainfall effects on metal liner
4.8. Removal of telltales
4.9. Potential corrosion impact from use of old verses new carbon steel Patch Plates
4.9.1. Potential Galvanic corrosion between new patch plate and old carbon steel liner
4.9.2. Potential for weld stress due to crevice corrosion in the gap between the steel liner and a new patch plate

5. Recommendations for Moving Forward

PURPOSE: The following topics were developed during discussions with the RAs during previous Scoping meetings from 4 June 2020 to 11 August 2020. These topics will be addressed, analyzed, and discussed thoroughly by Navy/DLA. The Navy/DLA will provide this information and documentation to the RAs as they are developed.

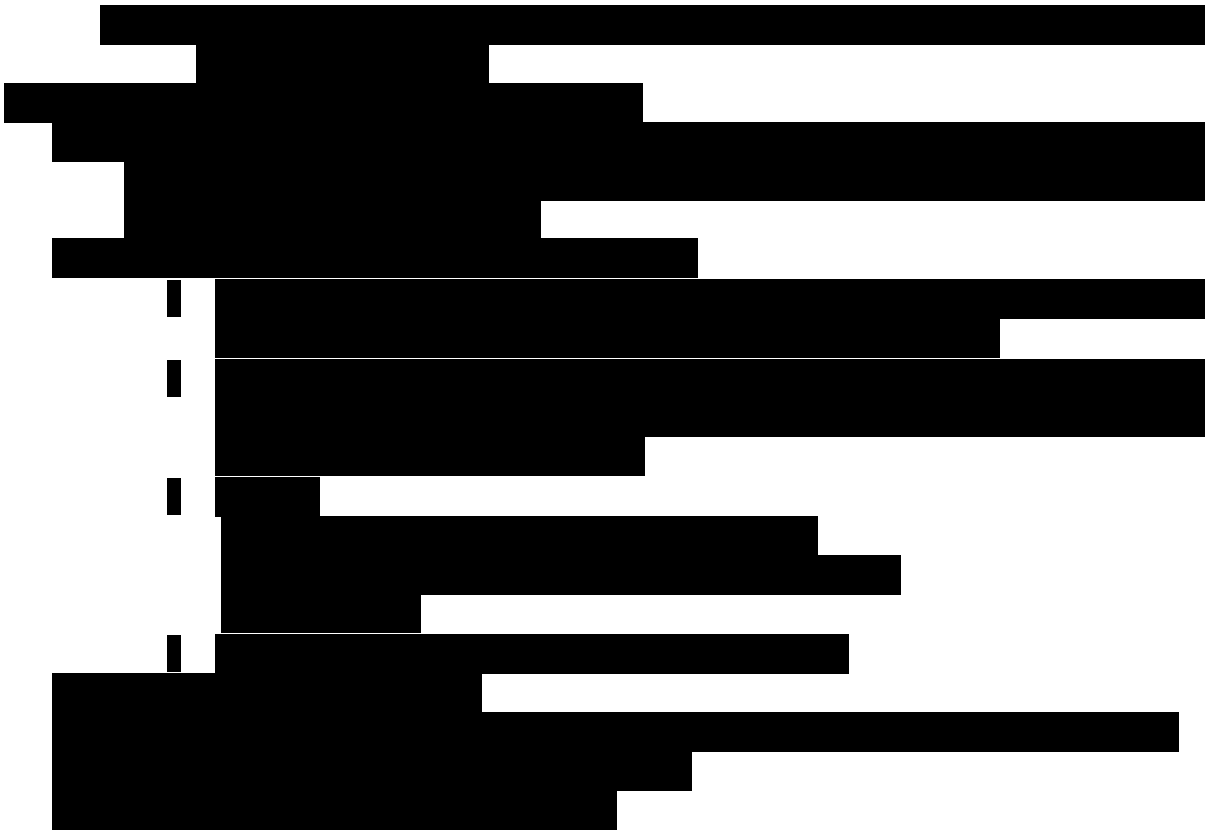
[redacted]

5.2. Factor of Safety
5.2.1. Comparison with other Industries (API, ASME, ASCE, etc.)
5.3. Corrosion Rates
5.3.1. Address extreme value (e.g., timber lodged behind plate) vs uniform rate
5.3.2. Comparison to API 650 tank steel bottom
5.3.3. Reevaluate the repair threshold and associated factor of safety to account for inaccuracies in NDE, corrosion rates, and possible delays in repair cycles.

[redacted]

5.3.5. Laboratory study to attempt to distinguish between recent and historic corrosion
5.4. Conduct additional analyses on the condition of the concrete structure and embedded reinforcing steel.
5.4.1. Study existing concrete pursuant to principles of ACI 364-1R
5.4.2. Cores might include embedded reinforcing steel
5.4.3. Physical, chemical, and mechanical properties of the concrete will be studied

[redacted]



5.7. Data Entry and Documentation
  5.7.1. Refine process to eliminate entry errors
  5.7.2. Eliminate intermediate steps in data handling
  5.7.3. Screening for outlier data
5.8. Auditing of Quality Control Program
  5.8.1. Spot checks (metal loss) using KTR NDE
  5.8.2. Spot checks (metal loss) using 3rd party NDE
  5.8.3. Spot checks (metal loss) using destructive means
  5.8.4. Spot checks of QC documentation
  5.8.5. Negative Performance Incentives (rework, removal of personnel, rejection of work)
  5.8.6. Acceptance sampling plan

6. Validation of Initiatives

PURPOSE: The results of the above five (5) initiatives will be incorporated into the following topics:

6.1. Report on results
6.2. Implement Changes to Specifications
  6.2.1. Specs, drawings, etc. that they give to the contractors. Those are what we should be reviewing.
  6.2.2. Qualification of Inspectors
  6.2.3. Testing procedures
  6.2.4. Reporting procedures
  6.2.5. Audit coupons
6.3. Changes to Quality Assurance procedures

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APPENDIX B - Schedule

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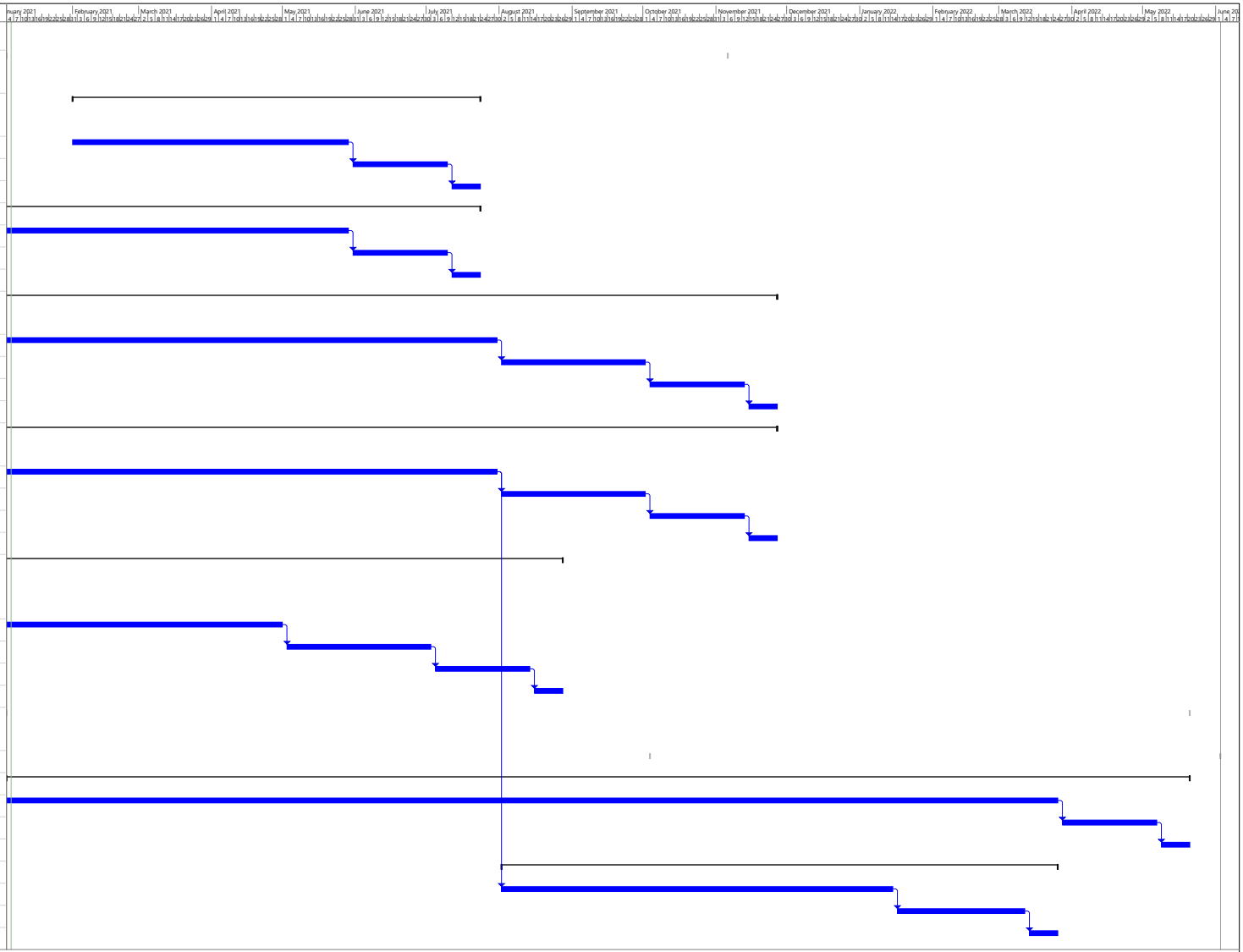
ID	Task Mode	Task Name	Start	Finish
1		**Section 5.4 Documents**		
2		**1 - Navy/DLA Interpretation of the Coupon Results**		
7		**2 - Preliminary Liner Corrosion Assesment Report**	**Mon 2/1/21**	**Fri 7/23/21**
8		Corrosion Consultant Develop Report	Mon 2/1/21	Fri 5/28/21
9		Government Review	Mon 5/31/21	Fri 7/9/21
10		Send to Regulators	Mon 7/12/21	Fri 7/23/21
11		**3 - Preliminary Concrete Assessment Report**	**Mon 10/5/20**	**Fri 7/23/21**
12		Concrete Consultant Develop Report	Mon 10/5/20	Fri 5/28/21
13		Government Review	Mon 5/31/21	Fri 7/9/21
14		Send to Regulators	Mon 7/12/21	Fri 7/23/21
15		**4 - Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks**	**Mon 10/5/20**	**Fri 11/26/21**
16		UH Develop Report	Mon 10/5/20	Fri 7/30/21
17		Peer Review	Mon 8/2/21	Fri 10/1/21
18		Government Review	Mon 10/4/21	Fri 11/12/21
19		Send to Regulators	Mon 11/15/21	Fri 11/26/21
20		**5 - Concrete Tank Degradation Inspection and Retrofit**	**Mon 10/5/20**	**Fri 11/26/21**
21		UH Develop Report	Mon 10/5/20	Fri 7/30/21
22		Peer Review	Mon 8/2/21	Fri 10/1/21
23		Government Review	Mon 10/4/21	Fri 11/12/21
24		Send to Regulators	Mon 11/15/21	Fri 11/26/21
25		**6 - Element, Phase, and Oxidation State Mapping of Red Hill UST Corrosion by Advanced Microscopy Methods**	**Mon 10/5/20**	**Fri 8/27/21**
26		UH Develop Report	Mon 10/5/20	Fri 4/30/21
27		Peer Review	Mon 5/3/21	Fri 7/2/21
28		Government Review	Mon 7/5/21	Fri 8/13/21
29		Send to Regulators	Mon 8/16/21	Fri 8/27/21
30		**7 – Inspection Data, LFET, and Step 2 Analysis Report**		
35		**8 – Robotic Inspection Report**		
41		**9 – TIRM Update Report**	**Mon 1/4/21**	**Fri 5/20/22**
42		Prepare Report (in-house)	Mon 1/4/21	Fri 3/25/22
43		Government Review	Mon 3/28/22	Fri 5/6/22
44		Send to Regulators	Mon 5/9/22	Fri 5/20/22
45		**10 – Overall Corrosion Assessment Report**	**Mon 8/2/21**	**Fri 3/25/22**
46		Corrosion Consultant Develop Report	Mon 8/2/21	Fri 1/14/22
47		Government Review	Mon 1/17/22	Fri 3/11/22
48		Send to Regulators	Mon 3/14/22	Fri 3/25/22



