National Park Service
U.S. Department of the Interior

Minuteman Missile National Historic Site
Phillip, South Dakota



Historic Structure Report

Delta-09 Launch Facility (LF)

Supplemental Analysis

Delta-01 Launch Control Center (LCC)

SUBMITTAL | JULY 19, 2024

PREPARED BY:
Seven Generations Architecture + Engineering, RATIO Architects, H.F. Lenz Company, ARSEE Engineers, Building Conservation Associates, Terracon, Kirk Value Planners

UNDER THE DIRECTION OF: The National Park Service, Midwest Regional Office (Regions 3, 4, 5)

Page intentionally left blank

Minuteman Missile National Historic Site

Historic Structure Report

For Delta 09 Launch Facility

Supplemental Analysis

For Delta-01 Launch Control Center

SUBMITTAL JULY 19, 2024

PREPARED BY:
Seven Generations Architecture + Engineering, RATIO Architects, H.F. Lenz Company, ARSEE Engineers, Building Conservation Associates, Terracon, Kirk Value Planners

UNDER THE DIRECTION OF: The National Park Service, Midwest Regional Office (Interior Regions 3, 4, 5)



Midwest Regional Office
National Park Service: Regions 3, 4, and 5

National Park Service
601 Riverfront Drive
Omaha, NE 68102-4226
(402) 661-1904

Minuteman Missile National Historic Site
24545 CottonWood Road
Philip, SD 57567

www.nps.gov/mimi

About the cover: Delta-09 LCC personnel access ladder. Source: Seven Generations AE.

The report presented here exists in two formats. A printed version is available for study at the park, the Midwest Regional Office of the National Park Service, and at a variety of other repositories. For more widespread access, this report also exists in a web-based format through ParkNet, the website of the National Park Service. Please visit www.nps.gov for more information.

Publication Credits: Information in this publication may be copied and used, with the condition that full credit is given to the authors, their companies, and the National Park Service. Appropriate citations and bibliographic credits should be made for each use. Notice: This manuscript has been produced by Seven Generations AE in consultation with Ratio Architects, ARSEE Engineers Inc., H.F. Lenz, Building Conservation Associates, Terracon, and Kirk Value Planners under IDIQ [140P6020D0003 / 140P6023F0037] with the National Park Service.

The United States Government retains and the publishers, by accepting the article for publication, acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes. United States Department of the Interior Mission Statement: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Minuteman Missile National Historic Site

Historic Structure Report

For Delta 09 Launch Facility

Supplemental Analysis

For Delta-01 Launch Control Center

ABIGAIL ALDRICH Digitally signed by ABIGAIL ALDRICH
Date: 2024.07.30 08:26:07 -06'00'

Approved by :

Superintendent Date

STEPHANIE STEPHENS Digitally signed by STEPHANIE STEPHENS
Date: 2024.07.31 13:52:51 -04'00'

Recommended by :

Chief, Cultural Resources, Partnerships and Science Division, Midwest Region Date

Digitally signed by HERBERT FROST
Date: 2024.08.02 16:17:40 -05'00'

Approved by :

Regional Director, Midwest Region Date

Page intentionally left blank

Table of Contents

Executive Summary and Administrative Data 11

Report Summary 11

Project Purpose and Need 11

Report Organization and Methodology 12

Summary of Treatment Recommendations 13

Project Data 13

Administrative and Location Data 13

National Register Data 14

Related Studies 14

Recommendations for Future Study 14

Project Team 14

The National Park Service 14

Consultant Team 14

Part 1A. Developmental History 17

Statement of Significance 17

Period of Significance 17

Part 1B. Character Defining Features 19

Introduction 19

Delta-01 Launch Control Center (LCC) 19

Delta-09 Launch Facility (LF) 30

Part 1C. Physical Description and Condition Assessment – Delta-09 Launch Facility 33

Introduction 33

Exterior Description 33

Launch Facility 33

Soft Support Building 33

Interior Description 34

Launch Facility 34

Soft Support Building 34

Delta-09 Launch Facility 34

Physical Description (structural) 34

Delta-09 Soft Support Building 35

Physical Description (structural) 35

Condition Assessment 35

Exterior Summary Table and Condition 35

UNIFORMAT II Outline Data 35

Interior Summary Table and Condition 35

UNIFORMAT II Outline Data 35
F: Special Construction – Delta-09 Soft Support Building 36
F10: Special Construction 37
F10: Special Construction 39
F10: Special Construction 40
F10: Special Construction 47
Plumbing 50
HVAC 52
Electrical 55

Part 2A. Ultimate Treatment and Use 61

Introduction 61
Ultimate Use 61
Ultimate Treatment 61

Part 2B. Treatment Requirements 63

Hazardous Materials: Lead 63

Part 2C. Treatment Recommendations & Alternatives 65

Work by NPS Staff 65
Exterior Preservation 65
Interior Preservation 66
Maintenance Deficiency Priority Ratings (5-Year Rating Period) 67
Critical – (Emergency/Immediate) 67
Serious – (Immediate/Short Term) 68
Minor – (Short Term/Long Term) 68
Structural 68
Delta-09 Soft Support Building Exterior 68
Delta-09 Soft Support Building Interior 69
Delta-09 Launch Facility - Exterior 69
Delta-09 Launch Facility - Interior 70
Plumbing 71
Delta-09 Soft Support Building 71
Delta-09 Launch Facility 71
HVAC 71
Delta-09 Soft Support Building & Launch Facility 71
Electrical 72
Delta-09 Soft Support Building 72
Delta-09 Launch Facility 73
Treatment Options Evaluation Table 74

Appendix A. Hazardous Materials 87

Appendix B. Paint Conservation Analysis 155

Appendix C. Structural Inspection Reports 245

Appendix D. Site Investigation Report 327

Appendix E. Existing Condition Drawings 343

Appendix F. Treatment Drawings 359

Appendix G. Cost Estimate 375

Page intentionally left blank

Executive Summary and Administrative Data

Report Summary

Project Purpose and Need

This document supplements the Historic Structure Report, Cultural Landscape Report and Environmental Assessment produced by Quinn Evans Architects in 2010, referred to in various sections of this document. Due to scope limitations, the 2010 HSR did not study the underground resources in depth. Therefore, this report focuses primarily on the features and components of the Delta-09 Launch Facility (missile silo, associated infrastructure and Soft Support Building) with supplemental analysis of Delta-01 Launch Control Center, the below grade capsule under the Delta-01 Launch Control Facility.

Resource Description

Delta-01

The underground Launch Control Center (LCC) is reached by elevator from the Launch Control Facility (LCF), a wood frame barracks facility on the surface. The elevator descends 31'8" to the V- shaped Tunnel Junction (elevator antechamber) of the LCC. The Tunnel Junction leads to the blast door that isolates the LCC capsule, a steel-reinforced pod with thick concrete walls and an interior diameter of 20 feet 6 inches and a 21 feet long cylindrical space in the center.

A bridge from the blast door leads to the Acoustical Enclosure, a suspended, shock-isolated, rectangular metal structure containing computers, equipment, and living accommodations for the Air Force personnel on rotating duty. At the opposite end of the capsule, there is a hatch to the Escape Tube which leads to the surface."

Delta-09

The Delta-09 Launch Facility (LF) missile silo and Soft Support Building are underground concrete structures within the south half of a rectangular enclosure defined by a historic security fence.

The Launch Facility (missile silo) has an orientation skewed slightly northwest from true north. The top of the silo is covered by a concrete slab at grade, with the launcher closure, a steel and concrete sliding door on two steel rails, covering the top of the Launch Tube and a circular access hatch. The launcher is now fixed in a partially open position with the opening is covered by a semi-octagonal viewing structure.

The central space of the Launch Facility is the Launch Tube, a steel-lined concrete cylinder approximately 12 feet in diameter and approximately 80 feet deep. Two service or equipment levels surround the upper part of the Launch Tube. These levels are housed within a steel reinforced concrete cylinder with an inside diameter of approximately 25 feet. The steel liner of the tube extends up through the center of both levels. The volume of the two levels is approximately 19 feet high, with the floor of the second (lower) level approximately 28 feet below grade. The equipment room levels are accessed via a ladder in the access hatch, housed within a cylindrical shaft approximately three feet six inches in diameter and connected to the equipment room levels by a corridor of the same width. The upper level has a shock-mounted floor and housed the computers and autocollimator bench. The lower level housed the batteries, generator, and air-conditioning unit.

The Soft Support Building measures roughly 14 by 24 feet and is of cast-in-place concrete. Its roof is exposed approximately 18 inches above grade. Areaways covered by steel gratings are located at the north and south ends of the building, with an access ladder and entry door in the north areaway. The interior of is a single rectangular room that contained a generator, electrical equipment, and heating, ventilation, and air-conditioning (HVAC) equipment.

Current Use

"Both Delta-01 and Delta-09 are preserved to interpret the deterrent value of the land-based portion of America's nuclear missile defense during the Cold War era and commemorates the people and events related to this key period of American history. "[1] The facilities are open to the public through guided tours (Delta-01) and un-guided access (Delta-09). Both structures are maintained to their appearance in the early 1990s when they were decommissioned by the U.S. Airforce.

At Delta-01 visitors must be accompanied by NPS staff; tours are arranged and depart from the Visitor Center. Visitors arrive at the site and park across the street where they meet their guide. Access to the Launch Control Center site is controlled via chain-link fence and accessed through a vehicular gate. On the surface, visitors are first introduced to the above ground Launch Control Facility and descend by elevator to the Launch Control Center.

The Delta-09 Launch Facility site has been developed to include a parking lot, restrooms, and interpretive shelter. The Launch Facility itself is surrounded by a chain-link fence and the launch tube is covered with a viewing structure that gives visitors a top-down view of the missile. Interpretive signage is mounted at various locations around the Launch Facility including adjacent fencing and under the nearby shelter. Visitors make the short walk from the parking lot via a paved sidewalk and enter through a gate that is locked and unlocked daily by MIMI staff.

Report Organization and Methodology

The Historic Structure Report, Cultural Landscape Report and Environmental Assessment published in October 2010 included a thorough level of research investigation of historical sources. Accordingly, this report does not include additional research. Informal interviews with MIMI staff and volunteers were conducted while onsite at both Delta-01 and Delta-09.

The structure investigation was non-destructive except for limited paint sampling to test for Hazardous Materials and paint conservation purposes.

Members of the consulting team for the HSR, Alex Hokkanen (Seven Generations AE), David Kroll and Benjamin L. Ross (RATIO Architects), Dan Calabrese (ARSEE Engineers), Paul Petrilli (H.F. Lenz), Josh Vogel (Terracon), and Zachary Marakovits (Precision Point Inc.) performed a site visit in October 2023. The purpose of the site visit was to record the current condition and catalog the character defining features of below ground resources at Delta-01 and Delta-09. This investigation is documented in Appendix D: Site Investigation Report. Field notes and digital photographs were taken to record character defining features as well as the condition of finishes, structural and mechanical systems. The team also took a series of LiDAR scans to produce a three-dimensional point cloud and Revit model that will serve as the basis for treatment drawings.

Report Organization

This report is organized into three parts (Executive Summary, Developmental History, and Treatment and Use) followed by a series of Appendices.

Part 0. Executive Summary
Part 1: Developmental History
- Part 1A. Site Significance
- Part 1B. Character Defining Features
- Part 1C. Physical Description and Condition Assessment

Part 2: Treatment and Use
- Part 2A. Ultimate Treatment and Use
- Part 2B. Requirements for Treatment
- Part 2C. Treatment Recommendations and Alternatives

Appendices
- Appendix A. Hazardous Materials Report
- Appendix B. Paint Conservation Analysis

1. National Park Service, "General Management Plan/ Environmental Impact Statement, Minuteman Missile National Historic Site," 3.

Appendix C. Ultrasonic Testing Report

Appendix D. Site Investigation Report

Appendix E. Existing Condition Drawings

Appendix F. Treatment Drawings

Appendix G. Class C Cost Estimate

Summary of Treatment Recommendations

Site

- Continue regular site maintenance.

Delta-09 Launch Facility

- Address Slab Delamination and Cracks
- Apply water repellent sealer to the concrete curbs around the viewing structure.
- Repaint protective coatings on steel surfaces to prevent corrosion.
- Regular service of Access Hatch motor and replacement of gaskets in kind to provide watertight seal.
- Glass Viewing Structure glazing replacement with improved performance for UV protection and anti-reflective performance.
- Address mold and mildew on HICS cables and other wiring following approved protocols established by a conservator familiar with these materials.
- Continued monitoring of the compromised locations as recommended by Gecko Robotics is prudent.
- Maintain historic paint finishes where possible.
- Improve interior environmental conditions to mitigate drastic swings in temperature and humidity that negatively impact the silo and its features.

Delta-09 Soft Support Building

- Remove and replace the split-slab structure concrete wear slab and underlying waterproofing membrane system.
- Repaint protective coatings on steel surfaces to prevent corrosion.
- Address mold and mildew on HICS cables and other wiring following approved protocols established by a conservator familiar with these materials.
- Continue regular maintenance and maintain historic paint finishes. See Appendix B for historic paint finishes and analysis.

Delta-01 Launch Control Center

The scope of work for this report did not include a condition assessment and treatment plan for Delta-01 LCC. Per consultation with the park and region, the following recommendations are provided:

- Continue regular maintenance and monitoring.
- Consider a future study of historic paint finishes, including evaluation of the potential to uncover overpainted morale art.

For additional information on Treatment Recommendations, Requirements, and Use for both sites see Parts 2A-2C of this document.

Project Data

Administrative and Location Data

Building Name(s):

Delta-01 Launch Control Center

Delta-09 Launch Facility

Location(s):

Southeast of Wall, South Dakota

Delta-01 LCC: 43°52’40.1”N 101°57’40.6”W

Delta-09 LF: 43.931343, -102.160039

CRIS Number:

Delta-01 Launch Control Center: 100478

Delta-09 Support Building: 100490

Delta-09 Missile Silo: 100488

Park:
Minuteman Missile National Historic Site

County:
Delta-01 Launch Control Center: Jackson

Delta-09 Launch Facility: Pennington

State:
South Dakota

NPS Region:
Region 5: Missouri Basin

National Register Data

Minuteman Missile National Historic Site was listed on the National Register of Historic Places on November 29, 1999. For additional discussion of the site's significance see the National Register Nomination and Chapter 4: Building/Landscape Analysis and Evaluation of the 2010 HSR/CLR/EA.