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APPENDIX C

Contract Statement of Work – Provide Red Hill Corrosion Assessment

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CONTRACT STATEMENT OF WORK

Project Title: Provide Red Hill Corrosion Assessment
Contract No: N39430-19-D-2170
Task Order: TBD
WON: 1674309
Contractor: Solomon Resources, LLC.
ACQR: 5810655

SOW HISTORY

Version	Date	Description
Basic Award	01 Jul 2020	Original Scope

Date: 01 Jul 2020
Submitted By: Frank Kern

Contents

1 NEED

Technology to screen the steel tank liners at the Red Hill Bulk Fuel Storage Facility (RHBFSF) for backside corrosion has been used at the Facility since circa 2006. Condition reports have been produced as part of individual tank inspection and repair evolutions. A facility-wide effort to consolidate tank corrosion and condition information into a facility-wide report has not been undertaken.

1.1 Background

During construction of the RHBFSF, twenty mined vertical cavities were lined with butt-welded carbon steel. The liners were used as forms when reinforced concrete with thickness ranging from 2 to 5 feet was placed. At the conclusion of construction, each tank was leak-tested with water and repairs were made based on the test results. Further information is available in GFI Attachment 5 Brief Background Red Hill Tank Construction.

The liners were coated with a thin film urethane epoxy between 1960-1970. Empirical data suggest the epoxy coating has been effective at preventing product-side corrosion.

During routine inspection and electromagnetic corrosion screening done on some tanks since 2006, areas of backside corrosion have been found and repaired. The standard for repair is a modified API Std 653 approach.

During tank filling at the conclusion of a routine repair evolution in 2014, a release took place. The subsequent investigation determined the underlying cause of the release was poor workmanship and unrepaired gas test holes installed by the repair contractor. As a result of the release, Navy entered into an administrative order with Regulatory Agencies (RA). Work products of this Statement of Work will be used in concert with others to further Navy efforts to satisfy requirements of the administrative order.

1.2 Goals and Objectives

The goals of this project are to receive preliminary reports that will better inform Navy and DLA. The primary objective is to review corrosion data and produce a preliminary report addressing steel liner corrosion. Secondary objectives are to provide Subject Matter Expert (SME) Consultant services in the form of review and analysis of expert documents, participation in stakeholder and public meetings, testimony before regulatory agencies regarding the assessment, and briefing Navy and DLA leadership. The tertiary objective is to produce an overall corrosion assessment report.

2 REQUIREMENTS

In order to meet project goals, this SOW contains requirements to review reports by others, analyze data with a consultant SME, produce a preliminary liner corrosion assessment report, and produce an overall corrosion assessment report. The source data and reports, analysis, and report are non-disclosable. Individuals involved will be required to sign a statement of non-disclosure.

Provide means and methods to execute this SOW. Provide appropriate subcontractor support from qualified companies, consultant(s), and specialists to execute this SOW. Provide and distribute submittals in accordance with Table S.

2.1 Corrosion Subject Matter Expert

Provide the services of a corrosion subject matter expert (SME) consultant qualified by education and experience to perform expert services of storage tank corrosion assessment. Minimum education is a doctorate in engineering or closely related field. Relevant experience in corrosion assessment and evaluation of large concrete structures is required. Submit SME Consultant resume for Govt approval.

Contractor and subcontractor employee(s) shall conduct themselves in a proper, efficient, courteous, and businesslike manner. Coordination and cooperation with others is a key element to success, and is required. The Contracting Officer may require the contractor remove from the work any individual the Govt reasonably determines is uncooperative, unqualified, fails to satisfactorily perform work, is careless, objectionable, contrary to public interest, or acts inconsistent with the best interests of National Security.

2.2 Task 1 Preliminary Liner Corrosion Assessment

All notes, data, comments, recommendations, specifications, and other documents collected and produced as part of this contract are property of the Govt. These data or images shall not be used, in whole or part, published or unpublished, in any technical or non-technical presentation, or otherwise released by the contractor without prior written approval of the Contracting Officer.

2.2.1 Preliminary Nature of Assessment

Metal thickness data are not available for each storage tank liner at Red Hill. In addition, some reports contain sparse data. For those reasons the assessment will be produced as preliminary and subject to change should further data become available.

2.2.2 Literature Review

Perform a review of literature relevant to carbon steel plates in intimate or close contact with concrete substrate. Consider (Petti, et al. 2011) and (Tuutti, 1982). Assess methods of corrosion rate determination in industry standards API 570 and 653. Review relevant Red Hill construction records which document tank design and construction. Assume electronic review of thirty vintage, hand-drafted Arch D as-built drawings.

2.2.3 Analysis of Inspection Records

Provide SME consultant analysis of the corrosion data per individual tank and as part of the entire facility. Perform data manipulation as-needed to inform the analysis. Review thickness data and analysis performed by the tank inspectors. Propose a meaningful basis for establishing and reporting rates, if different from current practice. Segregate data and analysis into categories of product-side and backside corrosion. Assume quantitative data are available for analysis in six reports, each containing approximately 25-relevant pages and a large spreadsheet. Assume qualitative data are available in four reports, each containing approximately 50-relevant pages.

2.2.4 Preliminary Liner Corrosion Assessment Report

Produce a preliminary liner corrosion assessment (PLCA) report. Overall objectives of the preliminary report are below.

a. Compare and contrast the science of storage tank bottom corrosion versus the methods of corrosion rate assessment in API Standards 653 and 570

b. Summarize the literature and science of corrosion of steel plates in contact with concrete, as it relates to conditions at Red Hill

c. Discuss estimates of liner corrosion rates

d. Recommendations to change in practice of corrosion rate determination

Provide a preliminary report which meets objectives, and contains commentary and analysis. Provide the PLCA Report at three levels of completion.

2.2.4.1 Draft PLCA

The Draft Report is an outline format containing placeholders for all elements of analyses. Populate the draft report with completed results. Analysis that is still in-progress might not be included in the draft. The Draft Report is progress-type with a level of completion expected to be 75%

2.2.4.2 Prefinal PLCA

The Prefinal Report contains all analysis and incorporates Govt and Subject Matter Expert (SME) comments.

2.2.4.3 Final PLCA

The level of completion of the Final Report is ready for publication and incorporates Govt and SME comments.

2.2.5 Electronic Meetings and Phone Calls

Provide SME consultant attendance and participation in technical, quality, and status meetings with the GTT. Meetings will be conducted only an as-needed basis. Assume periodicity ranges from once every two weeks to once per month. Duration is not expected to exceed 1 hour each. Assume electronic means are commercial web conferencing (Zoom, Google, Skype, Microsoft) without video capability.

2.3 Task 2 SME Consultant Work

2.3.1 External Report Analysis

It is expected external experts will produce documents and reports pertaining to RHBFSF corrosion. Provide peer review and critical analysis of the reports. The initial audience for the review and analysis is the GTT. However, expect discussion of external documents and reports to be a topic during electronic or onsite meetings with external stakeholders. Quantity of external document and report reviews is given in Table 2.1. Assume each report or document requires 6 hours for review and analysis.

Table 2.1 External Report Review

Type	Quantity (ea)
Corrosion or Practices Report	5

2.3.2 Third Party Review Response

Review and commentary on the PLCA will take place by external third parties and RA. Expect rounds of reviews to take place at any level of completion. Some review comments might not require a report revision and will only require a response to comments. In response to the third party and RA review comments, provide SME Consultant analysis and report deliverables per Table 2.2. Assume each effort requires 4 hours of time.

Table 2.2 Third Party Review Responses

Work Item	Quantity (ea)
Analysis	6

Review and Respond to Comments	5
Report Supplement	2

2.3.3 Appearance and Participation at Public and Regulatory Agency Meetings

Provide SME consultant participation in onsite and electronic public, Govt, and RA meetings. Assume electronic meetings are telephonic or commercial web conferencing (Zoom, Google, Skype, Microsoft). Using these means, video conferencing may take place with voice supplemented with pdf screen presentation as backup. See paragraph Mobilizations for onsite meeting requirements.

Meetings with RA will involve interaction, commentary, and criticism from forensic and specialty consultants representing their respective clients. Sworn testimony to the RA in support of the preliminary corrosion assessment report is expected. Meetings with public will involve direct interaction with individuals and organizations representing the complete range of technical knowledge and experience.

Provide SME Consultant electronic meeting participation per Table 2.3. See paragraph Work Hours for time of day requirements.

Table 2.3 Electronic Meeting Participation Schedule

Type of Involvement	Quantity of Meetings	Hours (per meeting)
Participation, Govt Only	6	2
Participation, Govt + RA + Public	2	6

2.3.4 Mobilizations

Provide SME consultant mobilizations to support the corrosion assessment as well as participate in onsite Govt, RA, and public meetings. Assume onsite meetings take place in Honolulu. Assume each mobilization requires five days (two travel days, three work days). Quantity and purpose of mobilizations is per the Table 2.4.

Table 2.4 Mobilization Schedule

Type of Participation	Quantity (ea)
Onsite Govt Meeting	1
Onsite RA Meeting	1

2.4 Task 3 Overall Corrosion Assessment

Preparation of a preliminary concrete assessment report (concrete report) is underway by others. The report will assess the quality and durability of RHBFSF reinforced concrete. Provide SME services to review the concrete report and be familiar with its principal findings. Formulate an Overall Corrosion Assessment (OCA) which amalgamates the concrete report and the PLCA into a unified synopsis of corrosion in the Red Hill storage tanks.

Assume the concrete report contents will not be available for inclusion until June 2021. The COR will advise of more specific delivery information once available. Assume relevant portions of the concrete report do not exceed 100-pages.

2.4.1 Overall Corrosion Assessment Report

Produce an OCA report based on the PLCA and the concrete report. Contents of the report are principal findings, conclusions, and opinions contained in both the concrete report and the PLCA report. The audience for the OCA report is Navy and DLA leadership and the general public.

Utilize the services of a technical writer to tailor the report to the audience. Make use of illustrative graphics and professional editing to ensure fundamental concepts are easily understood by non-technical individuals.

2.4.2 Prefinal OCA

The Prefinal OCA Report contains all analysis, graphics, and information. Produce the Prefinal Report no later than 90-days after receipt of information from the concrete assessment report.

2.4.3 Final OCA

The level of completion of the Final OCA Report is ready for publication and incorporates Govt comments.

2.5 Schedule

Within three weeks of award, provide a schedule which details performance of all work in this SOW. Use placeholder dates for the mobilizations. Build time into the schedule to receive the concrete report and perform Task 3 activities.

2.6 References

Petti, Jason P, Dan Naus, Richard E Weyers, Bryan A Erler, Neal S Berke, and Alberto Sagüés. 2011. *Nuclear Containment Steel Liner Corrosion Workshop: Final Summary and Recommendations Report.* Technical Report, Albuquerque: Sandia National Laboratories.

Tuutti, K. 1982. *Corrosion of Steel in Concrete.* Research Thesis, Stockholm: Swedish Cement and Concrete Research Institute.

3 GENERAL REQUIREMENTS

Comply with all federal, state, and local regulations. The term construction refers to any construction-type support activity which is required to execute this Statement of Work.

Coordinate planned work activities with the GTT. Report exceptions and deviations from this Statement of Work to the Contracting Officer. Only the Contracting Officer has the authority to authorize work or de-scope work elements of this Task Order.

3.1 Work Hours

Unless otherwise notified, SME Consultant meetings with Govt and RA will take place during normal business hours, Hawaii Standard Time. Meetings with the public are expected to take place between the hours of 1200 HST – 2100 HST.

3.2 No Waiver by the Government

The failure of the Govt in any one or more instances to insist upon strict performance to any of the terms of this contract or to exercise any option herein conferred shall not be construed as a waiver or

relinquishment to any extent of the right to assert or rely upon such terms or options on any future occasion.

3.3 Information Security

Security requirements apply to all contractors, subcontractors, and suppliers associated with this contract. In addition to special or extraordinary security requirements, comply with the following:

a. Do not publicly disclose information concerning any aspect of the design or services relating to this contract, without prior written approval of the Contracting Officer.

b. Do not disclose or cause to be disseminated information concerning the operations of the activity, operations of the activity's security, or information regarding the continuity of operations.

c. Do not disclose any information to any person not entitled to receive it. Failure to safeguard any classified information that may come to the Contractor or any person under his control, may subject the Contractor, his agents or employees to criminal liability under 18 U.S.C., Sections 793 and 798.

d. Direct to the Contracting Officer or Installation Security Officer for resolution all inquiries, comments or complaints arising from any matter observed, experienced, or learned as a result of or in connection with the performance of this contract, the resolution of which may require the dissemination of official information.

e. Coordinate photography with Installation requirements. Photo permit requests are processed by the Joint Base.

f. This effort will result in an aggregation of information which is sensitive and is protected from disclosure. A non-disclosure agreement will be required. Certain documents must be labeled privileged from disclosure.

Deviations from or violations of any of the provisions of this section, will, in addition to all other criminal and civil remedies provided by law, subject the Contractor to immediate termination for default and withdrawal of the Govt acceptance and approval of employment of the individuals involved.

3.4 Proprietary Rights

All field notes, drawings, photographs, specimens, specifications, findings, data, and documents collected and produced as part of this contract become property of the Govt. These data shall not be used, in whole or part, published or unpublished, as a part of any technical or non-technical presentation, or otherwise released by the Contractor without written approval of the Contracting Officer.

3.5 Installation Access

Submit request for access in accordance with DBIDS for JBPHH. Fulfill required background and fingerprint investigation information requests within one week of initiation. For workers already in possession of DBIDS access or a CAC, coordinate access requirements with the COR. For single-day access into Red Hill, it is not expected that all steps on the FLCPH badging flow chart will be required. Coordinate access requirements with the COR.

3.6 Safety and Occupational Health Requirements

Submit an abbreviated APP compliant with USACE EM 385-1-1 Appendix A. Submit matters of interpretation of standards to the COR for resolution before starting work. Where the requirements of this SOW, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply.

3.6.1 Accident Notification and Reports

For recordable injuries and illnesses, and property damage accidents resulting in at least $2,000 in damages, contractor shall:

a. Provide initial notification via telephone or email as soon as possible from the time of mishap.

b. Provide initial contractor Incident Reporting System (CIRS) report within 4-hours of mishap.

c. Conduct an accident investigation to establish the root cause(s) of the mishap.

d. Provide final CIRS report within five calendar days of mishap.

e. COR will provide forms or electronic system access for CIRS report.

Notify the Contracting Officer as soon as practical, but not later than four hours, after any accident meeting the definition of Recordable Injuries or Illnesses or High Visibility Accidents, property damage equal to or greater than $2,000, or any weight handling equipment accident. Include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (e.g., type of equipment being used, PPE used). Preserve the conditions and evidence on accident site until the Govt investigation team arrives and Govt investigation is conducted.

4 CONTRACT MEETINGS AND REPORTING

4.1 Kickoff Meeting / Teleconference

Upon Task Order award, within three weeks host a telephonic Kickoff Meeting with the GTT to establish the responsibilities of parties, to discuss the schedule, and to ensure mutual understanding of the scope. Prepare the meeting agenda. After opening remarks by the COR, lead the discussion of specific project requirements. Generate and submit meeting minutes for COR review and approval. This meeting shall occur prior to contractor personnel starting work.

4.2 Progress Meeting/Telcon

At various times, coordinate and host progress meetings with the GTT. The intent will be to discuss progress, quality, coordination, and mutual understanding. Meetings dates will be determined later. Assume they are telephonic. The COR will notify contractor when meetings are required. Prepare and submit brief minutes of the meetings per Table S.

5 PROPOSAL

5.1 Cost

Provide a detailed cost proposal for Tasks identified in Table 5.1 required to execute work in this SOW.

Table 5.1 Cost Proposal

Task 1 Preliminary Liner Corrosion Assessment	$
Task 2, SME Consultant Work	$
Task 3 Overall Corrosion Assessment (OCA)	$

Administrative Submittals	$

5.2 Technical

Provide proposal with succinct detail that demonstrates understanding and compliance with the principal means and methods. Identify proposed subcontractors. Provide a resume for the SME Consultant that demonstrates qualification and expertise.

6 OPTION ITEMS

In the event quantities of work are required in excess of what is in this SOW, Navy would like to establish unit prices for several Option Items. Should the work become necessary, unit prices will provide the basis for rapid execution of a change. Provide a fully burdened cost for optional work, using the referenced SOW paragraph as the basis for each Option Item, pursuant to the tables below. Option Item prices remain valid for the duration of the period of performance.

Only the Contracting Officer has the authority to authorize Option Item work. Do not proceed with any Option Item work unless the option has been exercised and the work is authorized by the Contracting Officer.

6.1 Option 1 - External Report Review and Analysis

Basis for the option work is paragraph External Report Analysis.

Table 6.1 Optional External Report Review

Type	Unit of Measure	Price
Corrosion or Practices Report	Each	$

6.2 Option 2 - Third Party Review Response

Basis for the option work is paragraph Third Party Review Response.

Table 6.2 Optional Third Party Review Responses

Work Item	Unit of Measure	Price
Analysis	Each	$
Review and Respond to Comments	Each	$
Report Supplement	Each	$

6.3 Option 3 - Electronic Meeting Participation

Basis for the option work is paragraph Appearance and Participation at Public and Regulatory Agency Meetings.

Table 6.3 Optional Electronic Meeting Participation

Type of Involvement	Unit of Measure	Price
Participation, Govt + RA + Public	Each Meeting	$

6.4 Option 4 - SME Consultant Mobilizations

Basis for the optional work is paragraph Mobilizations.

Table 6.4 Optional Mobilization

Type of Participation	Unit of Measure	Price
Onsite Meeting	Each	$

7 GOVERNMENT FURNISHED INFORMATION (GFI)

1. DBIDS for JBPHH
2. SECNAV 5512-1
3. FLCPH Badging Flow Charts
4. JB2 0-180
5. Brief Background Red Hill Tank Construction

8 PLACE OF PERFORMANCE

Joint Base Pearl Harbor Hickam, Honolulu, Hawaii.

9 PERIOD OF PERFORMANCE

The anticipated period of performance is 16 months from date of award.

10 PRIMARY POINTS OF CONTACT

Contracting Officer

Mr. Sal Vargas
NAVFAC EXWC Code ACQ72
1100 23rd Avenue, Building 1100, Port Hueneme, CA 93043-4347
(805) 982- 2565
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11 GLOSSARY

ACI	American Concrete Institute	EXWC	Engineering and Expeditionary Warfare Center
API	American Petroleum Institute	FLCPH	Fleet Logistics Center Pearl Harbor
ASCE	American Society of Civil Engineers	GTT	Government Technical Team
ASTM	American Society for Testing and Materials	Govt	Government
CAC	Common Access Card	GFI	Government Furnished Information
CD	Compact Disc	JBPHH	Joint Base Pearl Harbor Hickam
COR	Contracting Officer's Representative	KTR	Contractor
DBIDS	Defense Biometric Identification System	NAVFAC	Naval Facilities Engineering Command
DoD	Department of Defense	SEM	Scanning Electron Microscope
DLA	Defense Logistics Agency	SOW	Statement of Work
EDS	Energy-Dispersive X-ray Spectroscopy	USACE	US Army Corps of Engineers

END STATEMENT OF WORK

Table S Submittal List, Schedule, and Distribution

Submittal Description	Submittal Schedule			Distribution
	Initial	Govt. Review	Final	
Incident Reports	24 hrs after	-	-	EC
Project Schedule	3 WACA	1 week	-	EC
SME Consultant Resume	3 WACA	1 Week	-	EC
Safety Plan	3 WACA	2 weeks	1 WAGR	EC
Meeting Minutes	2 BD after	-	-	EC
Preliminary Liner Corrosion Assessment (PLCA) Report	1 WACO	1 Week	1 WAGR	EC
Overall Corrosion Assessment (OCA) Report	1 WACO	2 Week	2 WAGR	EC
External Report Review	1 WACO	1 Week	-	EC
Third Party Review Response	1 WACO	1 Week	-	EC

Legend / Notes:

WACA – Weeks after Contract Award
WACO – Weeks after Completion of Applicable Work
WAGR – Weeks after Govt Review
BD – Business Days
EC – Electronic Copy, subject to format / e-mail size requirements specified in the SOW
HC – Hard Copies, quantity four (4). Each hard copy shall include a CD/DVD insert including electronic copies of the report. contractor shall provide another eight (8) electronic copies of the report on CD/DVD
[1] – Weekly reports shall be e-mailed by 1000 local time of the first following business day

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APPENDIX D

Contract Statement of Work – Access Reinforced Concrete Red Hill

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CONTRACT STATEMENT OF WORK

Project Title: Assess Reinforced Concrete Red Hill
Contract No: N39430-19-D-2170
Task Order: N3943020F4219
WON: 1675241
Contractor: Solomon Resources, LLC.
ACQR: TBD

SOW HISTORY

Version	Date	Description
Basic Award	23 Sep 2020	Original Scope
Mod	26 Oct 2020	Add efflorescence tests on 6 samples; ASTM C496 Tensile strength tests, Paragraph 2.2.4

Date: 09 Jul 2020
Submitted By: Frank Kern

Contents

1 NEED

The Red Hill Bulk Fuel Storage Facility (RHBFSF) was constructed with unique methods. Into mined vertical cavities, welded steel tank liners and steel reinforcement were installed. Using the liners as forms, concrete batched in an onsite plant was placed. The concrete was later prestressed by pressure grouting and the entire envelope was surrounded by a massive quantity of consolidation grouting.