Related Studies

"Minuteman Missile National Historic Site: Historic Structure Report, Cultural Landscape Report and Environmental Assessment." Quinn Evans Architects, October 2010.

"Minuteman ICBM Launch Control Facility Delta-01 and Launch Facility Delta-09 Historic District." National Register of Historic Places Registration Form. Minuteman Missile National Historic Site, South Dakota: National Park Service, U.S. Department of the Interior, October 27, 2003.

Recommendations for Future Study

- NHS Oral History Project: At the time of this writing the Minuteman Missile National Historic Site is fortunate to have staff members and volunteers that possess personal recollections from the Period of Significance. The HSR team recommends the NPS conduct a formal Oral History project to seek out and record this lived experience for future generations. Short interviews were conducted for the production of the Park Film "Beneath the Plains" however, it seems that some staff were missed, or the inquiry was too narrow.

Project Team

The National Park Service

Minuteman Missile National Historic Site (MIMI)
Facility Operations Manager
Ken Thompson

Facilities Staff
Doug Bessette

Cheryl Ferguson

Curator
Alexandra Carrier

Education Technician
Jim Boensch

Volunteer
Alonzo "Al" Hall

Midwest Regional Office
Contracting Officer's Representative (COR)
John Rosemurgy

Contracting Officer
Tonya Bradley

Contracting Specialist
Nicholas Murray

Consultant Team

Seven Generations AE
Project Manager
Alex Hokkanen, Assoc. AIA, LEED AP BD+C

Project Coordinator
Taylor Cummings, Assoc. AIA, LEED AP BD+C, SEED AP

RATIO Architects
Historical Architect
Dave Kroll, Assoc. AIA

Preservation Specialist
Benjamin L. Ross, LEED AP

H.F. Lenz Engineering
Mechanical and Plumbing Engineer
Paul E. Petrilli, PE

Electrical Designer
Tyler A. Trostle

ARSEE Engineers
Structural Engineer
Daniel M. Calabrese, PE

Terracon
Environmental
Josh Vogel

Building Conservation Associates
Conservators
Dorothy Krotzer

Wei (Melissa) Lou-Hita

Kirk Value Planners
Cost Estimation
Don Parker



Figure 0.1: Minuteman National Historic Site map showing the location of the Visitor Center relative to the Delta-09 and Delta-01 sites.

Part 1A. Developmental History

Statement of Significance

The significance of the entire Delta Flight Launch Complex is discussed in Chapter 4.1: Analysis/ Statement of Significance of the combined Historic Structure Report, Cultural Landscape Report, and Environmental Assessment and applies to the underground resources. The discussion of similar resources across the country reinforces the unique role the Minuteman Missile NHS in interpreting the Cold War period and the physical infrastructure that made associated policies such as "massive retaliation" possible.

Period of Significance

This document affirms the Period of Significance determined in Chapter 4.1: Analysis/Statement of Significance of the combined Historic Structure Report, Cultural Landscape Report, and Environmental Assessment spanning from 1963 activation of the site through the 1993 deactivation of Delta-01 Launch Control Center and Delta-09 Launch Facility. The National Park Service works to maintain the appearance of both sites to the time of deactivation and turnover from the Air Force.



Figure 1A.1: Cover Page, HSR, CLR and EA prepared by Quinn Evans Architects in 2010 (Source: Quinn Evans Architects).

Page intentionally left blank

Part 1B. Character Defining Features

Introduction

Per the project scope of work, this section lists the characteristics of interior and exterior features that contribute to the physical character, integrity, and historic significance of the property. The scope of work at Delta-01 is limited to the Launch Control Center (LCC), the underground resource below the Launch Control Facility (LCF). The LCF is not included in the project scope.

Delta-01 Launch Control Center (LCC)

The Launch Control Facility (LCF) is a one-story, rectangular building built in 1963 and reflecting the Ranch style. It contained sleeping, mess, and living spaces for staff stationed here until 1993. The LCF was covered by the 2010 HSR and is not covered in this report. The LCF also contains the grade-level entrance to the elevator to the underground Launch Control Center (LCC).

The elevator descends from the LCF to the Tunnel Junction (elevator antechamber) of the LCC, a V-shaped room at the LCC level, 31feet 8 inches below the floor level of the LCF. The center lines of the two legs of this room are at a 120-degree angle from one another. The elevator leg measures 10 feet 4 inches wide while the blast door leg measures 11 feet 6 inches wide. The blast door provides entry to the capsule, a steel-reinforced concrete structure containing a pill-shaped void. The capsule measures 53 feet 9 inches long by 29 feet in diameter with walls ranging from 4 feet 3 inches to 7 feet 6 inches thick.

The capsule interior has a radius of 10 feet 3 inches, with a central cylindrical section 21 feet long. Within the capsule is the Acoustical Enclosure, a suspended, shock-isolated, rectangular metal structure containing the computers, equipment, bunk, and toilet space for the personnel on duty at the LCC. The Acoustical Enclosure is accessed via a bridge from the Blast Door. The longer sides of the capsule contain the Cable Protective Frame Enclosure and the Water Storage Tank. The Escape Tube hatch is placed nearly opposite the Blast Door opening.

Location	Feature	Contribution Status	Notes
Delta-01 Tunnel Junction (Elevator Antechamber) (LCC level)	Concrete walls, floor, and ceiling	Contributing	Both painted and unpainted
Delta-01 Tunnel Junction (LCC level)	Elevator	Contributing	Including gates, cab, and all hardware, with historic finishes
Delta-01 Tunnel Junction (LCC level)	Ladders	Contributing	Including painted finishes
Delta-01 Tunnel Junction (LCC level)	Blast door	Contributing	Including all associated hardware, frame, and bumper
Delta-01 Tunnel Junction (LCC level)	Morale art[1]	Contributing	On wall and exterior face of blast door
Delta-01 Tunnel Junction (LCC level)	Fire suppression system	Non-Contributing	
Delta-01 LCC Interior	Capsule liner	Contributing	Steel liner of capsule
Delta-01 LCC Interior	Doors	Contributing	Blast door and escape tube door
Delta-01 LCC Interior	Cable protective frame enclosure	Contributing	Enclosure on one side of capsule interior
Delta-01 LCC Interior	Water storage tank	Contributing	Enclosure on one side of capsule interior
Delta-01 LCC Interior	Acoustical enclosure and platform	Contributing	Including hangers and associated hardware
Delta-01 LCC Interior	HVAC equipment and ductwork	Contributing	All equipment from the POS
Delta-01 LCC Interior	Morale art	Contributing	Above blast door, currently covered by overpaint
Delta-01 LCC Interior	Railings at platform between blast door and acoustical enclosure	Non-contributing	Added by NPS for visitor safety

1. Morale Art is a type of folk art designed to build an esprit de corps with military personnel of a particular unit. This art often featured humorous images or slogans.

Acoustical Enclosure Interior	Computer cases and associated built-in equipment	Contributing	Including command control console, built-in desks, and other associated features
Acoustical Enclosure Interior	Chairs	Contributing	Including tracks
Acoustical Enclosure Interior	Other equipment	Contributing	
Acoustical Enclosure Interior	Built-in bunk (bed)	Contributing	
Acoustical Enclosure Interior	Toilet fixtures	Contributing	
Acoustical Enclosure Interior	Acoustical treatments	Contributing	Carpet and acoustic padding on ceiling
Acoustical Enclosure Interior	Light fixtures	Contributing	
Acoustical Enclosure Interior	Paint finishes	Contributing	

Figure 1B.1: [Right Spread] Detail of floorplan of Delta-01 Launch Control Center (LCC), 1961. The angled section at left is the elevator lobby. The elliptical section to the right is the capsule containing the suspended acoustical enclosure. Source: MIMI.

BASE STRUCTURE WALL SCHEDULE	
SITE	"W"
J-1	20"
ALL OTHER SITES	18"

REINFORCING FOR ALL BASE STRUCTURES IS THE SAME SIZE & SPACING

PLAN
TOP OF ACCESS HATCH
3/8" = 1'-0"

PLAN-PEDESTALS.
NO SCALE

SECTION Z-Z
NO SCALE

SECTION Y-Y
NO SCALE

DETAIL 1
1/2" = 1'-0"

SECTION A
1/2" = 1'-0"

PLAN
(PLAN @ ℄ L.C.C.)
3/8" = 1'-0"

TYP. LINER 12 FIELD SPLICE

TYP. LINER 12 SHOP SPLICE

OPERATIONAL AS BUILT

NOTE
1. FOR ELECTRICAL CONDUITS PENETRATING CAPSULE SEE SHT. E-10 & E-11.
2. FOR PIPING PENETRATING CAPSULE SEE SHT. P-5. & P-7
3. FOR TEMPORARY SHORING FOR L.C.C. PLATFORM SEE (2 / S-15) (BEFORE SHOCK ISOLATORS ARE INSTALLED)

"AS BUILT" DRAWING CERTIFICATION - CORPS OF ENGINEERS

FLIGHT A	4-2-63	Comp. Wonder Circle	
FLIGHT B	11-19-62		
FLIGHT C	3-7-63		
FLIGHT D	12-11-62		
FLIGHT E	1-23-63		
FLIGHT F	5-29-63	Comp. Wonder Circle	
FLIGHT G	3-22-63		
FLIGHT H	4-8-63		
FLIGHT I	1-31-63		
FLIGHT J	1-11-63		
FLIGHT K	1-28-63	Comp. Wonder Circle	
FLIGHT L	1-16-63		
FLIGHT M	3-11-63		
FLIGHT N	4-15-63		
FLIGHT O	4-25-63		

6	7-19-88	LCC LANYARD ATTACHMENTS	MCL U361	RIVET MINE LA
(3)	7-21-76	ADDED PLAN & DETAILS OF LCC FLOOR PEDESTAL SHORING DEVICES		44 CES DET
7 (2)		ADDED LIFT HANDLES & LIFT LUG AT PLAN	PAIR BORING	PARSONS
6 (10)		ADDED DIMENSIONS & DELETED CONSTRUCTION JOINT @ PLAN OF L.C.C. - REV. DET. 1 REF. AS BUILT		PARSONS
5 (1)	2-12-61	FIELD CHANGE - SHOW PLAN LOCATION OF HOIST HOOK CASE 50-MCL-283		3SS/DM RD SMB
4 (2)	2-8-61	FIELD CHANGE - 38/9E SWAY BRACE POCKET CASE 2-3		3SS/DM RD SMB
3 (2)	11-10-61	FIELD CHANGE - REVISED ACCESS HATCH DIMENSIONS (PLAN)		3SS/DM RD SMB
2 3	7-28-61	DELETE SWAY DAMPER SUPPORTS EXCEPT FOR INSERTS		DM PARSONS RD DM
1 (2)	9-22-61	REMOVED RADIATION DEVICE PLATFORM DC-6		DM/DM RD
(1)	7-14-61	ADDED GRAIN AROUND ACCESS SHAFT ON PLAN, ADDED DET. 9 SECT. A, C TYP LINER & SHOP SPLICE, ADDED NOTE 3 WASTED ZONE IN PLAN		DM/DM RD
REVISION	DATE	DESCRIPTION		AGENCY INIT.

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION (AFSC)
INGLEWOOD, CALIFORNIA

DESIGNED BY CRAIG & GRANT
DRAWN BY WILKINSON
CHECKED BY
SUBMITTED BY
DATE

A-E SHEET No. S-2
A-E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

LAUNCH CONTROL FACILITY
LAUNCH CONTROL CENTERS
PLAN

APPROVED
DATE 1 1 1961
R. K. Cranemyer MAJOR, USAF
DATE JUN 17 1961
Roy D. Simmons Capt USAF

SPECIFICATION No. FIELD CHANGE CASE 50-61-43
DATE JUNE 5, 1961 SCALE AS NOTED
CEBMCO SERIES NO. 132/13 SHEET 380

CORPS OF ENGINEERS
BALLISTIC MISSILE CONSTRUCTION OFFICE
APPROVED FOR CONSTRUCTION FEASIBILITY
FOR THE CORPS OF ENGINEERS
CLIFTON V. CHAMBERLAIN, JR
LT. COL., CORPS OF ENGINEERS
CHIEF ENGINEERING DIVISION

APPROVED SHEET No.

4

Figure 1B.2: [Right Spread] Detail of section of Delta-01 Launch Control Center (LCC), 1961. The L-shaped section at left is the elevator and ladder shaft and elevator lobby. The elliptical section to the right is the capsule containing the suspended acoustical enclosure. Source: MIMI

ACCESS SHAFT SCHEDULE

SITE NO	A	B	C	D	E	BASE SECTION
A-1	31'-2"	9'-6"	—	6'-8"	15'-0"	G
B-1	32'-10"	9'-6"	—	8'-4"	15'-0"	G
C-1	33'-9"	9'-6"	—	9'-3"	15'-0"	G
D-1	31'-8"	9'-6"	—	7'-2"	15'-0"	G
E-1	34'-10"	9'-6"	—	10'-4"	15'-0"	G
F-1	31'-2"	9'-6"	—	6'-8"	15'-0"	G
G-1	32'-10"	9'-6"	—	8'-4"	15'-0"	G
H-1	35'-0"	9'-6"	—	11'-6"	15'-0"	G
I-1	32'-10"	9'-6"	—	8'-4"	15'-0"	G
J-1	52'-4"	10'-2"	12'-2"	15'-0"	15'-0"	G
K-1	38'-2"	9'-6"	—	13'-8"	15'-0"	G
L-1	40'-10"	9'-6"	—	16'-4"	15'-0"	G
M-1	33'-0"	9'-6"	—	8'-6"	15'-0"	G
N-1	39'-0"	9'-6"	—	14'-6"	15'-0"	G
O-1	35'-8"	9'-6"	—	11'-2"	15'-0"	G

BARS SET 50 THEY ARE 4'-0" C AT CORNERS

#5@12" #5@8"

#5@12" #5@8"

3'-6" TYP

1'-0"

10'-4" SQ.