Empirical evidence and a preliminary assessment of the RHBFSF demonstrate the concrete is in good condition. Further information about the quality and durability of the RHBFSF concrete, and the potential for corrosion in the reinforcement is needed. The basis for this information is an analysis of mechanical, physical, and material properties. Due to characteristics of the facility and the potential for deleterious consequences of ad hoc destructive testing, a deliberate approach that will mitigate damage to the infrastructure is necessary.

1.1 Background

During construction of the RHBFSF, an onsite batch plant was used to prepare the concrete as well as crush, classify, and convey aggregate. The source of the aggregate was the mining operation which produced cavities that became the adits, tunnels, and tanks. An exception to this process was Tanks 1-3 which used ready-mix concrete procured from a local supplier during construction.

A preliminary assessment of the concrete, consistent with ACI 364-1R was initiated in 2018. During that assessment, a review of pertinent design and construction documentation and relevant literature was performed, a visual examination of the condition of the concrete was conducted, an appraisement of the technical standard of care used during design and construction was made, and laboratory test results from material samples obtained by others were reviewed. Samples of powdered efflorescence were obtained from gunite surfaces for examination.

1.2 Goals and Objectives

The goals of this project are to expand on the previous assessment, issue a preliminary report, and better inform Navy and DLA. The primary objective is to acquire concrete samples, test them in a laboratory, analyze results, and produce a preliminary assessment report of the reinforced concrete. Secondary objectives are to provide Subject Matter Expert (SME) Consultant services in the form of review and analysis of expert documents, participation in stakeholder and public meetings, testimony before regulatory agencies regarding the assessment, and briefing Navy and DLA leadership.

1.2.1 Assessment Plan Overview

In accordance with guidance in USACE EM 1110-2-2002, this study is intended to further the preliminary assessment already initiated with laboratory tests and analyses of specimens of the RHBFSF concrete. Pursuant to principles of ASTM C823/C823M, the current working hypothesis is the concrete is in good condition. Thus, the need for the assessment is not due to concrete deterioration or a failure to perform to expectations. Rather, the intent is to provide information to be used, consistent with principles of ACI 364-1R, to broaden the base of knowledge about the reinforced concrete and further inform the hypothesis. Information about service life will be developed considering concepts in ACI 365.1R.

In order to characterize the reinforced concrete at the Facility, the plan is to acquire data that bracket conditions both geometrically (upper and lower) and temporally (early, middle, late). These data will be compared to similar-vintage specimens. Concrete specimens will be obtained from three tanks as well from a vent structure.

Tests followed by qualitative and quantitative analyses will be performed on the specimens in the following categories.

a. Physical Properties

b. Chemical Properties

c. Petrographic Properties

2 REQUIREMENTS

In order to meet project goals, this Statement of Work (SOW) contains requirements to obtain samples of concrete, procure laboratory testing and petrographic examination of the samples, analyze results by a consultant SME, and produce a concrete assessment report. The test program, data, results, analysis, and report (collectively: Test) are non-disclosable. Individuals involved will be required to sign a statement of non-disclosure.

Provide means and methods to execute this SOW which includes the Task Order Specifications. Provide appropriate subcontractor support from qualified companies, consultant(s), and specialists to execute this SOW. Provide and distribute submittals in accordance with Table S and Task Order Specifications.

2.1 Task 1 Concrete Sample Acquisition

Contractor and subcontractor employee(s) shall conduct themselves in a proper, efficient, courteous, and businesslike manner. Coordination and cooperation with others is a key element to success, and is required. The Contracting Officer may require the contractor remove from the work any individual the Govt reasonably determines is uncooperative, unqualified, fails to perform satisfactory work, is careless, objectionable, contrary to public interest, or acts inconsistent with the best interests of National Security.

2.1.1 Concrete Cores

Engage a qualified mechanical contractor experienced and badged for entry into RHBFSF. Remove and secure eight core samples of reinforced concrete in accordance with Section 02 25 16.00 20. Approximate size of each sample is a 6-inch diameter x 12-inch long cylinder. Obtain three samples from areas accessed by the upper tunnel, and three from areas accessed by the lower tunnel. Two cores will be obtained from an atmospheric vent structure on the exterior of the facility. Assume interior samples are horizontal, blind cores removed from below the manway plug and at the base of the product piping bulkhead in the respective cross-tunnels of Tanks 1, 5, and 19. Assume the exterior samples are horizontal, blind cores at locations accessible without scaffold. Govt will designate locations for each sample. Assume 1P 120V 15A electrical service is available within 100-feet of each interior core location, and use a portable generator on the exterior location. Assume the concrete is very hard with large, basalt aggregate. Cores are expected to cross at minimum #8 steel reinforcement.

2.1.2 Documentation

Record and provide core specimen removal information in accordance with Section 02 25 16.00 20. Use the Concrete Core Information Form included as GFI.

2.1.3 Repair of Concrete

Minimize the time between removal of a core and repair of the cavity. Protect the hole from contamination at all times. Repair the cavity in accordance with Section 02 25 16.00 20. Do not allow repair materials to be damaged or contaminated.

2.1.4 Core Handling, Preparation, and Shipping

Take and maintain custody of the core samples from time they are removed to the time they are delivered to the shipping company. Provide rugged watertight shipping cases pursuant to Section 02 25 16.00 20.

Use commercial transport with tracking and signature service to deliver the core specimens to the test laboratory. Handle, prepare, protect, pack, and ship the core specimens in accordance with Section 02 25 16.00 20. At the conclusion of testing and petrographic examinations, ship the mounted sections and the shipping cases containing fitted polyethylene foam to the Navy laboratory at the direction of the Contracting Officer Representative (COR).

2.2 Task 2 Laboratory Testing, Examination, and Reports

All test notes, data, photographs, specimens, sections, results, designs, comments, recommendations, specifications, and other documents collected and produced as part of this contract are property of the Govt. These data or images shall not be used, in whole or part, published or unpublished, in any technical or non-technical presentation, or otherwise released by the contractor without prior written approval of the Contracting Officer.

Provide sample preparation, laboratory testing, and report by an accredited laboratory to accomplish goals and objectives of this SOW and in accordance with Section 02 25 16.00 20. Analyze physical and chemical properties, and perform petrographic examination on the concrete specimens in two phases. Analyze chemical properties on six samples of powdered efflorescence which will be provided by Govt. Overall objectives of the laboratory testing and examination are below.

a. Provide the basis for SME analysis.

b. Determination of the condition of the concrete.

c. Determination of probable future performance of the concrete.

2.2.1 Laboratory Accreditation

Use an experienced laboratory accredited, in accordance with Section 02 25 16.0 20, by ISO 17025 for test methods to be performed.

2.2.2 Efflorescence Samples

Perform tests on the efflorescence samples and report their primary chemical constituents. They are expected to contain carbonates.

2.2.3 Phased Laboratory Examination

In Phase 1, perform and report a visual inspection and photo documentation of each specimens. Perform an initial petrographic examination to identify differences in the concrete, determine which are suitable for strength testing and which are suitable for other testing, and inform a recommended plan for the palette and sequence of physical, chemical, and petrographic tests on the specimens. Once determinations are made, schedule a Lab Test Plan meeting with the GTT and the SME Consultant to discuss the plan.

In Phase 2, execute the plan along with preliminary petrographic analysis to determine which specimens are most suited for ASTM C457 testing. Assess the quantity of SEM examinations recommended to be conducted.

2.2.3.1 Lab Test Plan Meeting

Purpose is to achieve concurrence between the Laboratory, the SME Consultant, and the Government technical team as to which tests will be conducted and the proposed order of testing. Duration is not expected to exceed 2 hours. Electronic means are commercial voice, or web conferencing (Zoom, Google, Skype, Microsoft) without video capability.

2.2.4 Physical Properties

Perform tests on the concrete specimens in accordance with Section 02 25 16.00 20. Test compressive

strength on specimens from early, middle, and late batch production categories. Test two samples and report results for splitting tensile strength (Brazilian) per ASTM C496.

2.2.5 Chemical Properties

Perform tests on the concrete specimens in accordance with Section 02 25 16.00 20. Test soluble chloride and sulfate concentration as a function of depth of concrete from the surface.

2.2.6 Petrographic Examination

Perform tests on the concrete specimens in accordance with Section 02 25 16.00 20 and ASTM C856. Prepare, mount, and polish thin sections from the surface and interior as needed to perform examination. Capture data from at least early, middle, and late batch production categories. Specific purposes of the petrographic examination are consistent with ASTM C856 Test Specimens from Actual Service, supplemented by judgement of the petrographer during Phase 1 examinations. The complexity and depth of the required petrographic study is consistent with Stage 3 Confirmatory Identification as well as elements of Stage 4 such as air-void sizes and aggregate proportions (Poole and Sims 2016).

Use phenolphthalein to determine pH as a function of depth. Verify extent of carbonation using thin sections.

Use petrographic and polarizing light microscopy in the examinations. Expect use of advanced examination techniques such as x-ray diffraction. Select samples for scanning electron microscope examination, assuming four are required. Assess for the presence of delayed ettringite.

2.2.7 Laboratory Report

Provide a report which contains results and analysis of the individual tests. Prepare a description by the petrographer of the observations and examinations made during the examinations, and interpretation of the findings insofar as they relate to goals and objectives of this SOW. Provide the laboratory report at three levels of completion.

2.2.7.1 Draft

The Draft Report is an outline format containing placeholders for all tests and analyses. Populate the draft report with completed test results. Testing that is still in-progress and the petrographic analysis might not be included in the draft. The Draft Report is progress-type with a level of completion expected to be 75%

2.2.7.2 Prefinal

The Prefinal Report contains all test results, petrographic analysis, and incorporates Govt and Subject Matter Expert (SME) comments.

2.2.7.3 Final

The level of completion of the Final Report is ready for publication and incorporates Govt and SME comments.

2.3 Task 3 SME Consultant Work

Provide the services of a Professional Civil Engineer qualified by education and experience to perform expert services of concrete assessment. Minimum education is a doctorate in geology or geological engineering. Relevant experience in assessment of large civil structures, Koolau basalt, and corrosion mechanisms in reinforced concrete is required. Submit SME Consultant resume for Govt approval.

2.3.1 Laboratory Report Analysis

Review and provide comments on the laboratory report and individual tests performed on the concrete

specimens. Expect laboratory report iterations of draft, prefinal, and final.

2.3.2 External SME Report Analysis

It is expected external experts will produce documents and reports pertaining to RHBFSF concrete. Provide peer review and critical analysis of the reports. The initial audience for the review and analysis is the GTT. However, expect discussion of external documents and reports to be a topic during electronic or onsite meetings with external stakeholders. Quantity of external document and report reviews is given in Table 2.1. Assume each report or document requires 6 hours for review and analysis.

Table 2.1 External Report Review

Type	Quantity (ea)
Technical Document	3
Corrosion or Repair Practices Report	2

2.3.3 Preliminary Nature of Assessment

Quantitative data are not available for all the concrete at Red Hill. In addition, the mix design is not known. For those reasons the assessment will be produced as preliminary and subject to change should further data become available.

2.3.4 Preliminary Concrete Assessment

Use the Preliminary Assessment initiated in 2018, the Laboratory Report, the literature, Red Hill storage tank construction and inspection records, and the petrographic analysis as the basis for a Preliminary Concrete Assessment Report. Compare, contrast, and characterize the Red Hill concrete environment with typical examples in the literature such as (Petti, et al. 2011), (P. K. Mehta 1988), (Ozaki and Sugata 1988), and (Tuutti, 1982). Consider adjectival classifications of environmental aggressivity provided in (Schiessel and Bakker 1988).

Informed by basis data, provide site-specific insight into concepts of residual service life considering (Tuutti, 1980) and (Andrade, Alonso and Gonzalez 1990), as well as durability considering (Samarin 1987), (Naus and Ellingwood 1986), and (Mehta and Monteiro 2006). Interpret chloride concentration results as they relate to durability and limitations inherent to the method.

Use the comparator cores as analogues to draw distinctions or similarities in materials or condition. Develop and discuss a preliminary performance analogue.

2.3.5 Preliminary Concrete Assessment Report

Use the services of a technical writer if necessary to prepare and format the report to the level required for publication. Below is an overview of expected elements in the preliminary report.

a. Identified performance issues or degradation mechanisms
b. Specimen to comparator analogue
c. Estimation of water to cement ratio
d. Characterization of the environment
e. Suitability of concrete for the environment
f. Quality of the concrete

g. Condition of the concrete

    1) Potential for ingress of corrosion inducing substances

h. Probable future performance of the concrete

i. Likelihood of performance impediments due to corrosion in the reinforcement

Plan three progress submittals and a record preliminary report as noted below.

2.3.5.1 Draft

The Draft Report is an outline format containing placeholders for all known elements. Populate the draft report with known test result information from the Laboratory Report. The level of completion of the Draft Report is expected to be 50%

2.3.5.2 Prefinal

The Prefinal Report contains fleshed-out analysis for all elements, complete test result information from the Laboratory Report, and incorporates Govt comments. Some conclusions and recommendations might be in draft. The level of completion of the Prefinal Report is expected to be 100%.

2.3.5.3 Final

The Final Report contains PreFinal contents expanded to full analysis for all elements, conclusions supported by data and graphics, and incorporates Govt comments. The level of completion of the Final Report is ready for publication and incorporates Govt comments. Final is the last Govt review.

2.3.5.4 For Record

The record report incorporates Govt comments and includes signed professional seal(s) and is the Preliminary Concrete Assessment Report.

2.3.5.5 Third Party Review Response

Review and commentary on the report will take place by external third parties and Regulatory Agencies (RA). Expect rounds of reviews to take place at any level of completion. Some review comments might not require a report revision and will only require a response to comments. In response to the third party and RA review comments, provide SME Consultant analysis and report deliverables per Table 2.2. Assume minor effort requires 4 hours, and substantial effort requires 12 hours of time.

Table 2.2 Third Party Review Responses

Work Item	Type	Quantity (ea)
Analysis	Minor	6
Analysis	Substantial	2
Review and Response to Comments	Minor	5
Review and Response to Comments	Substantial	2

Report Supplement	Minor	4
Report Supplement	Substantial	2

2.3.6 Electronic Meetings and Phone Calls

Provide SME consultant attendance and participation in technical, quality, and status meetings with the GTT. Meetings will be conducted only an as-needed basis. Assume periodicity ranges from once every two weeks to once per month. Duration is not expected to exceed 1 hour each. Assume electronic means are commercial web conferencing (Zoom, Google, Skype, Microsoft) without video capability.

2.3.7 Participation in Public and Regulatory Agency Meetings

Provide SME consultant participation in onsite and electronic public, Govt, and RA meetings. Assume electronic meetings are telephonic or commercial web conferencing (Zoom, Google, Skype, Microsoft). Using these means, video conferencing may take place with voice supplemented with pdf screen presentation as backup. See paragraph Mobilizations for onsite meeting requirements.

Meetings with RA will involve interaction, commentary, and criticism from forensic and specialty consultants representing their respective clients. Meetings with public will involve direct interaction with individuals and organizations representing the full range of technical knowledge and experience.

Provide SME Consultant electronic meeting participation per Table 2.3. See paragraph Work Hours for time of day requirements.

Table 2.3 Electronic Meeting Participation Schedule

Type of Involvement	Quantity of Meetings	Hours (per meeting)
Participation, Govt Only	6	2
Participation, Govt + RA	5	3
Participation, Govt + RA + Public	2	6
Presentation to Govt	2	3
Presentation to Govt + RA	2	3

2.3.8 Mobilizations

Provide SME consultant mobilizations to support the concrete assessment as well as participate in onsite Govt, RA, and public meetings. Assume onsite meetings take place in Honolulu. Assume each mobilization requires five days (two travel days, three work days). Quantity and purpose of mobilizations is per the Table 2.4.

Table 2.4 Mobilization Schedule

Type of Participation	Quantity (ea)
Concrete Review	1

Govt Meeting	2
RA Meeting	1
Public Meeting	1

2.4 Schedule

Within three weeks of award, provide a schedule which details performance of all work in this SOW. Use placeholder dates for the mobilizations. Other than the onsite concrete review, assume mobilizations take place at and after production of the Final Preliminary Concrete Assessment Report.

2.5 Informative References

Andrade, C, M.C. Alonso, and J.A. Gonzalez. 1990. "An Initial Effort to Use the Corroion Rate Measurements for Estimating Rebar Durability." *Corrosion Rates of Steel in Concrete.* Ann Arbor: American Society for Testing and Materials. 29-37.

Mehta, P K. 1988. "Durability of Concrete Exposed to Marine Environment - A Fresh Look." *Second International Conference on the Subject of Performance of Concrete in Marine Environment.* Detroit: American Concrete Institute. 1-29.

Mehta, P. Kumar, and Paulo J M Monteiro. 2006. *Concrete Microstructure, Properties, and Materials, 3rd Ed.* New York: McGraw-Hill.

Naus, D J, and B R Ellingwood. 1986. *Report on Aging of Nuclear Power Plant Reinforced Concrete Structures.* Technical Report, Oak Ridge: Oak Ridge National Laboratory.

Ozaki, S, and N Sugata. 1988. "Sixty-Year-Old Concrete in a Marine Environment." *Second International Conference on the Subject of Performance of Concrete in Marine Environment.* Detroit: American Cocrete Institute. 587-597.

Petti, Jason P, Dan Naus, Richard E Weyers, Bryan A Erler, Neal S Berke, and Alberto Sagüés. 2011. *Nuclear Containment Steel Liner Corrosion Workshop: Final Summary and Recommendations Report.* Technical Report, Albuquerque: Sandia National Laboratories.

Poole, Alan B, and Ian Sims. 2016. *Concrete Petrography, A Handbook of Investigative Techniques.* Boca Raton: CRC Press.

Samarin, Alek. 1987. "Methodology of Modeling for Concrete Durability SP 100-62." *Concrete Durability Katherine and Bryant Mather International Conference.* Detroit: American Concrete Institute. 1205-1225.

Schiessel, Peter, and R. Bakker. 1988. *RILEM Report 60-CSC Corrosion of Steel in Concrete.* RILEM Technical Committee 60-CSC, New York: Chapman and Hall.

Tuutti, K. 1982. *Corrosion of Steel in Concrete.* Research Thesis, Stockholm: Swedish Cement and Concrete Research Institute.

Tuutti, K. 1980. "Service Life of Structures with Regard to Corrosion of Embedded Steel SP 65-13." *International Conference on Performance of Concrete in Marine Environment.* Detroit: American Concrete Institute. 223-236.

2.6 Normative References

ACI 207.3R (2018) *Report on Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions*

ACI 364.1R (2019) *Guide for Assessment of Concrete Structures before Rehabilitation*

ACI 365.1R (2017) *Report on Service Life Prediction*

ASTM C33/C33M (2018) *Standard Specification for Concrete Aggregates*

ASTM C39/C39M (2020) *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*

ASTM C42/C42M (2018a) *Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*

ASTM C295/C295M (2019) *Standard Guide for Petrographic Examination of Aggregates for Concrete*

ASTM C387/C387M (2017) *Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar*

ASTM C457/C457M (2016) *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*

ASTM C469/C469M (2014) *Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression*

ASTM C642 (2013) *Density, Absorption, and Voids in Hardened Concrete*

ASTM C823/C823M (2012, R2017) *Standard Practice for Examination and Sampling of Hardened Concrete in Constructions*

ASTM C856/C856M (2020) *Standard Practice for Petrographic Examination of Hardened Concrete*

ASTM C1218/C1218M (2017) *Standard Test Method for Water-Soluble Chloride in Mortar and Concrete*

ASTM C1723 (2016) *Standard Guide for Examination of Hardened Concrete Using Scanning Electron Microscopy*

ASTM D4327 (2017) *Standard Test Method for Anions in Water by Suppressed Ion Chromatography*

USACE ER 1110-2-2002 (1995) *Evaluation and Repair of Concrete Structures*

3 GENERAL REQUIREMENTS

Comply with Task Order Specifications, all federal, state, and local regulations. As used in the Task Order Specifications, the term construction refers to any construction-type support activity which is required to execute this Statement of Work.

Coordinate planned work activities with the Government Technical Team (GTT). Report exceptions and deviations from this Statement of Work to the Contracting Officer. Only the Contracting Officer has the authority to authorize work or de-scope work elements of this Task Order.

3.1 Work Hours

Unless otherwise indicated, onsite concrete assessment work will be located on a Govt compound, military installation, or station. Work hours are normally eight-hour days between 0700 and 1700 Monday through Friday. Obtain advance approval from the Contracting Officer for contractor personnel to remain on site beyond normal working hours. Notify the Contracting Officer at least 48-hours in advance to obtain approval for access to the jobsite or work outside of normal working hours or on Saturday, Sunday, and Federal Holidays.

Unless otherwise notified, SME Consultant meetings with Govt and RA will take place during normal business hours, Hawaii Standard Time. Meetings with the public are expected to take place between the hours of 1200 HST – 2100 HST.

3.2 No Waiver by the Government

The failure of the Govt in any one or more instances to insist upon strict performance to any of the terms of this contract or to exercise any option herein conferred shall not be construed as a waiver or relinquishment to any extent of the right to assert or rely upon such terms or options on any future occasion.

3.3 Information Security

Security requirements apply to all contractors, subcontractors, and suppliers associated with this contract. In addition to special or extraordinary security requirements, comply with the following:

a. Do not publicly disclose information concerning any aspect of the condition reports or services relating to this contract, without prior written approval of the Contracting Officer.

b. Do not disclose or cause to be disseminated information concerning the operations of the activity, operations of the activity's security, or information regarding the continuity of operations.

c. Do not disclose any information to any person not entitled to receive it. Failure to safeguard any classified information that may come to the Contractor or any person under his control, may subject the Contractor, his agents or employees to criminal liability under 18 U.S.C., Sections 793 and 798.

d. Direct to the Contracting Officer or Installation Security Officer for resolution all inquiries, comments or complaints arising from any matter observed, experienced, or learned as a result of or in connection with the performance of this contract, the resolution of which may require the dissemination of official information.

e. Coordinate photography with Installation requirements.

f. This effort will result in an aggregation of information which is sensitive and is protected from disclosure. A non-disclosure agreement will be required. Certain documents must be labeled privileged from disclosure.