PLAN-SECTION (B) 3/8"=1'-0"

BARS SET 50 THEY ARE 4'-0" C AT CORNERS.

#6@12" #5@8"

#6@12" #5@8"

3'-6" TYP

1'-4"

1'-6" FLIGHT K ONLY

10'-4" SQ.

PLAN-SECTION (C) 3/8"=1'-0"

BARS SET 50 THEY ARE 4'-0" C AT CORNERS

#6@12" #6@8"

#6@12" #6@8"

3'-6" TYP

1'-6"

10'-4" SQ.

PLAN-SECTION (D) 3/8"=1'-0"

FIN. FL. OF L.C.C. SUPPORT BLDG.

L 5-12

"A" "B" "C" "D" "E"

45° TYP

HOIST HOOK SEE 1/—

C.J. @ FLT. E ONLY

NOTE: FOR ELECT. BOXES MOUNTED ON WALL IN SHAFT. SEE SHT. E-8

NOTE: FOR RECESSED BOXES IN TUNNEL. SEE SHT. E-8

BASE STRUCTURE G/— E/—

1'-0" 1'-6" 4" 1½ TYP

DRILL HOLE IN DOOR FRAME FOR REBAR

7 5-12

℄ BUMPER

7 A-7

BASE STRUCTURE

8'-0"

3'-6"

5'-0"

1'-8"

FLIGHT B & E ONLY

RECESSED LIGHT IN ELEV. PIT — SEE SHT. E-9

C.J. (OMIT @ FLT. A & E)

F.D. SEE SHT. P-5

4'-4"

#6@8" E.W.E.F.

#5@8"

OMIT @ FLIGHT A & B

#6@8" D.C. E.W.E.F.

#5@8"

1'-8"

C.J. (OMIT @ FLT. E)

#5@8"

5 5-12

3 5-12

G-0"

3'-0" DIA

HOLES IN ℄ AS INDICATED ON SHT. P-5

#5@10" O.C. E.W.E.F.

5'-0" DIA

#8@10" E.W.E.F.

CONSTRUCTION JOINT FLIGHT "H" ONLY

SPLICE #11@7½" #10@8"

#10@8"

#10@8"

G-#8@8" SEE A 5-11

G-#10@4'-0" LG. TOP & BOTT.

6'-0"

5'-6"

5'-5¾" FLIGHT G & K ONLY

10'-3" R

4'-9"

5'-9"

5'-10"

NOTE: RECESS FOR LIGHT SEE 4 7-7 LINER B CONT. AROUND FIXTURE

B-#7 BD 30 x 11'-0" LG.

B-#7 BD SPACED x 11'-0" LG.

G-0"

7'-0½"

C 5-9

5½" R

PAINT LINER B WITH ACID RESISTANT PAINT. (SEE SECTION C ON 5-11)

2'-0"

FOR OPENINGS & PIPES IN BOX SEE SHT. P-5

5-#11 DOWELS @ 4'-0" LOCATE IN FIELD TO MISS DRAIN

K 5-10

CONC. TO BE POURED AFTER DRAINS ARE IN PLACE

ANCHORS #8 @ 8" FOR SPACING AT DOOR SILL HEAD, & 24" JAMB.

AT DOOR FRAME BEND BARS DOWN NO DOWELS @ DOOR FRAME

3/8" R

3'-0"

#10@8"

△ SPRAYED ON VINYL WATERPROOFING 2" CONCRETE 2500 PSI. (TYP) 1'-0" MIN CUSHION MATERIAL

TYP 12"ø WELDED STUD ANCHORS 1'-2" O.C. E.W.

SECTION (A) 5-3 5-2 3/8"=1'-0"

OPERATIONAL AS BUILT

△ Cafe 9 22 61

△ CMC

CORPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE APPROVED FOR CONSTRUCTION FEASIBILITY FOR THE CORPS OF ENGINEERS

CLIFTON H. CHAMBERLAIN, JR. LT. COL., CORPS OF ENGINEERS CHIEF ENGINEERING DIVISION

ELEVATION (G) — 1"=1'-0"

¾" SCALE 0 4 8 FEET

3'-6" #6@8" #6@8" #8@8" #6@8" #6@8" 1'-8" 2'-2" 2'-0" 8'-0" 3'-6" 3'-0"

℄ STRUC. ABOUT

FOR SITE J-1 ONLY

SECTION (E) 5-3 5-2

OMIT @ FLT. A, B & F

3'-6" #6@8" #6@8" #6@8" #6@8" 1'-6" 2'-0" 8'-0" 3'-6" 2'-0"

℄ STRUC. ABOUT

TYPICAL FOR ALL SITES EXCEPT J-1

SECTION (G) 5-3 5-2 3/8"=1'-0"

#6@8" #8@8" #6@8"

SECTION (F) 5-3 5-2 3/8"=1'-0"

12-9½", 5-½", 0-9½" 5½" 7/8 BAR 9½" 3½" 1'-0" 3/4@8 UNIT COMPOUNDED ANCHORS (4 TOTAL) 5½" 1½"

DETAIL (1) 5-3 5-12 1"=1'-0"

"AS BUILT" DRAWING CERTIFICATION — CORPS OF ENGINEERS

	DATE	SIGNATURE
FLIGHT A	4-2-63	
FLIGHT B	3-29-63	
FLIGHT C	3-27-63	
FLIGHT D	12-7-62	
FLIGHT E	1-23-63	
FLIGHT F	3-27-63	
FLIGHT G	3-22-63	
FLIGHT H	4-8-63	
FLIGHT I	1-3-63	
FLIGHT J	1-3-63	
FLIGHT K	1-3-63	
FLIGHT L	1-3-63	
FLIGHT M	5-11-63	
FLIGHT N	6-15-63	
FLIGHT O	6-20-63	

REVISION	DATE	DESCRIPTION	AGENCY	INIT.
△	7-11-60	LOC. LANYARD ATTACHMENTS (M.C.L. 6341)	RIVET MILE	LM
△ (16)		NOT ON CONTRACT (SEE CONST. DIVISION ATLAS REPRODUCTION SHEET A REVISED SECTION)		
△ (3)	6-2-61	FIELD CHANGE ADD HOIST HOOK ON SECT A ADD DET & REV. ℄ CASE 50 MCL 343	PARSONS	GHD
△ (11)	9-28-61	REMOVED ANIMATION DEVICE PLATFORM O.C.-G	PARSONS	WHM
△ (3)	7-14-61	REVISED TOP OF ACCESS SHAFT & ADDED WATER STOP	PARSONS	

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION (AFSC)
INGLEWOOD, CALIFORNIA

DESIGNED BY WILKINSON
DRAWN BY
CHECKED BY
SUBMITTED BY

A/E SHEET No. S-3
A/E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

LAUNCH CONTROL FACILITY
LAUNCH CONTROL CENTERS
SECTIONS AND DETAILS

APPROVED: [illegible] MAJOR, USAF DATE 7-14-61
APPROVED: [illegible] Capt USAF DATE
APPROVED:

SPECIFICATION No.
FIELD CHANGE CASE 50-61-43
DATE JUNE 5, 1961 SCALE AS NOTED
CEBMCO SERIES NO. 132/14 SHEET 381

ARMED INDEX No.

Page intentionally left blank

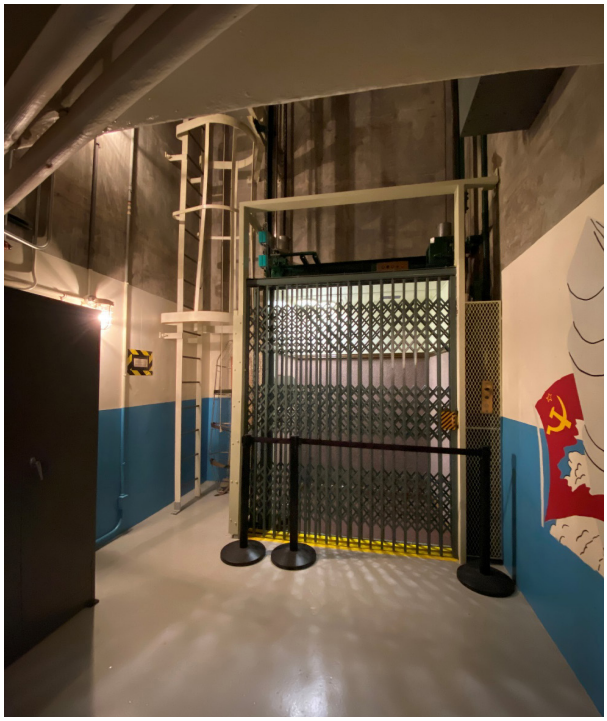


Figure 1B.3: Elevator enclosure and ladder in elevator lobby of Delta-01. Source: RATIO, 2023.



Figure 1B.4: View up shaft in elevator lobby of Delta-01. Source: RATIO, 2023.



Figure 1B.5: Morale art on the elevator lobby wall and blast door of Delta-01. The mural at left was painted in 1988 and that on the blast door was painted by Deputy Missile Combat Crew Commander Tony Gatlin (born 1962) in 1990. The "30 minutes or less" was classified information at the time this was painted. Source: RATIO, 2023.



Figure 1B.6: Interior of capsule showing interior of blast door opening and platform connecting to acoustical enclosure (off-camera at right). The circular spot above the door is overpainted morale art. Source: RATIO, 2023.



Figure 1B.7: View from capsule toward blast door and elevator lobby. Source: RATIO, 2023.



Figure 1B.8: Overpainted morale art on the capsule wall above the blast door opening. Park staff report that the Air Force painted over this art shortly before turning the property over to NPS; it is believed to show a skull and crossbones (partially visible through the overpaint) and reportedly included the words "kick ass." Source: RATIO, 2023.



Figure 1B.9: View from top of acoustical enclosure showing escape tube door (center), cable protective frame enclosure (right), acoustical enclosure suspension system (right foreground), and historic HVAC equipment and ductwork (bottom left and center). Source: RATIO, 2023.



Figure 1B.10: View into acoustical enclosure showing computer cases, built-in equipment, the bunk, chairs, light fixtures, and acoustical treatments. Source: RATIO, 2023.



Figure 1B.11: View from the back of the acoustical enclosure toward the door showing computer cases, built-in equipment, the bunk, chairs, light fixtures, and acoustical treatments. Source: RATIO, 2023.



Figure 1B.12: Toilet within acoustical enclosure. Source: RATIO, 2023.

Delta-09 Launch Facility (LF)

Location	Feature	Contribution Status	Notes
Delta-09 Launch Facility Exterior	Launcher closure (silo door) and associated systems and hardware	Contributing	Including concrete and steel door, tracks, launcher, and other associated hardware
Delta-09 Launch Facility Exterior	Launcher viewing structure	Non-Contributing	Added by NPS in 2001
Delta-09 Launch Facility Exterior	Access hatch	Contributing	Including controller and all associated hardware
Delta-09 Launch Facility Exterior	Hardened ultra high frequency antenna	Contributing	
Delta-09 Launch Facility Exterior	Improved Minuteman physical security system	Contributing	
Delta-09 Launch Facility Interior	Paint finishes	Contributing	
Delta-09 Launch Facility First (upper) Level	Access hatch ladder and hatch equipment	Contributing	
Delta-09 Launch Facility First (upper) Level	Steel walls, floor, and ceiling	Contributing	
Delta-09 Launch Facility First (upper) Level	Autocollimator bench	Contributing	Originally held autocollimator
Delta-09 Launch Facility First (upper) Level	Actuator	Contributing	Originally opened the launcher closure
Delta-09 Launch Facility First (upper) Level	Computer and power systems components	Contributing	
Delta-09 Launch Facility Second (lower) Level	Access hatch ladder and hatch	Contributing	Including removable top section of ladder
Delta-09 Launch Facility Second (lower) Level	Steel walls, floor, and ceiling	Contributing	

Delta-09 Launch Facility Second (lower) Level	Battery hardware	Contributing	The batteries themselves are no longer present
Delta-09 Launch Facility Second (lower) Level	Equipment	Contributing	Including the generator and air conditioner
Delta-09 Launch Facility Launch Tube Interior	Steel walls and floor	Contributing	Including access door. missile mount, and missile support brackets
Delta-09 Soft Support Building Exterior	Concrete roof wearing slab and foundation	Contributing	
Delta-09 Soft Support Building Exterior	Steel gratings and cover plates	Contributing	
Delta-09 Soft Support Building Areaways	Steel ladders	Contributing	Safety equipment postdating the POS is non-contributing
Delta-09 Soft Support Building Interior	Concrete walls, floor, and ceiling	Contributing	Including historic paint finishes
Delta-09 Soft Support Building Interior	Steel louvers	Contributing	In end walls
Delta-09 Soft Support Building Interior	Light fixtures	Contributing	
Delta-09 Soft Support Building Interior	Equipment	Contributing	All equipment from the POS, including the generator, HVAC equipment and ductwork, electrical equipment and conduits, communications equipment and wiring

Page intentionally left blank

Part 1C. Physical Description and Condition Assessment – Delta-09 Launch Facility

Introduction

The following is a physical description and condition assessment of the structures at the Delta-09 Launch Facility. Note: based on priority of resource maintenance needs, the scope of work for this report focuses on Delta-09 LF but does not include a similar examination of the Delta-01 LCC.

Exterior Description

The Delta-09 Launch Facility (LF) missile silo and Soft Support Building are underground concrete structures within Minuteman Missile National Historic Site and are located on the west side of 195th Avenue south of the 239th Street interchange on Interstate 90 near Wall, South Dakota. These resources are within a rectangular enclosure defined by a historic security fence. The ground within this enclosure is covered by crushed stone (gravel). The resources are located within the south half of the enclosure.

Launch Facility

The Launch Facility (missile silo) sits west of center within the enclosure. Its orientation skews slightly northwest from true north. The top of the silo is covered by a teardrop-shaped concrete slab on grade. In the center of the circular portion of the slab is the launcher closure, a steel and concrete sliding door covering the top of the Launch Tube. The launcher closure is an irregular octagon. It rests on two steel rails and a central steel maintenance track, all of which slope down toward the south. The launcher is now fixed in a partially open condition. The opening is covered by a semi-octagonal viewing structure (known by park staff as the greenhouse), added by the NPS in 2001 and consisting of a concrete curb topped by a sloped glass skylight in an aluminum frame. The tapered extension of the slab contains the Personnel Access Hatch. This hatch is a circular steel and concrete door with controls located under a dome-shaped steel cover.