Deviations from or violations of any of the provisions of this section, will, in addition to all other criminal and civil remedies provided by law, subject the Contractor to immediate termination for default and withdrawal of the Govt acceptance and approval of employment of the individuals involved.

3.4 Proprietary Rights

All field notes, drawings, photographs, specimens, reports, findings, data, and documents collected and produced as part of this contract become property of the Govt. These data shall not be used, in whole or part, published or unpublished, as a part of any technical or non-technical presentation, or otherwise released by the Contractor without written approval of the Contracting Officer.

3.5 Installation Access and Red Hill Badging

Within five days after award, for workers requiring Red Hill access, submit request(s) for access and badges in accordance with Task Order Specifications, DBIDS for JBPHH, and FLCPH Badging Flowcharts. Fulfill required background investigation information requests within one week of initiation. For workers already in possession of DBIDS access, a CAC, or a Red Hill badge, coordinate access requirements with the COR.

3.6 Safety and Occupational Health Requirements

Comply with USACE EM 385-1-1 and Section 01 35 26. Ensure a qualified Site Safety and Health Officer is onsite during work at Red Hill.

Submit matters of interpretation of standards to the COR for resolution before starting work. Where the requirements of this SOW, Task Order Specifications, applicable laws, criteria, ordinances, regulations, and referenced documents vary, the most stringent requirements shall apply. Govt safety oversight will be led by designated representatives.

3.6.1 Accident Notification and Reports

For recordable injuries and illnesses, and property damage accidents resulting in at least $2,000 in damages, contractor shall:

a. Provide initial notification via telephone or email as soon as possible from the time of mishap.

b. Provide initial contractor Incident Reporting System (CIRS) report within 4-hours of mishap.

c. Conduct an accident investigation to establish the root cause(s) of the mishap.

d. Provide final CIRS report within five calendar days of mishap.

e. COR will provide forms or electronic system access for CIRS report.

Notify the Contracting Officer as soon as practical, but not later than four hours, after any accident meeting the definition of Recordable Injuries or Illnesses or High Visibility Accidents, property damage equal to or greater than $2,000, or any weight handling equipment accident. Include contractor name; contract title; type of contract; name of activity, installation or location where accident occurred; date and time of accident; names of personnel injured; extent of property damage, if any; extent of injury, if known, and brief description of accident (e.g., type of equipment being used, PPE used). Preserve the conditions and evidence on accident site until the Govt investigation team arrives and Govt investigation is conducted.

4 CONTRACT MEETINGS AND REPORTING

4.1 Kickoff Meeting / Teleconference

Upon Task Order award, within three weeks host a telephonic Kickoff Meeting with the GTT to establish the responsibilities of parties, to discuss the schedule, and to ensure mutual understanding of the scope. Prepare the meeting agenda. After opening remarks by the COR, lead the discussion of specific project requirements. Generate and submit meeting minutes for COR review and approval. This meeting shall occur prior to contractor personnel starting work.

4.2 Concrete Core Preparatory Phase Meeting

Schedule and hold onsite a preparatory meeting prior to starting Task 1 work. Agenda is to discuss safety, and all technical aspects of Task 1 work.

4.3 Progress Meeting/Telcon

At various times, coordinate and host progress meetings with the GTT. The intent will be to discuss progress, quality, coordination, and mutual understanding. Meetings dates will be determined later. Assume they are telephonic. The COR will notify contractor when meetings are required. Prepare and submit brief minutes of the meetings per Table S.

5 PROPOSAL

5.1 Cost

Provide a detailed cost proposal for Tasks identified in Table 5.1 required to execute work in this SOW.

Table 5.1 Cost Proposal

Task 1 Concrete Sample Acquisition, Repair, Shipping; Mechanical KTR Mobilization	$
Task 2, Laboratory Testing, Examination, and Reports	$
Task 3 SME Consulting Work	$
Administrative Submittals	$

5.2 Technical

Provide proposal with succinct detail that demonstrates understanding and compliance with the principal means and methods. Identify the SME Consultant, mechanical support subcontractor, and test laboratory.

6 OPTION ITEMS

In the event quantities of work are required in excess of what is in this SOW, Govt would like to establish unit prices for several Option Items. Should the work become necessary, unit prices will provide the basis for rapid execution of a change. Provide a fully burdened cost for optional work, using the referenced SOW paragraph as the basis for each Option Item, pursuant to the tables below. Option Item prices remain valid for the duration of the period of performance.

Only the Contracting Officer has the authority to authorize Option Item work. Do not proceed with any Option Item work unless the option has been exercised and the work is authorized by the Contracting Officer.

6.1 Option 1 - External Report Review and Analysis

Basis for the option work is paragraph External SME Report Analysis.

Table 6.1 Optional External Report Review

Type	Unit of Measure	Price
Technical Document	Each	$
Corrosion or Repair Practices Report	Each	$

6.2 Option 2 - Third Party Review Response

Basis for the option work is paragraph Third Party Review Response.

Table 6.2 Optional Third Party Review Responses

Work Item	Type, Unit of Measure	Price
Analysis	Minor, Each	$
Analysis	Substantial, Each	$
Review and Response to Comments	Minor, Each	$
Review and Response to Comments	Substantial, Each	$
Report Supplement	Minor, Each	$
Report Supplement	Substantial, Each	$

6.3 Option 3 - Electronic Meeting Participation

Basis for the option work is paragraph Appearance and Participation at Public and Regulatory Agency Meetings.

Table 6.3 Optional Electronic Meeting Participation

Type of Involvement	Unit of Measure	Price
Participation, Govt Only	Each Meeting	$
Participation, Govt + RA	Each Meeting	$
Participation, Govt + RA + Public	Each Meeting	$

6.4 Option 4 - SME Consultant Mobilizations

Basis for the optional work is paragraph Mobilizations.

Table 6.4 Optional Mobilization

Type of Participation	Unit of Measure	Price
Onsite Meeting	Each	$

6.5 Option 5 - Laboratory Testing

Basis for the optional work is paragraph Laboratory Testing and Examination.

Table 6.5 Optional Laboratory Work

Type	Unit of Measure	Price
Engineer	Hour	$
Chemist	Hour	$
Petrographer	Hour	$
SEM/EDS	Hour	$
Technician	Hour	$

7 GOVERNMENT FURNISHED INFORMATION

1. DBIDS for JBPHH
2. SECNAV 5512-1
3. FLCPH Badging Flow Charts
4. JB2 0-180
5. Task Order Specifications
6. Submittal Register
7. Concrete Core Information Form

8 PLACE OF PERFORMANCE

RHBFSF, Joint Base Pearl Harbor Hickam, Honolulu, Hawaii.

9 PERIOD OF PERFORMANCE

The anticipated period of performance is estimated to be 16 months from date of award.

10 PRIMARY POINTS OF CONTACT

Contracting Officer

Mr. Sal Vargas
NAVFAC EXWC Code ACQ72
1100 23rd Avenue, Building 1100, Port Hueneme, CA 93043-4347
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salvador.r.vargas1@navy.mil

Government Technical Team

Project Manager

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Project Engineer
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(805) 982- 1187
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Design Manager, COR
Mr. Frank Kern
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Port Hueneme, CA 93043
(805) 982- 2149
frank.kern@navy.mil

11 GLOSSARY

ACI	American Concrete Institute	EXWC	Engineering and Expeditionary Warfare Center
API	American Petroleum Institute	FLCPH	Fleet Logistics Center Pearl Harbor
ASCE	American Society of Civil Engineers	GTT	Government Technical Team
ASTM	American Society for Testing and Materials	Govt	Government
CAC	Common Access Card	GFI	Government Furnished Information
CD	Compact Disc	JBPHH	Joint Base Pearl Harbor Hickam
COR	Contracting Officer's Representative	KTR	Contractor
DBIDS	Defense Biometric Identification System	NAVFAC	Naval Facilities Engineering Command
DoD	Department of Defense	SEM	Scanning Electron Microscope
DLA	Defense Logistics Agency	SOW	Statement of Work
EDS	Energy-Dispersive X-ray Spectroscopy	USACE	US Army Corps of Engineers

END STATEMENT OF WORK

Table S Submittal List, Schedule, and Distribution

Submittal Description	Submittal Schedule			Distribution
	Initial	Govt. Review	Final	
Incident Reports	24 hrs after	-	-	EC
Project Schedule	3 WACA	1 week	-	EC
SME Consultant Resume	3 WACA	1 Week	-	EC
Safety Plan	3 WACA	2 weeks	1 WAGR	EC
Meeting Minutes	2 BD after	-	-	EC
Laboratory Report	1 WACO	1 Week	1 WAGR	EC
Concrete Assessment Report	1 WACO	2 Week	2 WAGR	EC
External Report Review	1 WACO	1 Week	-	EC
Third Party Review Responses	1 WACO	1 Week	-	EC
As Found in Task Order Specifications (Submittal Register)	-	-	-	EC

Legend / Notes:

WACA – Weeks after Contract Award

WACO – Weeks after Completion of Applicable Work

WAGR – Weeks after Govt Review

BD – Business Days

EC – Electronic Copy, subject to format / e-mail size requirements specified in the SOW

HC – Hard Copies, quantity four (4). Each hard copy shall include a CD/DVD insert including electronic copies of the report. contractor shall provide another eight (8) electronic copies of the report on CD/DVD

[1] – Weekly reports shall be e-mailed by 1000 local time of the first following business day

APPENDIX E

Proposal - Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks

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Inspect and Repair Protocols Project

for Red Hill Underground Storage Tanks (IRPP RhUST)

Lloyd Hihara

14 February 2020

Hawaii Corrosion Laboratory
Department of Mechanical Engineering
Holmes Hall 302
College of Engineering
University of Hawaii at Manoa
2540 Dole St., Honolulu, Hawaii 96822
Telephone: (808) 956-2365
e-mail: hihara@hawaii.edu

Inspect and Repair Protocols Project for Red Hill Underground Storage Tanks (IRPP RhUST)

L.H. Hihara

IRRP RhUST proposes to 1) elucidate the limits of nondestructive evaluation on severely corroded steel panels with adherent corrosion products, 2) determine in situ corrosion rates of the steel shell of the Red Hill underground fuel storage tanks (USTs), and 3) evaluate repair and patch protocols to prevent premature failures.

Low-frequency electromagnetic testing (LFET) is frequently used to examine the remaining wall thickness of the UST steel shell plates. Thick, adherent steel corrosion products (i.e., magnetite) on the back side of the plates could affect the LFET signals and indicate remaining wall thicknesses greater than actual values. To study the extent of which magnetite and other steel corrosion products can affect LFET signals, control test panels will be fabricated by generating an array of pits of varying geometries and sizes. Three dimensional profilometry scans will be conducted on the plates to generate three-dimensional scans of the defects, which can be later compared to LFET scans. The defects in the control panels will then be backfilled with magnetite as well as other types of rust corrosion products (e.g., goethite, lepidocrocite). The coupons with the backfill corrosion products will be later scanned using LFET and compared to the previous LFET scans (prior to back filling the defects) and compared to the 3-dimensional profilometry scans. This will determine the limits of LFET to accurately identify and screen corrosion pits on plates with adherent backside corrosion products. Ideally, additional allowances for the presence of magnetite etc. can be identified and incorporated into minimum wall thickness thresholds. The LFET scanning may be completed in a follow-on phase of this project.

Currently, the real time corrosion rates of the steel shell of the Red Hill USTs are unknown. The actual corrosion rate is needed to determine safe time intervals between scheduled maintenance. A protocol for measuring in situ corrosion rates of the UST walls will be developed and tested in the laboratory which can then be successfully applied to the actual USTs. The actual implementation to measure the corrosion rates in situ at Red Hill will depend on access to out-of-service USTs in which locations of corrosion pits are known (by prior NDE screening), and may have to be conducted on a follow-on phase.

Since steel corrosion products are expansive and can bend metal and fracture concrete, the current repair and patch protocols will be re-examined to minimize premature failures. Patch plate coupons will be fabricated and subjected to accelerated corrosion testing to gain insight on likely failure modes. The repair and patch protocols will be redesigned if necessary to maximize life expectancy. In this phase of the project, repair protocols will be studied, accelerated test coupons will be fabricated, and accelerated corrosion testing will be initiated. Study of the failure modes and modeling may be completed in a follow-on phase.

If the above tasks are successfully completed and implemented in the operation of the USTs, a more accurate assessment of the minimum wall thickness and real time corrosion rates will allow more accurate inspection and repair intervals to be determined. Improvements made to the current patch protocols may help to enhance the life expectancy of the UST wall.

The risk are low as the research will not involve compromise to the USTs. The cost for this phase of the project is $750k (Personnel $385k, Materials and Supplies $18k, Equipment $160k, Travel $2k, Overhead 185k), and proposed to be completed within approximately one year. Progress can be measured on an incremental basis by determining if the milestones on the attached Gantt chart are met.

Inspect and Repair Protocols Project for Red Hill UST

PI: Lloyd Hihara / University of Hawaii at Manoa

Objective

The proposed work is the clean, inspect, and repair category:

1) Understand the limits of non-destructive evaluation (NDE) (e.g., low-frequency electromagnetic technique (LFET)) on severely corroded steel panels with adherent backside corrosion products.
2) Understand the operating corrosion mechanisms of the underground storage tank (UST) steel shell, and obtain in situ corrosion rates. Determine if corrosion rates are stable, decelerating, or accelerating.
3) Evaluate repair and patch protocols to prevent premature failures. Since steel corrosion products are expansive and can bend metal and fracture concrete, the current repair and patch protocols should be examined under accelerated testing conditions to anticipate failure modes.

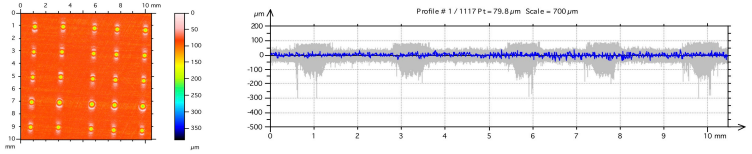


Figure 1: Example 3D and 2D profilometry scans to be compared with NDE scans.

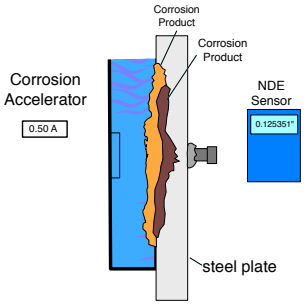
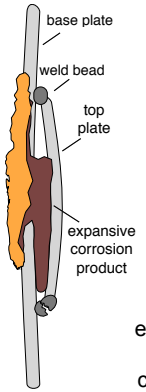


Figure 2: Mounted NDE sensor to determine in situ corrosion rates (proof of concept).

Figure 3: Possible effect of crevice corrosion and expansive corrosion products.

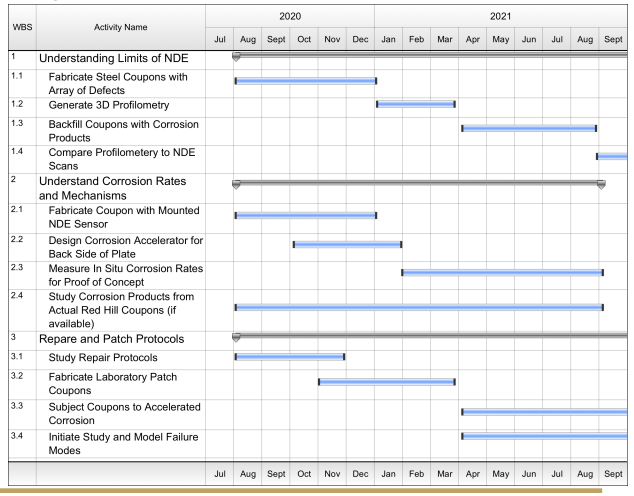


expansive steel corrosion products can fracture concrete and bend metal

Approach

1) Fabricate control steel plate specimens with defects of different sizes and geometries that are backfilled with different types of rust (e.g., magnetite, goethite, lepidocrocite). Compare 3D profilometery scans to NDE scans. The samples will be used in future LFET examinations.
2) Measure backside corrosion rates on laboratory corrosion coupons utilizing ultrasonic sensors for proof of concept. Apply in the future to out-of-service USTs
3) Fabricate welded patch-plate coupons for accelerated corrosion testing, and study failure modes.

Key Milestones



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APPENDIX F
Proposal - Concrete Tank Degradation Inspection and Retrofit

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RED HILL BULK FUEL STORAGE FACILITY
NAVFAC/NAVSUP
Concrete Tank Degradation Inspection and Retrofit

Contact: Lin Shen
Dept. Civil and Environmental Engineering
2540 Dole Street, Holmes Hall 383
Honolulu, Hawaii 96822
email: linshen@hawaii.edu

The objectives of this portion (secondary containment-corrosion in concrete) of the project are to 1) identify the locations and extent of cracking/degradation of the concrete and steel structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete and steel degradation based on chemical and mineralogical analysis, and 3) propose appropriate retrofitting technologies and strategies.

1) Identify locations/extents of concrete degradation

This phase will be conducted based on the findings of from the "Inspection" part of this project, where drones carrying ultrasonic, infrared, and electromagnetic sensors can provide information about the general location and extent of deterioration. Several locations will then be selected and state-of-art inspection techniques such as Half-Cell Potential (for steel corrosion probability), linear polarization method (for corrosion rate), and ground penetrating radar will be performed to get the detailed information about concrete degradation and steel corrosion. Small samples will also be collected for further lab analysis in the next phase .

2) Using chemical and mineralogical analysis of cored sample to evaluate the causes of degradation

Samples will be analyzed in the lab based on petrographic analysis, Scanning Electron Microscopy (SEM)-with Energy-Dispersive X-Ray Spectroscopy (EDS), X-Ray Diffraction, Mercury Intrusion Porosimetry, etc.

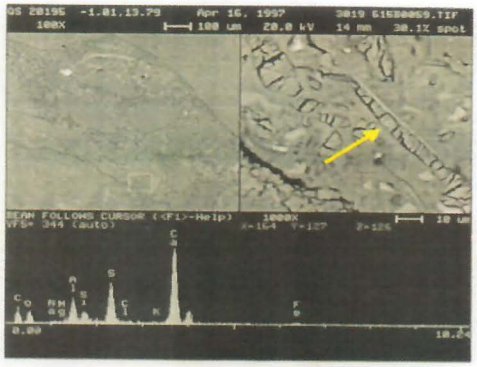


Fig1. Scanning Electron Microscopy (SEM)- with Energy-Dispersive X-Ray Spectroscopy (EDS)

There are many potential reasons for leakage and degradation of concrete and steel degradation. For example, leakage may be caused by cracking of concrete due to reaction between chemicals in the soil/ground water and concrete, or cracking due to corrosion of reinforcement, or cracking due to reactive aggregate of the concrete. The exact causes and severity of concrete and steel degradation will be identified in phase 2.

3) Propose appropriate retrofitting technologies based on the findings from 1) and 2).

Appropriate retrofitting technologies will be proposed by identifying the exact causes and extent of concrete and steel degradation based on the field inspection and laboratory analysis, and by considering the actual constructability of various retrofitting techniques for the Red Hill Fuel Storage system. For example, if voids and cracking are found responsible for leakage and degradation, low-viscosity monomers maybe injected to seal cracks and voids which are unreachable from conventional repair strategies. For repair of corroded steel layer, information about speed, probability, and extent of corrosion will greatly facilitate future retrofitting plan.

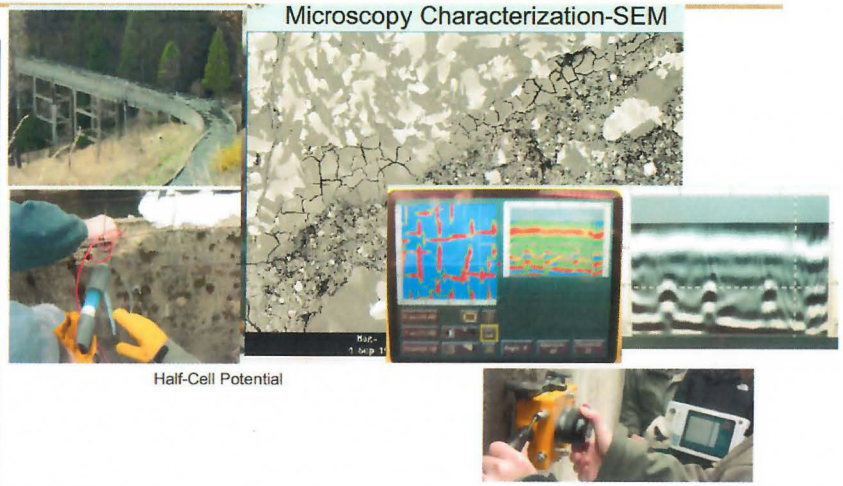
SPONSOR

Red Hill Project – 2 Secondary Containment (corrosion in concrete)

PI: Lin Shen / University of Hawaii at Manoa

Objective

The objectives of this portion (secondary containment-corrosion in concrete) of the project are to 1) identify the locations and extent of cracking/degradation of the concrete structure surrounding the oil tanks, 2) understand the causes and mechanism of the concrete degradation based on chemical and mineralogical analysis, and 3) propose appropriate concrete retrofitting technologies and strategies.



Approach

1) Identify locations/extents of concrete degradation based on the findings of PIs from the "Inspection" part of this project together with state-of-art concrete inspection techniques such as Half-Cell Potential and ground penetrating radar;

2) Using chemical and mineralogical analysis of cored sample to evaluate the causes of degradation;

3) Propose appropriate retrofitting technologies based on the findings from 1) and 2).

Co-Is/Partners: David Ma, Ian Robertson, Roger Babcock, Lloyd Hihara et al.