The Outer Zone Security (IMPSS) Antenna is a white cylindrical mast with a conical cap mounted adjacent to the launcher closure. The hardened ultra- high frequency (UHF) antenna is located just northwest of the silo and consists of a circular concrete slab with a shallow (saucer) dome) topped by a blunted conical stell tip.h

Soft Support Building

The Soft Support Building measures roughly 14 by 24 feet. Its roof is exposed approximately 18 inches above grade. The exposed foundation walls are of cast-in-place concrete. The roof of the building is covered by an exposed concrete wearing slab. Two large steel cover plates are located in the east half of the roof. These plates provided access for the installation or removal of large pieces of equipment. Areaways covered by steel gratings are located at the north and south ends of the building. The north areaway (Areaway No. 1) contains the access ladder leading down to the entry door. The south areaway (Areaway No. 2) contains a large louver and also a ladder for service access to the areaway itself.

Interior Description

Launch Facility

The central space of the Launch Facility (missile silo) is the Launch Tube (also called the "launcher tube" or "silo"), a steel-lined concrete cylinder approximately 12 feet in diameter and approximately 80 feet deep. The launcher closure (silo door) forms the roof of this tube. Service access within the tube is via a spider lift that runs along a track at the top of the tube. An access door at the first (upper) level equipment room also provides access to the launcher tube.

Two equipment room levels surround the upper part of the Launch Tube. These levels are housed within a steel reinforced concrete cylinder with an inside diameter of approximately 25 feet. This larger tube shares the same vertical center axis with the launcher tube and effectively forms a collar around its upper section. The steel liner of the tube extends up through the center of both levels. The volume of the two levels is approximately 19 feet high, with the floor of the second (lower) level approximately 28 feet below grade. The equipment room levels are accessed via a ladder in the access hatch. This hatch is housed within a cylindrical shaft approximately three feet six inches in diameter and is connected to the equipment room levels by a corridor of the same width.

The floor of the first (upper) level equipment room is eight feet above the floor of the second (lower) level. The northwest half of this floor is a shock-mounted floor that does not touch the outer walls or the launcher tube liner and hangs from shock absorbers mounted to the ceiling. These features were designed to protect the computers and equipment from vibration. The other half of the floor is not shock-mounted but is at the same level and holds the autocollimator bench. An access door in the launcher tube liner provides access to the launcher tube. This door is hinged to fold down into the launcher tube, forming a platform known as the diving board. The south side of the first level contains the actuator system.

The second (lower) level is accessed from the first level via a ladder on the south side of the corridor from the access hatch. A hinged trapdoor in the first floor level of this corridor opens to provide access to the ladder. The second level contains locations for 12 batteries (no longer present) along its west side. The north side contains the motor generator and the northeast area contains the air conditioning unit. The southeast part of this level contains electrical equipment, including the cable protector frame enclosure.

Soft Support Building

The interior of the Soft Support Building is a single rectangular room with cast-in-place concrete walls, floor, and ceiling. All surfaces except the floor slab are painted. The ceiling is subdivided into four bays by integral cast concrete beams. The two eastern panels are slightly narrower and contain the openings with cover plates. A sump pump pit is located in the southwest part of the floor. The interior contains a generator, electrical equipment, and heating, ventilation, and air-conditioning (HVAC) equipment.

Delta-09 Launch Facility

Physical Description (structural)

The Launch Facility is a reinforced concrete structure that extends approximately 80' below grade. According to the original construction drawings created by Parsons-Staven and dated June 5, 1961, the upper 28 feet of the below grade structure houses the equipment room first and second levels and generally consists of reinforced concrete walls up to 2 feet 3 inches in thickness with the interior surface covered by a 1/4 inches steel plate liner. The launch tube steel plate at the equipment room levels is shown as 3/8 inches in the Parsons-Staven drawings. Below the equipment room second level, the remaining 52 feet of the launch tube consists of a reinforced concrete wall with an interior 1/4 inches steel plate liner. The thickness of the reinforced concrete wall within the 52 feet depth varies between 12 inches near the upper wall and up to 28 inches near the lower portions of the wall (refer to Appendix C report). The floor construction consists of a steel plate over concrete with thicknesses varying between 30 to 50 inches according to the October

23, 2023 Olson Engineering report (refer to Appendix C). The Closure Door assembly is constructed of structural steel and concrete. The Door is positioned on steel closure tracks placed on concrete at grade and are located on the outside of the Door with a maintenance track at the middle of the Door. The transport-erector jacking points and tie downs are in the concrete slab-on-grade adjacent to the Launch Facility concrete roof edge. In 2001, the viewing structure was constructed overtop the launch tube, displaying the training missile on display inside the tube structure.

Delta-09 Soft Support Building

Physical Description (structural)

The Soft Support Building is a reinforced concrete structure that extends below grade. The lid of the structure is a split-slab construction, meaning the reinforced concrete structural roof slab is covered by a waterproofing membrane system and topped with a reinforced concrete wear slab. According to the original construction drawings created by Parsons-Staven and dated June 5, 1961, the wearing slab is 2 feet 1/2 inches and a polyvinyl spray-applied membrane system was specified. Control joints were not installed in the Delta-09 wear slab.

Condition Assessment

Exterior Summary Table and Condition

UNIFORMAT II Outline Data			Assessment Rating
Topic	Code	Subtopic	
F1010	Special Structures	Delta-09 Launch Facility Exterior	
		Launcher closure (silo door) and associated systems and hardware	Good
		Launcher viewing structure	Good
		Access hatch	Good
		Hardened ultra high frequency antenna	Good
		Improved Minuteman physical security system	Good
F1010	Special Structures	Delta-09 Soft Support Building Exterior	
		Concrete roof wearing slab and foundation	Fair/Poor
		Steel gratings and cover plates	Good
		Areaway steel ladders	Fair

Interior Summary Table and Condition

UNIFORMAT II Outline Data			Assessment Rating
Topic	Code	Subtopic	
F1010	Special Structures	Delta-09 Launch Facility Interior	
		Paint finishes	Fair
		Delta-09 Launch Facility First (upper) Level	

		Access hatch ladder and hatch equipment	Good
		Steel walls, floor, and ceiling	Fair
		Autocollimator bench	Fair
		Actuator	Good
		Computer and power systems components	Fair
		Delta-09 Launch Facility Second (lower) Level	
		Access hatch ladder and hatch	Good
		Steel walls, floor, and ceiling	Fair
		Battery hardware	Fair
		Equipment	Fair
		Steel walls and floor	Fair
F1010	Special Structures	Delta-09 Soft Support Building Interior	
		Concrete walls, floor, and ceiling	Good
		Steel louvers	Good
		Light fixtures	Fair
		Equipment	Fair

F: Special Construction – Delta-09 Soft Support Building

The exposed concrete foundation wall and grade level surfaces were visually assessed and damaged conditions were documented. Acoustic sounding using a hammer was performed across randomly selected exposed exterior surfaces to identify delaminations in the concrete. Inside the Soft Support Building, the concrete structure was visually assessed and select wall surfaces were randomly selected for hammer sounding, including wall surfaces near the floor slab that had paint coating damage. The following is a summary of observations and deficiencies identified during the onsite assessment.

F10: Special Construction

F1010: Special Structures – Soft Support Building Exterior

- The exterior exposed concrete of the Soft Support Building structure is in good condition while the split-slab construction across the top of the Soft Support Building is in fair/poor condition (Figure 1C.1).
- Previously treated and untreated cracks were documented within the concrete wear slab and the exposed concrete foundation walls above finished grade (Figure 1C.2). NPS staff have treated some cracks via gravity-fed epoxy injection work (Figure 1C.3). Other cracks have been covered with sealant as part of a previous repair.
- Delaminated concrete was identified within the 2-1/2 inches wear slab, which is the uppermost part of the split-slab roof structure on the Soft Support Building (Figure 1C.4).
- The waterproofing layer between the concrete wear slab and structural roof slab is original and was not visible due to the presence of the wear slab. The gap between the two slabs was caulked tight, which restricts water present at the waterproofing layer from freely exiting the split-slab system (Figure 1C.5). White calcium stains and residue are visible across the vertical walls below the caulked gap indicating moisture has previously exited through the gap. Moisture migration through the structural concrete roof slab construction was visible inside the soft support building, indicating the 62-year-old waterproofing system has deficiencies. Given its age and moisture infiltration issues, the waterproofing has reached the end of its useful service life.
- Previous applied coatings on the exposed foundation walls have failed (Figure 1C.6).



Figure 1C.1. View of the Soft Support Building as seen from grade level.

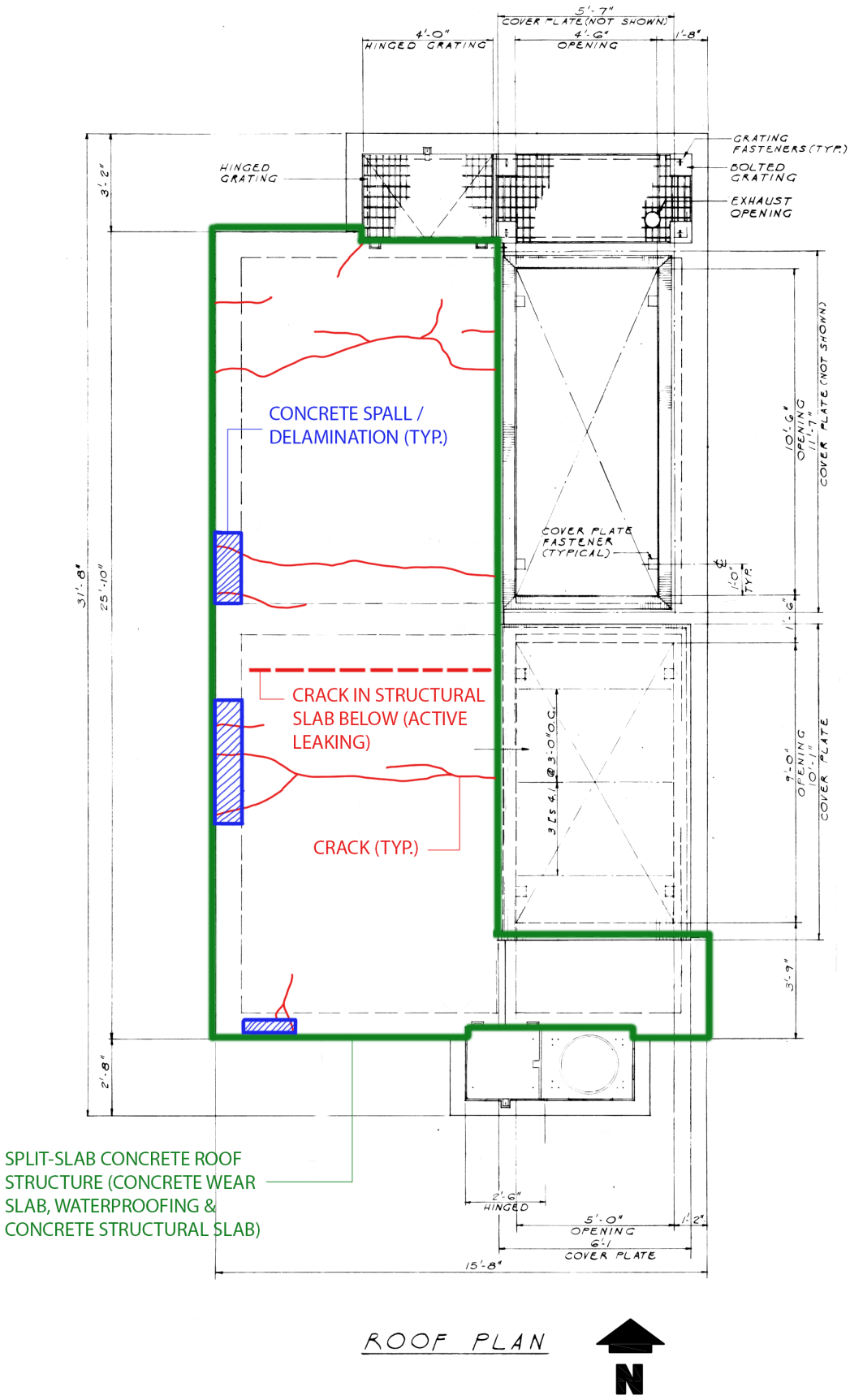


Figure 1C.2. Soft Support Building roof plan showing documented cracks and concrete delaminations. Original plan view adapted from Sheet A-8 created by Parsons-Staven dated June 5, 1961.



Figure 1C.3. Repaired cracks in the concrete wear slab that utilized epoxy and sealant material.



Figure 1C.6. The previous coating material on the exposed portion of the foundation wall has failed.



Figure 1C.4. An example of a cracked and delaminated portion of the concrete wear slab.



Figure 1C.5. The perimeter gap between the concrete wear and structural slabs has been sealed tight with sealant.

F10: Special Construction

F1010: Special Structures – Soft Support Building Interior

- The concrete foundation walls and floor slab are in good condition. The underside of the concrete roof structure of the underground building is in good/fair condition.
- Active moisture leaking through a crack in the concrete roof slab structure was observed approximately halfway across the roof slab and adjacent to the sump pump pit in the floor below (Figures 1C.7 and 1C.8).
- Surface rust coming through the paint coating was visible across the structural steel members supporting the removeable cover plate infill at the roof structure (Figure 1C.9).
- One small (< 1 SF) spall was noted in the concrete floor slab near the center of the equipment room floor. No delaminations were found within the floor slab or foundation wall structure during the sounding survey.
- Ambient moisture conditions in the underground structure have been conducive for organic growth. Such growth was observed across much of the coating applied to the underside surface of the concrete roof structure (Figure 1C.10). Painted coatings on the walls were delaminated and spalling away near the base of the concrete walls.



Figure 1C.7. View of the underside of the Soft Support Building structural slab with an active leaking crack.



Figure 1C.8. Close-up view showing the slab crack and stalactite formation resulting from the active moisture migration.



Figure 1C.9. Rusted steel surfaces were observed on the removeable cover plate infill structure.



Figure 1C.10. Organic growth was visible on the underside painted surface of the structural concrete roof slab.

F: Special Construction – Delta-09 Launch Facility

The exposed concrete surfaces on the exterior and interior of the Launch Facility were visually assessed and damaged conditions were documented. Acoustic sounding using a hammer was performed across randomly selected exposed exterior surfaces to identify delaminations in the concrete. Inside the Launch Facility, select wall and floor surfaces across the steel plate liner within the launch tube were randomly selected for hammer sounding including steel plate wall surfaces at the equipment room first and second levels. A non-destructive evaluation (NDE) investigation was separately performed by Olson Engineering (refer to Appendix C) of the lower 52 feet of the cylindrical steel lined concrete launch tube walls. Both impact echo and spectral analysis of surface waves equipment were used as part of the Olson NDE investigation. Additionally, a study performed by Gecko Robotics used ultrasonic thickness probes to measure the thickness of the steel plate liners within the Launch Facility structure (refer to Appendix C). Figures 1C.11 and 1C.12 illustrate a typical grade level plan and cross-sectional view of the Launch Facility, respectively, with relevant components noted and discussed in further detail below. The following is a summary of observations and deficiencies identified during the onsite assessment.

F10: Special Construction

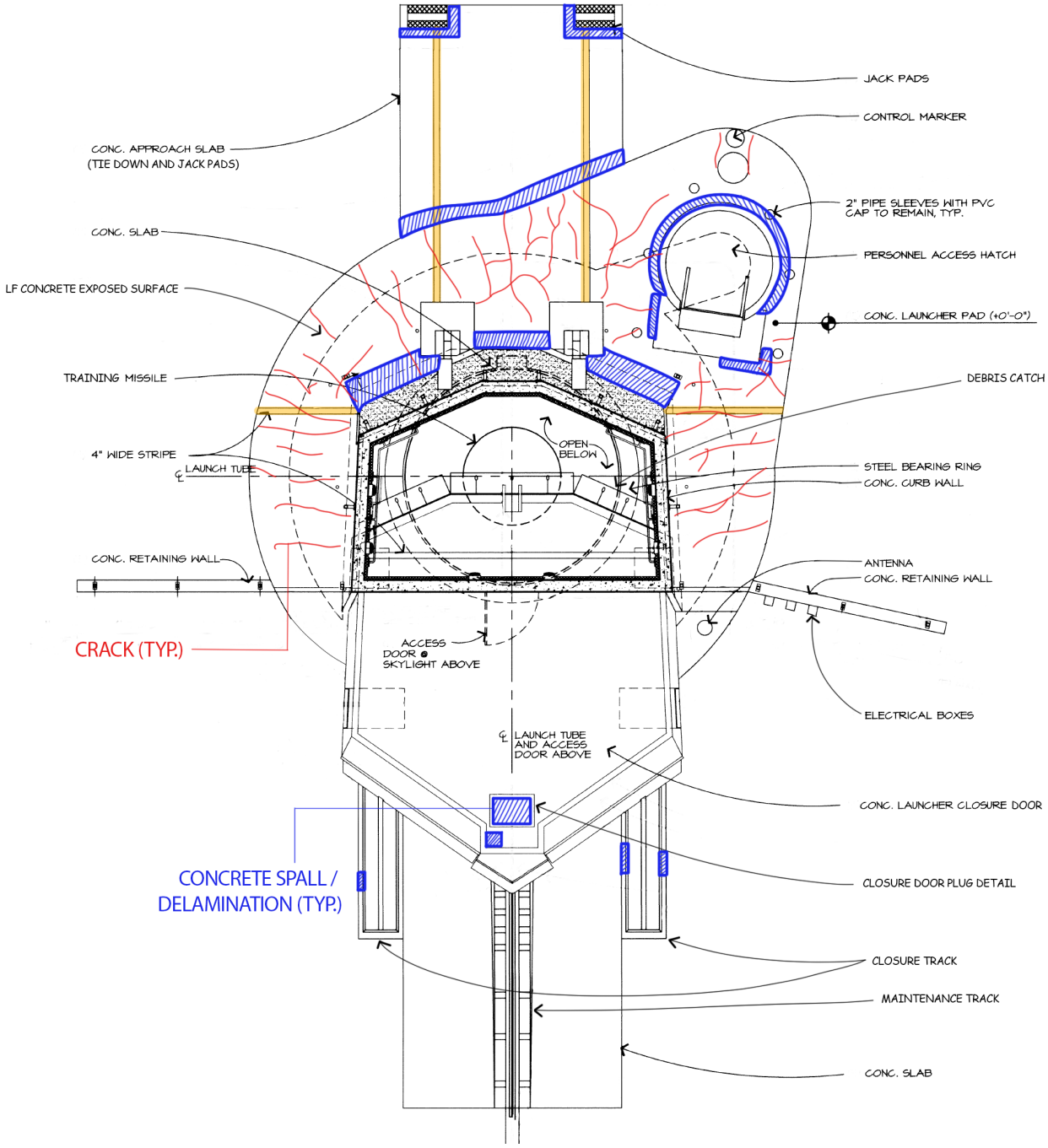


Figure 1C.11. Launch Facility grade level plan. Original plan view adapted from Sheet A1 created by The Roybal Corporation dated June 28, 1996.

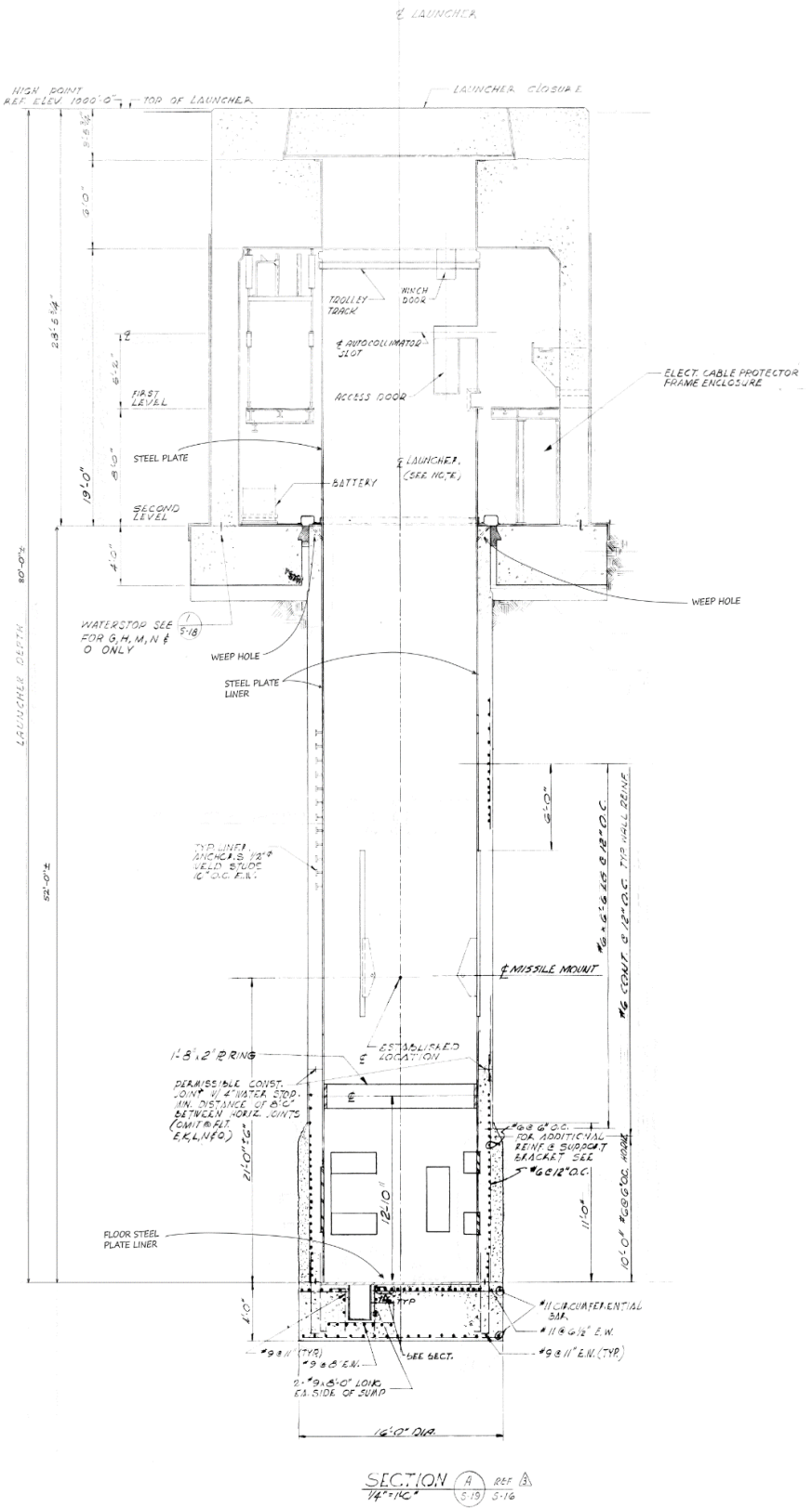


Figure 1C.12. Launch Facility cross-sectional view. Original section view adapted from Sheet S-19 created by Parsons-Staven dated June 5, 1961.

F1010: Special Structures – Launch Facility Exterior

Viewing Structure

- The perimeter wall construction below the viewing structure framing consists of an 8 inches reinforced concrete wall with 2-1/4 inches EIFS on the interior of the enclosure applied directly over the concrete. While shrinkage cracks were apparent in the exterior face of the 8 inches concrete wall (Figures 1C.13 and 1C.14), the concrete itself was found to be in sound condition when sounded with a hammer.
- The site is isolated and unstaffed and park staff have noted footprints on the launcher viewing structure glass, indicating that visitors have stood on the glazing.



Figure 1C.13. View of the concrete curb supporting the viewing structure.



Figure 1C.14. Shrinkage cracks were observed within the concrete curb and no delaminations were noted.

Closure Door and Tracks

- Delaminated and cracked concrete was noted at the front (south end) of the closure door adjacent to and within the plug detail (Figure 1C.15). In addition, a narrow strip of delaminated concrete along the northern edge of the closure door inside the viewing structure was observed. Because that area is located inside the viewing structure and sheltered from the exterior elements, that delaminated strip of concrete could remain untreated.
- Narrow to hairline shrinkage cracking was widespread across the skyward face of the closure door concrete.
- The concrete adjacent to the steel rails and plates at the closure and maintenance tracks (Figure 1C.16) is generally in sound condition with small delaminations (about 1 SF in size) and few cracks found in the track concrete (Figure 1C.17).
- Corrosion of steel surfaces on the underside of the closure door steel framing was observed (Figure 1C.18). Similarly, light corrosion was present on the surface of the steel rails embedded in the concrete closure and maintenance tracks.
- A debris catch was added to the back (north face) of the closure door in the 1970s (Figure 1C.19) and appeared to be in good condition. According to a retired Air Force service member at the site, the intent of the steel catch was to collect any debris that would have been on the top of the door when it opened, preventing the debris from contacting the missile that was exiting the launch tube.

Launch Facility Structure



Figure 1C.15. View of the plug detail on the skyward facing surface of the closure door. The concrete infill within the plug was cracked and delaminated. Concrete beyond the plug along the edge of the steel-framed closure door was also delaminated in limited areas.



Figure 1C.18. View of the underside surface of the closure door. Corrosion was visible across much of the leading edge of the closure door steel structure.



Figure 1C.16. View of the closure door tracks and middle maintenance track supported by concrete below.



Figure 1C.17. View of a small delamination in the concrete below one of the closure door tracks.



Figure 1C.19. View of the stainless steel debris catch that was anchored to the closure door in the 1970s.

- The concrete retaining walls flanking either side of the Launch Facility structure are generally in good condition (Figure 1C.20). The stainless steel railing assemblies mounted to the top of the walls were installed as part of the viewing structure project in 2001. According to the original construction drawings for the viewing structure (created by The Roybal Corporation, dated June 28, 1996), the railing base plates are mounted using 3/8 inches diameter expansion bolt anchors into the concrete. Some shrinkage cracks in the concrete wall have been previously treated with sealant while others remain untreated. Some cracks near the expansion bolt anchors were observed.
- The jack and tie down approach slab north of the main Launch Facility concrete structure was in fair/poor condition. Delaminations and spalls were noted at the edge of the jack and tie down slab-on-grade against the original concrete structure (Figure 1C.21). The concrete around the launcher jack pads was delaminated and the carbon steel sheet metal between the steel pads and the concrete was heavily corroded (Figures 1C.22 and 1C.23).
- The exposed surface of concrete launch structure is generally in sound condition but has widespread cracking across the skyward face (Figure 1C.24). Many of those cracks have been previously treated through a combination of sealant and epoxy repairs while others have not yet been treated (Figure 1C.25). Delaminated conditions in the exposed surface of the launch structure were limited to around the access hatch (Figure 1C.26) where a narrow delamination ring followed the circular hatch opening. The perimeter sealant at that location was also in poor condition. The original barrier poles and railing around the access hatch were replaced in the 1980s with the current pole and railing structure that includes steel sleeves embedded in the concrete. It appeared to be in good condition.



Figure 1C.20. View of the concrete retaining wall structure extending to the east from the Launch Facility structure. Cracking was observed within the concrete wall. Some cracks have been previously treated while others have not yet been repaired.



Figure 1C.21. Delaminations and spalls were located on the jack and tie down slab-on-grade directly adjacent to the Launch Facility concrete structure.



Figure 1C.22. View of the jack and tie down slab with the two jack pads in the foreground.



Figure 1C.23. Delaminated concrete, failed previous patching, and epoxy repairs around the jack pads were observed. The sheet metal between the slab and the jack pad was heavily corroded.



Figure 1C.24. The exposed skyward facing surface of the Launch Facility concrete structure has widespread cracking. Many of those cracks have been previously repaired.



Figure 1C.25. A close-up view of the skyward facing concrete surface showing some cracks that have received an epoxy treatment and others that have not yet been repaired.