Key Milestones

- Milestone #1 Identify locations/extents of concrete degradation
  6 month after NTP
- Milestone #2 Analyze samples and evaluate causes of degradation
  12 months after NTP
- Propose appropriate retrofitting technologies and strategies
  18 mon after NTP

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APPENDIX G

Proposal - Element, Phase, and Oxidation State Mapping of Red Hill UST Corrosion by Advanced Microscopy Methods

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Red Hill Corrosion Monitoring for Mitigation: Element, Phase, and Oxidation State Mapping

White Paper on the Red Hill Bulk Fuel Storage Facility

PI: Dr. Hope Ishii, hope.ishii@hawaii.edu, HIGP POST 602, 1680 East-West Rd, Honolulu, HI
Organization: Advanced Electron Microscopy Center, University of Hawai'i at Mānoa

Corrosion is a fluid-mediated redox phenomenon that modifies oxidation state, structure, and composition. It often initiates around nanoscale defects, rapidly propagates, and ultimately leads to failure. Fuel tanks located in the Red Hill Bulk Fuel Storage Facility (U.S. Navy) regularly undergo non-destructive examination methods to monitor the effects of corrosion and metal fatigue. Recently, destructive testing was also performed, and the impact of corrosion on tank wall thickness was measured in coupons extracted at the exterior surface in contact with the concrete casing [1]. The analyses validate the current non-destructive methods, but the underlying corrosion problem has yet to be addressed. The local water source(s)/pathway(s), and specific corrosion mechanism(s) that result, are not yet well understood. The current solution is a literal Band-Aid: Where a tank wall has lost thickness due to corrosion, an extra layer of steel is welded in place to retain structural integrity. The Navy's ongoing interest in improving fuel storage has resulted in discussions of upgrades and new fuel tank designs, and we propose to contribute to these future improvements and to ongoing corrosion mitigation efforts with improved understanding of the corrosion mechanisms operating in existing tanks.

We propose three objectives: 1) Determine the micrometer-scale corrosion pathways and roles of indigenous/induced structural defects; 2) Search for foreign corrosive species, check for concentration and/or oxidation state gradients, and seek their source(s) in local materials; and 3) Assess the possibility of distinguishing historic from contemporary corrosion episodes.

We will characterize fuel tank samples using state-of-the-art electron and ion beam instruments, unique in the State of Hawai'i. They are a focused ion beam–scanning electron microscope (FIB-SEM, Fig. 1) with energy dispersive x-ray spectrometer (EDS) and a scanning transmission electron microscope (S/TEM) with electron energy-loss spectrometer (EELS) and EDS (Fig. 2). They provide images and spectral maps for visualizing structure and morphology as well as corrosion product distribution, phases, compositions, and oxidation states in sample regions of centimeters down to the nanoscale. See attached quad chart.

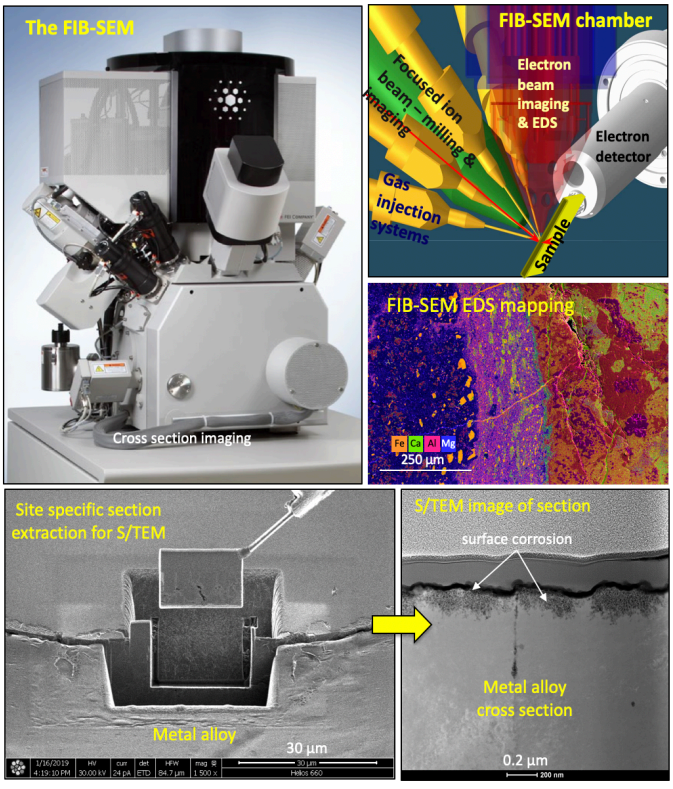
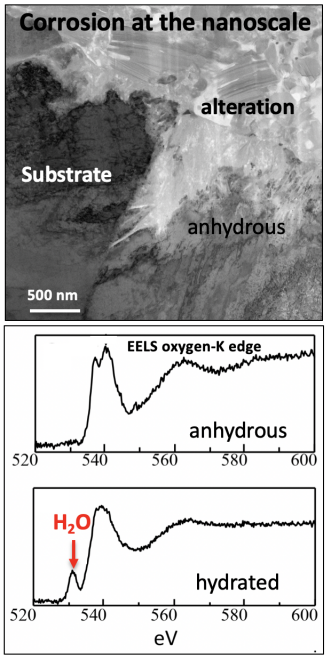


Figure 1: *The FIB-SEM, interior schematic, and examples of element mapping by EDS, site-specific cross-section by FIB for mapping, and coupon extraction for S/TEM imaging.*

Specifically, we will first image and map element composition on large areas of corroded surfaces for overall chemistry and morphology. This low- to high-magnification approach mitigates the risk of focusing on non-representative regions. We will then generate cross-section, image, and map compositions of the corroded interface to investigate the relationship of corrosion to defects that may facilitate corrosion (delamination, fractures, grain boundaries, manufacturing defects, etc.), assess local scale corrosion depth and material loss, determine corrosion product phases, and assess foreign corrosive species that may act as "tracer" elements to fingerprint water pathways and distinguish old from new corrosion. Gradients in "tracer" species, if present, will be mapped, and additional analyses materials surrounding the tank (e.g. concrete casing, gunite, basalt bedrock) may lead us to the source(s) of those species. For a selected subset of samples, we will extract micrometer-sized coupons in cross-section in order to obtain high-resolution imaging, element maps, and oxidation state maps in corrosion products. We will map the oxidation states of iron as well as those of "tracer" elements.

We propose to study coupons from multiple regions in the tank to ensure robust and statistically significant findings. For cost and time estimates, we assume a total of 6-8 coupons. If all coupons are allocated at the project start, we estimate that work can be completed within 6 months. Initial analysis by SEM and EDS typically requires 1-2 hrs/sample (depending on sample dimensions). Based on the initial analyses, a subset of coupons will be subjected to higher spatial resolution analysis and oxidation state analysis: Site-specific, electron-transparent coupons will be extracted using the FIB, a process that typically requires 4-6 hrs. These will be characterized by S/TEM-EDS and -EELS, typically 1-2 hrs/sample. The fee for SEM-FIB is $110 per hour and STEM-EDS and -EELS is $160/hr. Total project cost and duration will depend on total number of samples provided.

Figure 2: *S/TEM imaging and oxygen EELS spectrum demonstrating hydration.*



We expect our proposed investigation to provide significant insights into the underlying cause(s) and mechanisms of corrosion of the Red Hill tanks, key input for design of future tanks, and a potential way to determine if corrosion is historic or contemporary. Our team (Ishii, Bradley and Ohtaki) has extensive experience in characterization of weathering and corrosion phenomena in metals, alloys, ceramics (including concretes), and geological materials.

References: [1] T.N. Ackerson and J. Breetz (IMR test lab) "Destructive Analysis of 10 Steel Coupons Removed from Red Hill Fuel Storage Tank #14" Report No. 201801967 (2018). [2] K.K. Ohtaki, J.P. Bradley, H.A. Ishii "Combined focused ion beam-ultramicrotomy method for TEM specimen preparation of porous fine-grained materials." *Microsc. Microanal.* doi: 10.1017/ S1431927619015186 (2019). [3] G.B. Freeman, B.R. Livesay, J.P. Bradley et al. "Intermetallic embrittlement of thin unsupported tin/copper specimens", *J. Electronic Mat*. 23 (9), 1-7 (1994). [4] T.A. Abrajano, J.K. Bates, J.P. Bradley, "Analytical Electron Microscopy of Leached Nuclear Waste Glasses," *Ceramic Trans.* 9, 211-228 (1990). [5] C. Zevenbergen, J.P. Bradley et al., "Natural weathering of MSW bottom ash in a disposal environment." *Microbeam Analysis* 3, 125-135 (1994). [6] Graham G.A. et al. "Applied focused ion beam techniques for sample preparation of astromaterials for integrated nano-analysis." *Meteor. Planet. Sci.* 43, 561-569 (2008).

Red Hill Corrosion Monitoring for Mitigation:
Element, Phase, and Oxidation State Mapping

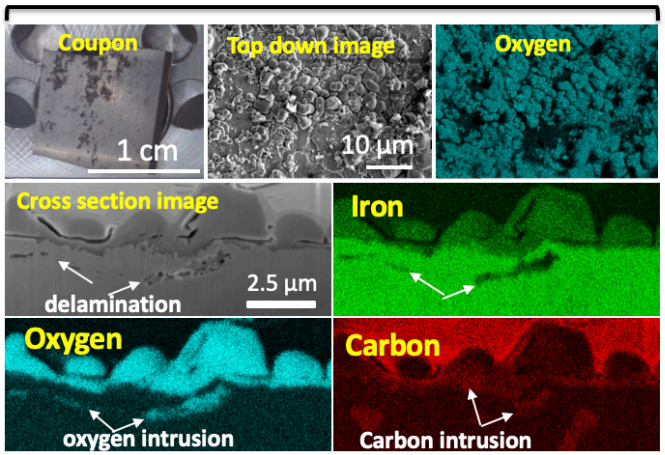
PI: Dr. Hope Ishii / Advanced Electron Microscopy Center, U. Hawai'i at Mānoa

Objectives

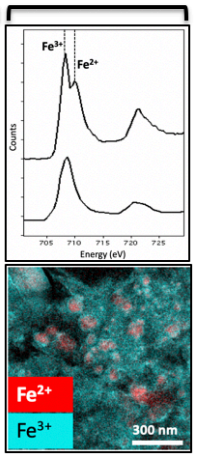
1. Determine the micrometer-scale corrosion pathways and roles of indigenous and induced structural defects (surface delamination, intrusion at fractures, grain boundaries, or manufacturing defects, etc.).
2. Search for foreign corrosive species ("tracers"), check for concentration and/or oxidation state gradients, and seek their source(s) among local materials (concrete liner, gunite, local bedrock).
3. Assess the possibility of distinguishing between historic and contemporary corrosion episodes.

Electron imaging & element and oxidation state mapping

Morphology and element distributions



Fe ox. state



Approach

1. Cut steel coupons, polish in cross-section
2. Collect electron micrographs and elemental maps with full X-ray spectrum at each pixel, first on surface, then in cross-sections
3. Extract maps of "tracer" elements, e.g. Na, K, P, Cl, S
4. Analyze local materials, as appropriate
5. Perform S/TEM oxidation state maps
6. Compare chemical maps (elemental and oxidation state) across different locations
7. Compile imaging and map data to assess corrosion pathways, tracer elements, and episodic corrosion

Co-Is/Partners: Dr. Kenta Ohtaki and Dr. John Bradley

Key Milestones

	Estimated completion*
• Project start	t_0
• Sample preparation	t_0 + 2 weeks
• Imaging & Mapping of initial sample set	t_0 + 1.5 months
• Feedback on additional sample locations	t_0 + 1.5 months
• Imaging & Mapping of follow-up samples	t_0 + 3 months
• High resolution imaging, element mapping, and oxidation state mapping	t_0 + 4 months
• Report on "tracer" elements and episodic corrosion	t_0 + 6 months
• Report on corrosion pathways	t_0 + 6 months

* Assumes 6-8 samples

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