Figure 1C.26. Delaminated concrete and failed sealant were observed around the launch structure access hatch.

F10: Special Construction

F1010: Special Structures – Launch Facility Interior

Launcher Access Shaft

- The steel plate liner within the access hatch visually appeared to be in good condition when viewed from within the shaft. However, the Gecko Robotics study found there to be isolated locations with up to 40% steel section loss according to Figure 42 in their report (refer to Appendix C). Paint coatings on the steel within the shaft are in fair to poor condition.

Launcher Equipment Room - First and Second Levels

- The steel plate liner on the Launch Facility structure walls at the first and second levels visually appeared to be in good condition. The Gecko Robotics study found the measured steel plate liner thickness to generally be consistent with the 1/4 inches reported nominal thickness (refer to Figures 6, 7, 43, and 44 in Appendix C report). The sounding of the steel plate liner was performed using a hammer at random locations. Both sound and hollow audible conditions were observed during the hammer sounding survey. Due to the presence of the steel plate liner, suspected debonding behind the steel was not visible. The Olson Engineering NDE investigation did not address the steel lined concrete walls at this level of the Launch Facility.
- Corrosion of the steel floor plate across the second level walking surface was especially noted around the fan equipment and adjacent to the electrical room (Figure 1C.27). The failed paint coating on the adjacent steel columns, base plates, and connection hardware was accompanied by light to moderate amounts of corrosion debris (1C.28). Using a Check-Line Ultrasonic Micrometer wall thickness gauge at multiple locations, we determined that the floor plate and steel column base plates have not experienced section loss given the measurement readings were consistent with the steel dimensions shown in the Parsons-Staven drawings.
- The neutralizer pit and adjacent floor drain on the second level were found to be holding water. During the condition assessment site visit, NPS staff used a shop vacuum to remove water from both locations (Figure 1C.29). Gravel and debris were found in the base of the neutralizer pit after removing the water. The pipe connecting the two was found to be blocked along with the pipe extending from the drain to the weep at the inside face of the launch tube. NPS staff reported that they will snake the pipes and clear the obstruction following our visit.
- Weep slots were originally cast into the backup concrete of the launch tube walls at the second level and were diagonally sloped downward, draining through the steel plate liner and into the launch tube (Figures 1C.30 and 1C.31). Some of the slots were found to be blocked with debris (Figures 1C.32 and 1C.33) while others were unobstructed, and daylight could be seen coming through the open hole (Figure 1C.34).



Figure 1C.27. Corrosion of the steel floor plate at the second equipment room level was apparent around the fan equipment and adjacent to the electrical room.



Figure 1C.28. Moisture damage has resulted in failed coatings and corrosion of the steel.

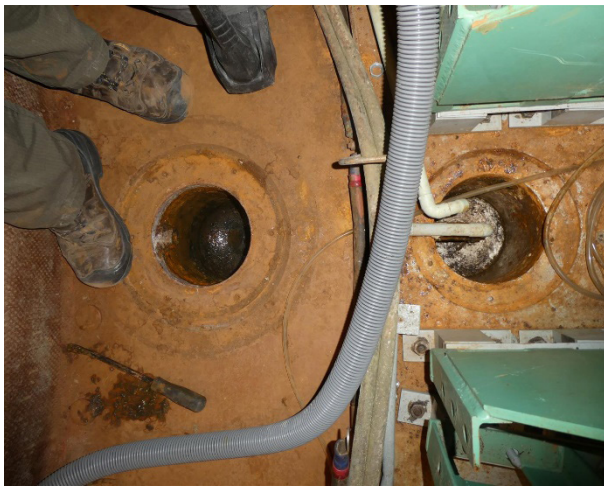


Figure 1C.29. The neutralizer pit and adjacent drain were full of water at the time of our visit. NPS staff vacuumed out the water to expose the inside surfaces of both assemblies.



Figure 1C.30. View from the second equipment room level pointing at one of the weep holes through the steel plate liner at the launch tube.



Figure 1C.31. View from inside the launch tube showing three weep holes through the steel plate, all with various degrees of corrosion debris on the steel surface below the holes from moisture draining through the weeps.



Figure 1C.32. Some of the weep holes were blocked with debris. One example is shown here as viewed from the second equipment room level.



Figure 1C.33. View of another blocked weep hole as observed from inside the launch tube.



Figure 1C.34. An example of an open, unobstructed weep hole is shown here.

Launch Tube

- The steel plate liner on the launch tube wall appeared to be in good condition and was originally constructed with multiple rows of steel panels that were welded together. The Gecko Robotics study found there to be isolated locations within the launch tube where the steel plate liner has up to 25% section loss (refer to Figures 5 and 26 in Appendix C report). While the steel plate material did not exhibit any signs of distress, the paint coatings on the steel varied from fair to poor condition (Figures 1C.35 and 1C.36). Parts of the steel plate liner have greater amounts of corrosion compared to others. Some of this damage can be attributed to moisture runs down the face of the liner and subsequent corrosion following a similar pattern. Bubbled areas of the coating are indicative of moisture related damage. One of the weep holes was actively leaching moisture at the time of our visit. In addition to moisture related issues, paint damage can also be attributed to the apparent brittle nature of the existing coating. While riding in the basket, we observed paint disengaging from the walls when the basket contacted the steel plate surface. A red-colored coating layer was visible behind the white-colored topcoat. Paint flakes collected on horizontal surfaces near the bottom of the launch tube (Figure 1C.37).
- The sounding of the steel plate liner was performed from the manlift using a hammer at random locations across the height of the launch tube walls and on the bottom floor plate. Both sound and hollow audible conditions were observed during the hammer sounding survey. With the presence of the steel plate liner inside the launch tube, suspected debonding behind the steel was not visible. Such conditions, however, were identified in the Olson Engineering NDE investigation (refer to Appendix C report). Based on the Olson impact echo testing, approximately 60% of the readings identified sound conditions while the remaining 40% found a variation between "thin" echoes and debonded conditions. Of the 40%, nearly half of the results were debonded conditions. The spectral analysis of surface waves testing findings included similar results. While it is likely that the hollow conditions found during the hammer sounding align with concrete wall debonding identified in the Olson Engineering study, there is currently no documented correlation between the two separately performed studies.
- Using a Check-Line Ultrasonic Micrometer wall thickness gauge, we measured the steel plate liner thickness in three separate locations across the height of the launch tube. The readings all measured approximately 1/4 inches, agreeing with the Parsons-Staven drawings.



Figure 1C.35. View of the inside painted surface of the launch tube steel plate liner. The platform used to access the manlift basket is seen in the upper right corner of the image.



Figure 1C.36. Areas of the steel plate liner have greater amounts of corrosion compared to others. Some of this damage can be attributed to moisture while other areas are associated with damage from the manlift basket contacting the coating during operation.



Figure 1C.37. Paint flakes that disengaged from the steel plate liner surface collected on horizontal surfaces near the bottom of the launch tube.

Plumbing

Delta-09 Launch Facility

The sanitary sewer system serving the Delta-09 Launch Facility provides drainage for the battery area on the Level 1 Equipment Room and condensate drainage for the Level 2 Equipment Room air-handling unit which cooled the equipment racks.

The sanitary system originally consisted of a 12 inches deep acid neutralizing basin located with the battery area and a floor drain outside of the battery area connected to a 1" drain line which extended into the launch tube and down to a 30" deep sump in the floor of the launch tube. The Parsons-Staven "as-built" drawings indicate that the line was replaced with a with 1-7/8 inches vinyl tubing in 1977. Additionally, a floor drain located near the air-handling unit extends down to the sumps, although we could not physically verify its routing.

A submersible sump pump located in the sump with a capacity of 20 gpm at 105 feet of head pumps any water collected in the sump back up to Level 2 where it exits the Launch Facility and travels underground over to approximately 36 inches of the Delta-09 Soft Support Building, turns parallel to the Soft Support Building wall and ties into the pump discharge from the Soft Support Building's sanitary system and "daylights' to grade.

The 1996 "D9 Viewing Structure-Contract Drawings" indicate that a ¾ inches condensate drain from a dehumidifier added under that project was extended to a floor drain located on Level 2 Equipment Room. We believe that this is the same floor drain that served the air-handling unit that cooled the equipment racks.

The sump pump is in fair condition and remains in operation as condensate from the dehumidifier drains to the sump and is pumped out of the building. At the time of our visit, we observed that the acid neutralizing basin and adjacent floor drain were filled with water; the most likely cause being that the drain line is blocked with rust and scale deposits.



Figure 1C.38. The acid neutralizing basis located in the battery area was backed up with water, indicating a blocked drain line (Source: H.F. Lenz Company)

Delta-09 Soft Support Building

The plumbing systems that serve the Delta-09 Soft Support Building include a storm water system and a fuel oil storage/distribution system.

The storm water system includes two area way drains with 3 inches underground storm lines that travel under the floor of the Soft Support Building a grated floor sump. A submersible sump pump capable of pumping 10 gpm of water at 20 feet of each is located within the sump and pumps the storm water up, out through the wall facing the Delta-09 Launch Facility. The 1 inch pump discharge line connects into the pump discharge line approximately 36 inches away from the Soft Support Building wall. After the connection point, the common pump discharge line increases to a 3 inches diameter line and "daylights" to grade.

A 2,500-gallon single-wall, diesel fuel underground storage tank (UST) provided bulk diesel fuel storage for the standby power system. Diesel fuel is transferred to a 312-gallon day tank which feeds the standby diesel generator.

During our site investigation, the tank vent and manway cover were visible. The underground diesel storage tank was removed by the US Air force before turnover to the National Park Service.



Figure 1C.39: The submersible sump pump located in the Delta-09 Soft Support Building (Source: H.F. Lenz Company)



Figure 1C.40: The vent, manway cover and fill box for the diesel fuel UST remain in place (Source: H.F. Lenz Company)

HVAC

Delta-09 Launch Facility

The original HVAC systems serving the Delta-09 Launch Facility consisted of an equipment rack cooling system and a launch tube heating system. While both of these systems remain in place, the equipment rack cooling system is no longer operational as a result of the U.S. Air Force decommissioning the silo. The Parsons-Staven drawings also indicate that a 6 inches diameter fresh air intake pipe ran between Level 2 – Equipment Room in the Launch Facility to the Delta-09 Soft Support Building.

The equipment rack cooling system consists of an air-handling unit which fed cold air to a supply air plenum located above the equipment racks. Air was forced down through the equipment racks. The air-handling unit cooled the air using chilled brine that was pumped from the Soft Support Building.

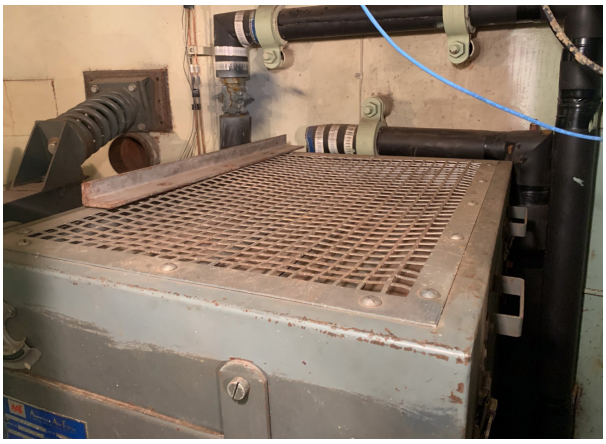


Figure 1C.41: Air-handling unit return air section draws air from the Equipment Room to cool before supplying air to the equipment racks. The black piping is the chilled brine piping from the Delta-09 Soft Support Building. (Source: H.F. Lenz Company)



Figure 1C.42: The equipment racks. The ductwork connections are visible at the top of the racks. (Source: H.F. Lenz Company)



Figure 1C.43: Perforated air distribution plates supply cool air from the equipment cooling system to the equipment racks. (Source: H.F. Lenz Company)

The launch tube heating system consists of a ducted electric unit heater and fan which draws air from the equipment room and heats it to maintain a launch tube temperature of 60°F to prevent condensation from occurring. The tube heater remains operational; however, the heating element was disconnected but the blower fan remains operational to circulate air to the bottom of the silo to aid in corrosion control.



Figure 1C.44: The electric tube heater which maintained a consistent tube temperature of 60°F (Source: H.F. Lenz Company)



Figure 1C.45: Flexible ductwork from the tube heater connects to a plenum to discharge heated air into the launch tube. (Source: H.F. Lenz Company)

As part of the viewing enclosure project, new HVAC equipment was added as follows:

- A ducted electric unit heater was installed to distribute warm air across the viewing cover. The heating is controlled by a thermostat mounted to the wall just out of view below the viewing cover.
- A floor mounted dehumidifier located on Level 1 – Equipment Room was ducted to the launch tube. A 10 inches x 30 inches opening was saw cut in the launch tube liner and a drum louver installed in the opening. The design drawings call for the drum louver to be rotated upward toward the viewing cover; however, the actual installation has the louver turned slightly downward. A humidistat is installed in Level 1 – Equipment Room.
- The drawings also indicate electric heat trace cable being installed; however, the drawings do not clearly define the purpose or location of the heat trace cable.
- The multiple glazing surfaces of the viewing structure allows solar heat to enter the missile silo during all daylight hours while also allowing conduction heat loss anytime the exterior tempature is lower than the interior temperature. The heat loss is offset by the electric heater provided with viewing strucutre project.
- The heat gain has a limited impact on the overall silo as it is small when compared to the heat loss through the silo walls. The average ground tempature in South Dakota is approximatley 51 deg-F while the launch tube design temperature is 60 deg-F, which requires heating year round now that the launch control equipment is no longer installed an operating.



Figure 1C.46: Warm air is discharged up to the viewing structure to minimize condensation and melt snow to provide visitors with a view in the launch tube. (Source: H.F. Lenz Company)



Figure 1C.47: A dehumidifier added by the National Park Service to control humidity in the launch tube. (Source: H.F. Lenz Company)



Figure 1C.48: A drum louver connected to the dehumidifier to discharge dry air into the launch tube. (Source: H.F. Lenz Company)

The Delta-09 Soft Support Building

The Delta-09 Soft Support Building houses an air-cooled brine chiller which produced low temperature chilled brine pumped to the air-handling unit in the Delta-09 Launch Facility. The brine chiller has an integral ducted air-cooled condenser section. Air within the Soft Support Building is drawn through the condenser to allow excess heat from the brine chiller to be rejected. During the warmer months, an outdoor air intake damper is open, pulling outside air into the building. The hot air from the condenser is then exhausted out through the exhaust areaway on the opposite site of the support building. During cooler periods, the intake damper is closed, and air is recirculated in the Soft Support Building to warm the space to a minimum of 40°F. Alternately, the if cooling is no longer required in the Launch Facility, an electric unit heater operates to heat the Soft Support Building.

The outdoor air intake damper is also interlocked with the standby diesel fuel generator and opens whenever the generator operates. All of the equipment has been decommissioned and no longer operates. The equipment is obsolete and only has historical value at this time.



Figure 1C.49: The air-cooled brine chiller is used to produce chilled brine to cool the equipment racks in the Launch Facility. (Source: H.F. Lenz Company)

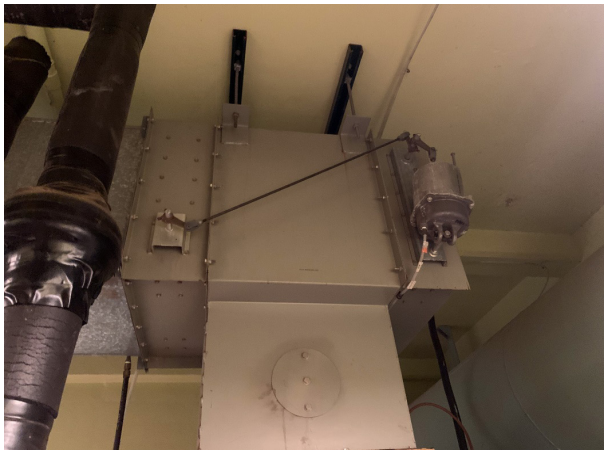


Figure 1C.50. The damper arrangement for the brine chiller condenser fan allows air to either be exhausted out of the Soft Support Facility or recirculate the air to heat the space. (Source: H.F. Lenz Company)

Electrical

Electric Service

The Delta-09 Launch Facility (LF) site is served via a 208Y/120V-3PH overhead electric service that sits just outside the East secured fence line. A bank of three-phase 30KVA pole-mounted transformers serves both the Delta-09 Soft Support Building and LF. Secondary conductors travel overhead and down a meter pole to the utility provided meter. From the meter pole, secondary conductors travel overhead to a dip pole, where the overhead distribution transitions to underground distribution, and enters the Delta-09 Soft Support Building (Fig 1C.51).



Figure 1C.51. Overhead electric service entering the Delta-09 site just outside the East fence line. (Source: H.F. Lenz Company)



Figure 1C.52. Front view of Panel 'LDB', dedicated to serving equipment in the Delta-09 LF. (Source: H.F. Lenz Company)

Delta-09 Launch Facility Main Distribution

Electrical distribution for the LF consists of one singular distribution panel (Panel 'LDB'), located in the lower level of the facility. Panel 'LDB' is a 200A, 208Y/120V, 3PH-4W panelboard, manufactured by Federal Pacific, and is original to the Delta-09 LF. Panel 'LDB' was dedicated to the LF and served various loads such as lighting, receptacles, mechanical equipment, and mission critical cooling racks for launch controls and missile guidance systems. Externally, no rust or corrosion can be seen on the panelboard's protective enclosure (Fig 1C.52). The front protective cover of the panelboard was not removed for further investigation.

Lighting and Branch Wiring

Lighting fixtures in the LF are approximately 18 inches in diameter, surface mounted or suspended type luminaires with 150W incandescent bulbs.

Delta-09 Soft Support Building Main Service Disconnect

Below grade, secondary conductors enter beneath the soft support building, where they land on four (4) 350A power line filters (used for mitigation of electromagnetic and radio interferences) and continue on to the main service disconnect. Heavy corrosion was observed on the power line protection filter assembly (Fig 1C.53). The main service disconnect appears to be rated for 350A based on existing documentation provided by the National Park Service (NPS); however, the front protective cover was not removed for precautionary reasons and safety concerns. The exact rating of the main service disconnect could not be visually field verified.



Figure 1C.53. Corrosion and rust setting in on the load of the power line protection filter assembly. (Source: H.F. Lenz Company)

Ken Thompson of the NPS, provided photos of the internal electrical components of the main service disconnect, from a prior site investigation (Fig 1C.54). Due to excessive flooding and untimely failure of the sump pump, the main service disconnect suffered heavily from corrosion, lack of dehumidification, and flood waters breaching the protective enclosure.

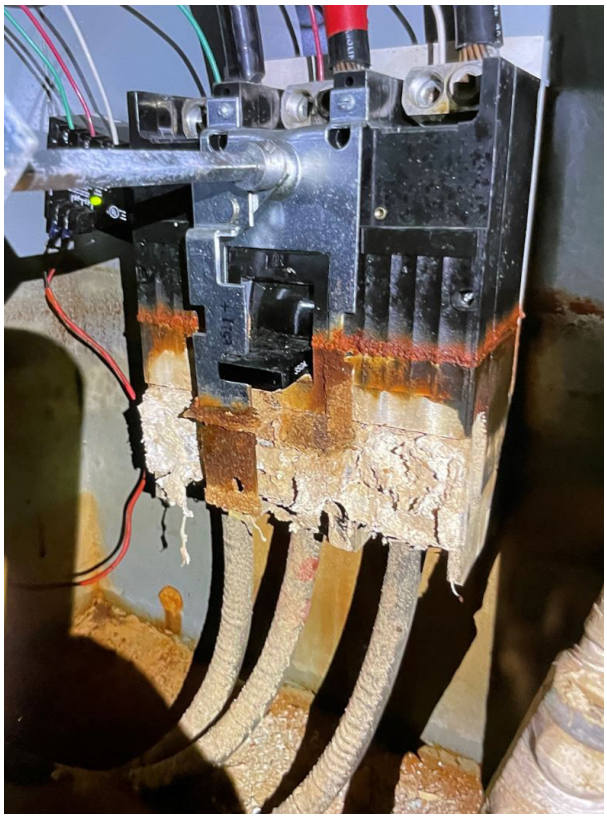


Figure 1C.54. Flood damage and onsetting corrosion can be seen on the main service disconnect within its protective enclosure. (Source: Ken Thompson, NPS)

Main Distribution

Load side conductors off the main service disconnect travel overhead to a 400A, 208Y/120V, 3PH-4W Main Distribution Panel 'LDA' and terminate on the distribution panels 350A main circuit breaker (MCB). This MCB serves as the disconnecting means to the normal feed of the Automatic Switching Unit (Automatic Transfer Switch (ATS)). Conductors off the load side of the ATS, travel back overhead, through disconnect contactor 'D1', and tap directly on to the bussing of Distribution Panel 'LDA'.

Distribution Panel 'LDA', manufactured by Federal Pacific, serves as the main electrical distribution panel for the entire Delta-09 site (Delta-09 Soft Support Building and LF) and appears to be original to the Soft Support Building. Visually, 'LDA' looks to have succumbed to excessive exposure to a combination of flood waters entering its protective enclosure and a lack of dehumidification. Bubbling and cracking of the protective paint on the metal housing, exposing bare metal to moisture, was observed (Fig 1C.55). Corrosion and rust accumulation on the panels over current protection devices (Fig 1C.56) and interior sides of its protective enclosure (Fig 1C.57) are visual indicators of condensation build up over time. Branch panelboards served by 'LDA' include Panel 'LDC', Panel 'LLA' and Panel 'LDB'.



Figure 1C.55. Cracking of paint and rust accumulating on Panel 'LDA' protective enclosure. (Source: H.F. Lenz Company)

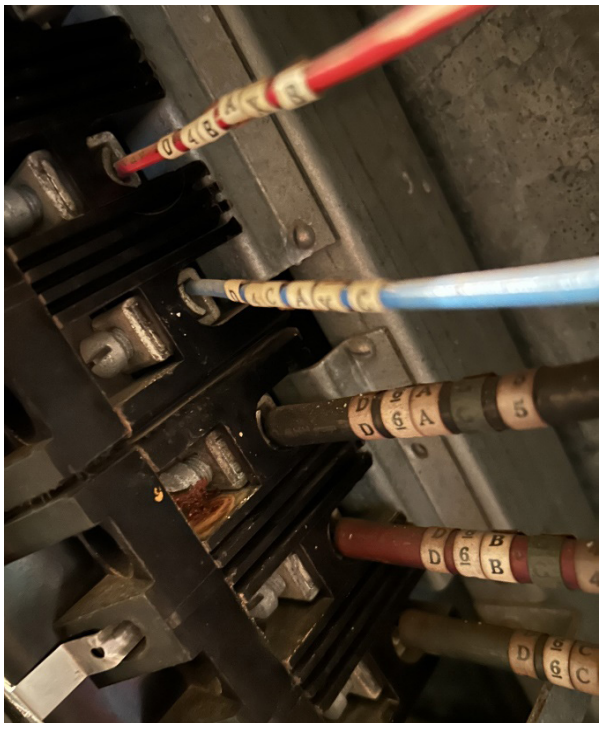


Figure 1C.56. Rust accumulating on Panel 'LDA' overcurrent protection devices. (Source: H.F. Lenz Company)



Figure 1C.57: Interior side of Panel 'LDA' protective enclosure. (Source: H.F. Lenz Company)



Figure 1C.58: Interior side of Panel 'LDC' protective enclosure. (Source: H.F. Lenz Company)

Panel 'LDC', also located in the Soft Support Building, is a 100A, 208Y/120V, 3PH-4W panelboard that was at one point dedicated to serving mechanical equipment such as brine pumps, condenser fans and refrigeration compressors. Based on the difference in manufacturer (General Electric) compared to other electrical distribution equipment and the type and condition of overcurrent protection devices, Panel 'LDC' appears to have been replaced and retrofitted in its existing enclosure in recent years. No visual indicators of corrosion or rust were observed on the internal components of Panel 'LDC' however, the paint on the original enclosure, internally and externally, looks to have suffered from high humidity (Fig 1C.58).

Lighting, receptacles, and other general loads for the Delta-09 Soft Support Building are served via Panel 'LLA'. Panel 'LLA' is a 100A, 208Y/120V, 3PH-4W panelboard manufactured by Federal Pacific and appears to be original to the Soft Support Building. Internally, an accumulation of rust and corrosion can be seen accumulating on the panel's main lugs, overcurrent protection devices and interior portions of the panelboard's protective enclosure.

Standby Power Distribution

The 75KW 208Y/120V, 3PH-4W diesel generator, associated control panel, cranking panel and battery charger look to be abandoned in place and decommissioned. Splotches of rust and bubbling and cracking of protective paint was observed on all pieces of equipment associated with the decommissioned standby diesel generator (Fig 1C.59). Water lines from past flooding can be seen on the interior side of the enclosure door of the 300A Automatic Transfer Switch along with corrosion setting in on the emergency lugs (Fig 1C.60).

Lighting and Branch Wiring

Lighting fixtures in the LF are approximately 18 inches in diameter, pendant mounted type luminaires with 150W incandescent bulbs. All branch wiring observed was copper in type. No aluminum conductors were observed in any areas of the Soft Support Building. Visually, Copper conductors appeared to be healthy and undisturbed.

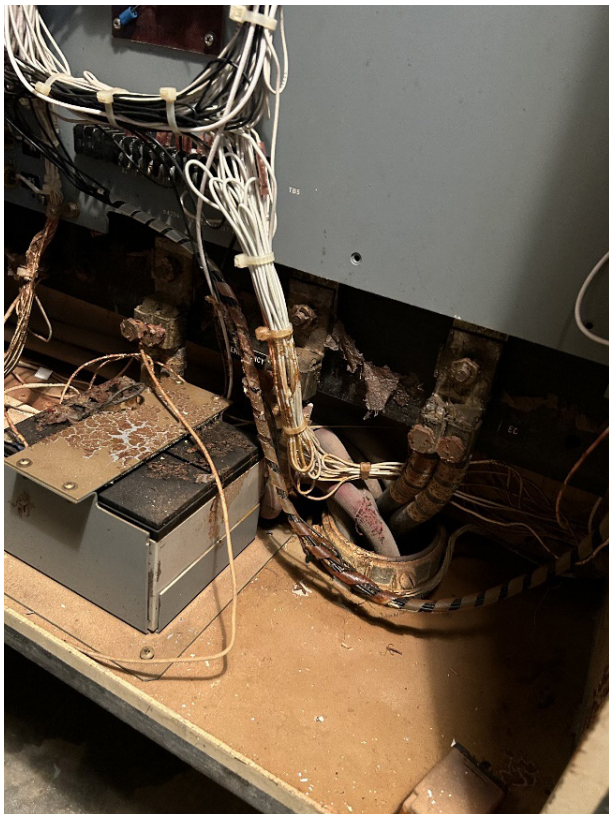


Figure 1C.59: Onsetting corrosion and rust on the Automatic Transfer Switch emergency lugs. (Source: H.F. Lenz Company)



Figure 1C.60:. Front view of Generator battery charger and cranking panel. (Source: H.F. Lenz Company)

Page intentionally left blank

Part 2A. Ultimate Treatment and Use

Introduction

The revised scope of work for this project states that the report will include "preservation / restoration treatment recommendations at Delta-09 only" and that "This report's findings will form the basis for the corrosion mitigation project scheduled for 2026-2027."

Ultimate Use

The NPS plans continued use of the resource as a visitor attraction to interpret Cold War Nuclear armament per the park's enabling legislation.

Ultimate Treatment

The 2010 HSR-CLR documents Preservation as the management approach for these resources.

> Preservation is also the most appropriate management approach for the historic buildings and structures at Delta-01 and Delta-09. These resources have, with minor exceptions, been preserved exactly as they were when the Ellsworth Air Force Base Minuteman Missile wing was decommissioned in 1993. Those minor exceptions included the removal of some classified equipment, installation of a fire suppression system, the substitution of a training model of a missile for the active ICBM in the silo, and the installation of a viewing enclosure over the missile silo. The intention for the buildings and structures at Delta-01 and Delta-09 is to preserve them in as authentic a condition as possible so that visitors can experience the buildings as they were during their active use. Any alterations or additions necessary to their interpretive and operational functions should have minimal impact on the historic resources. Preservation is an appropriate treatment for the buildings and structures because of the very high integrity of the sites and their intended interpretive use.[1]

The Secretary of the Interior's Standards for the Treatment of Historic Properties defines Preservation as follows:

> Preservation is defined as the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. The limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code-required work to make properties functional is appropriate within a preservation project. However, new exterior additions are not within the scope of this treatment. The Standards for Preservation require retention of the greatest amount of historic fabric along with the building's historic form.[2]

Any treatment should anticipate regular maintenance and repair campaigns every 10 to 15 years. The recommended ultimate treatment would maintain this significant resource for future generations while allowing ongoing interpretation.

1. *Minuteman Missile National Historic Site: Historic Structure Report, Cultural Landscape Report and Environmental Assessment* (October 2010), 6.11.
2. Anne E. Grimmer, *The Secretary of the Interior's Standards for the Treatment of Historic Properties (Revised)* (Washington, D.C.: National Park Service, 2017) 2, https://www.nps.gov/orgs/1739/upload/treatment-guidelines-2017-part1-preservation-rehabilitation.pdf

Page intentionally left blank

Part 2B. Treatment Requirements

Hazardous Materials: Lead

Occupational Safety and Health Administration (OSHA) standard, 29 Code of Federal Regulations (CFR) 1926.62 (Lead in Construction), does not reference a specific concentration of lead in a paint surface coating for applicability of the aforementioned regulation. The requirements under OSHA 29 CFR 1926.62 are applicable to any concentration of lead found above the analytical method's reporting limit. When disturbed, paints containing lead in any concentration represent an airborne exposure hazard that could exceed the OSHA legally enforceable action level (AL) or permissible exposure limit (PEL). Contractors that bid or conduct work activities that will disturb surfaces with lead-containing paint should be made aware of those so that they can plan for proper compliance with the OSHA Lead in Construction standard. Additionally, contractors should be aware that untested paint surfaces, if any, should be assumed to also contain lead unless sampling and analysis refute lead content.

Protection is required where lead containing coatings or paint are present on structures when performing the following:

(A) Abrasive blasting,

(B) Welding,

(C) Cutting, and

(D) Torch burning.

Regulatory Requirements when disturbing lead-containing paint:

- Personal Protective clothing and equipment
- Change areas
- Handwashing
- Biological monitoring consists of blood sampling and analysis for lead and zinc protoporphyrin levels.
- Training as required: Paragraph (l)(1)(i) regarding Hazard Communication.
- Training as required: Paragraph (l)(2)(iii) regarding the use of respirators.
- Training as required: 29 CFR 1926.21 Safety Training and Education.

See Appendix A: Hazardous Materials for the Limited Lead Paint Testing Report findings and additional requirements for treatment.

Hazardous Materials: Asbestos

The federal asbestos NESHAP (40 CFR Part 61, Subpart M) regulates asbestos fiber emissions and asbestos waste disposal practices. The asbestos NESHAP regulation also requires the identification and classification of existing ACM according to friability prior to demolition or renovation activity. Friable ACM is a material containing more than 1% asbestos that, when dry, can be crumbled, pulverized, or reduced to powder by hand pressure. All friable ACM is considered regulated ACM (RACM).

The federal asbestos NESHAP regulation classifies material subject to demolition or renovation as RACM, Category I non-friable ACM, or Category II non-friable ACM. RACM includes all friable ACM (pre-disturbance); Category I nonfriable ACM that becomes friable (during disturbance) or is subject to sanding, grinding, cutting, or abrading; or Category II nonfriable ACM with a high probability of becoming crumbled, pulverized, or reduced to powder by forces expected to act on the material during disturbance. Category I nonfriable ACMs are asbestos-containing packings, gaskets, resilient floor coverings, and asphalt roofing products that contain more than 1% asbestos. Category II non-friable ACMs are all other non-friable materials (other than Category I non-friable ACM) that contain more than 1% asbestos. Category II nonfriable ACM generally includes (but is not limited to) cementitious material such as cement pipes, cement siding, cement panels, glazing, mortar, and grouts.

RACM must be properly removed by a state-licensed asbestos abatement contractor prior to

demolition or renovation activities that will disturb the materials. If the amount of RACM exceeds 260 linear feet of pipe insulation, greater than 160 square feet for other building components, or will generate more than one cubic meter of waste, the owner or operator must provide the State of South Dakota with written notification of planned removal activities at least 10 working days prior to the commencement of asbestos abatement activities. Removal of RACM must be conducted by an appropriately accredited and South Dakota licensed asbestos abatement contractor. For friable abatement projects that are equal to or greater than (≥) 260 linear feet or any combination that is ≥160 square feet and linear feet, third party final clearance air sampling is required following abatement activities. In addition, the landfill receiving the ACM materials must be notified of the asbestos content.

The Asbestos Section of the South Dakota Department of Agriculture and Natural Resources (DANR) is responsible for regulating asbestos abatement projects in the state of South Dakota. The emission standards for asbestos during remodeling or demolition projects are adopted from the federal NESHAP standards in Administrative Rules of South Dakota 74:36:08. The DANR office provides technical assistance, issues worker certifications, receives abatement job notifications, conducts inspections, and conducts complaint investigations. Training and certification rules are found in Administrative Rules of South Dakota 74:31. DANR has the authority to enforce the South Dakota asbestos program in lieu of the USEPA. Both the building owner and the contractor share the responsibility of making sure the federal and state asbestos requirements are met. All RACM must be removed from a structure being demolished or renovated before any activities are carried out that would break up, dislodge or similarly disturb the materials or prevent access to materials for subsequent removal. Under these rules, resilient floor coverings and asphalt roofing materials are defined as Category I nonfriable materials. The term “friable” means that a material can be easily crushed or reduced to powder thereby releasing asbestos fibers into the air. Nonfriable materials, such as floor tile and asphalt roofing, are not easily crumbled and are less likely to release fibers unless mishandled. According to the current regulations, Category I nonfriable materials are not required to be handled or disposed of as regulated asbestos materials as long as they remain nonfriable during removal and handling. Also, non-friable materials are not required to be handled by certified asbestos workers if they remain non-friable. Any Category I materials which are not in poor condition and are not made friable during handling can be disposed of as normal waste but may be subject to local landfill requirements. Any friable materials exceeding 160 square feet, or 260 linear feet must be properly removed, handled, and disposed of according to all NESHAP requirements. Projects involving the removal of RACM must be notified to the state and must be postmarked 10 working days prior to the start of any activity that may disturb RACM. It should be noted that the federal Occupational Safety and Health Administration (OSHA) has additional regulations which may apply to any asbestos projects and the EPA has additional rules regarding asbestos in schools. The South Dakota OSHA regional office number is (720) 264-6550. As stated above, every landfill has the final approval of what types of materials they will accept and how they will accept them, so it is a good practice to check with the landfill operator prior to disposal of any ACM.

The federal OSHA asbestos standard for the construction industry (29 CFR 1926.1101) regulates workplace exposure to asbestos. The OSHA standard requires that employee exposure to airborne asbestos fibers be maintained below the permissible exposure limits (PELs) of 0.1 asbestos fiber per cubic centimeter of air (0.1 f/cc) as an 8-hour time-weighted average (TWA) or 1.0 f/cc as a 30-minute excursion limit. The OSHA standard specifies work practices and precautions that employers must follow when engaging in specific classes of asbestos work.

See Appendix A: Hazardous Materials for the Asbestos Inspection Report findings and additional requirements for treatment.

Part 2C. Treatment Recommendations & Alternatives

Work by NPS Staff

- Monitor and document conditions on a quarterly basis using a maintenance checklist. Copies of the checklist should be kept on file at the park so that changes in condition are tracked.
- Continue regular maintenance.
- Consider the interpretive potential of maintenance, repair, and rehabilitation, and restoration work, both during a major project and during regular maintenance.

Exterior Preservation

Exterior work encompasses the following tasks:

Site

- Continue regular maintenance.

Launch Facility

Concrete Substrates

- Perform repairs to address slab delaminations and cracks.
- Apply a clear, penetrating water repellent sealer to the viewing structure vertical concrete curb surfaces.
- Install a hi-solids polyurethane waterproof membrane system over the exposed horizontal concrete surfaces.

Steel Substrates

- Monitor paint coatings for signs of failure or steel corrosion. Prepare and apply a high-performance coating system primer and topcoats as needed to maintain protective seal.

Access Hatch

- Continue regular service of hatch motor.
- Replace gaskets in kind as required to provide a water-tight seal.

Launcher Viewing Structure

- Consider replacement of the existing glazing and framing of the non-historic clerestory and viewing structure. This feature was installed by NPS to provide visitors with a view down into the missile silo. Glazing technology has evolved significantly since this feature was installed. It may be possible to provide glass with a more transparent appearance but improved performance, both in U-value (insulation) and reduced solar heat-gain (reducing high summer temperatures noted since installation of the viewing structure. "Non-reflective UV light filtering film should be installed to reduce solar heat gain. Anti-reflection performance of the glazing supports improved viewing into the launcher tube." It may also be possible to reduce the width of the mullions, improving visitors' view of the silo interior. The site is isolated and unstaffed and park staff have noted footprints on the viewing structure glass. For this reason, any new viewing structure glass must be rated to withstand such abuse by unsupervised visitors.

Soft Support Building

Concrete Substrates

- Remove and replace the split-slab concrete topping slab and underlying waterproofing membrane system. The structural slab underneath the topping slab and waterproofing membrane system is to remain while injection of cracks in that remaining concrete will address moisture infiltration issues.

Steel Substrates

- Monitor paint coatings for signs of failure or steel corrosion. Prepare and apply a high-performance coating system primer and topcoats as needed to maintain a protective seal.

Interior Preservation

Interior should be assumed to include the following tasks:

Launch Facility

Interior Systems

- Address mold and mildew on HICS cables and other wiring. Treatment of microbial growth in historic structures requires a continual cycle of observation and treatment. MIMI staff should continue to compile temperature and relative humidity data in the historic structures. In addition, an Environmental Assessmetn of the historic Delta-01 and Delta-09 structures will provide MIMI staff with a data driven, long term, and sustainable treatment plan to address the microbial growth found on structural features and improve the park's understanding of fluctuations impacting the building envelopes and interior features and contents.
- Replace existing dehumidification equipment with new equipment with greater capacity to lower the indoor relative humidity to prevent condensation from occurring. The NPS is currently undertaking a dehumidification and ventilation project planned for construction in 2024. The scale and scope of the project is limited. There will be a need to reevaluate the effectiveness and consider alternatives for long-term dehumidification management.
- Install additional electric unit heaters to maintain the launch facility temperature at 60°F which will inherently lower the space relative humidity.
- Replace existing sump pump controls and alarms with a system capable of being remotely monitored.

Interior Concrete and Steel Substrates

- Debonding and delaminations within the reinforced concrete launch tube wall are evident based on the audible hammer sounding results. Verified conditions from the impact echo and spectral analysis of surface waves testing performed by Olson Engineering also support the debonding and delaminations present. Continued monitoring of the concrete wall structure is prudent for documenting changes over time.
- The launcher access shaft steel plate liner section loss reported by Gecko Robotics in their study (refer to Appendix C) is nearly 40% in isolated locations. The condition of this damage should be monitored through continued testing. See below for paint finishes.
- The launcher equipment room steel plate liner section loss reported by Gecko Robotics in their study (refer to Appendix C) is nearly 25% at isolated locations. The condition of this damage should be monitored through continued testing. See below for paint finishes.
- The launch tube steel plate liner section loss reported by Gecko Robotics in their study (refer to Appendix C) is nearly 25% at isolated locations. The condition of this damage should be monitored through continued testing. See below for paint finishes.
- Reopen and maintain the drain operation of the neutralizer pit and adjacent floor drain.
- Reopen and maintain the open nature of all weep holes through the launch tube steel wall at the equipment room second level.
- The current studies and testing performed by Gecko Robotics and Olson Engineering have developed a condition assessment baseline. Both the Gecko and Olson testing should be repeated within the next 1-2 years and changes in the documented deterioration within the steel plate and concrete wall structure should be noted. The rate of deterioration can be charted through future testing. The results of the next round of testing by both Gecko and Olson can instruct the future frequency of monitoring and when to implement appropriate treatment options. The current treatment recommendation is to continue monitoring the concrete wall structure, documenting changes in damage, so the rate of deterioration can be tracked. Pending the results of future testing, medium level treatments may include supplemental steel plate strengthening to address steel corrosion or blindside injection of epoxy

resins from inside the launch tube to address debonding and thin conditions within the concrete wall structure. Continued testing following such repairs can verify the effectiveness of the repair installation while also continuing to monitor for new or progressive damage. Should conditions continue to worsen and deteriorate at an accelerated rate, more invasive, higher level treatments may be necessary to preserve the integrity of the below-grade structure. Such work may involve excavation of portions of the launch tube wall to directly expose the conditions in need of repair.

Interior Paint Finishes

- Maintain historic paint finishes where possible.
- In areas that have suffered corrosion, photographically document surviving paint finishes prior to paint removal associated with corrosion mitigation and repair work.

Soft Support Building

Interior Systems

- Address mold and mildew on HICS cables and other wiring. Treatment of microbial growth in historic structures requires a continual cycle of observation and treatment. MIMI staff should continue to compile temperature and relative humidity data in the historic structures. In addition, an Environmental Assessmetn of the historic Delta-01 and Delta-09 structures will provide MIMI staff with a data driven, long term, and sustainable treatment plan to address the microbial growth found on structural features and improve the park's understanding of fluctuations impacting the building envelopes and interior features and contents.
- Replace existing sump pump controls and alarms with a system capable of being remotely monitored.
- Replace the electric unit heater and temperature controls to provide heat to lower the space relative humidity and minimize condensation of the building and equipment interior surfaces.
- Modify the existing ventilation system and controls to allow the building to be ventilated during warmer, humid months to minimize condensation.
- Retrofit existing electrical equipment required for lighting and serving minimal maintenance equipment (hoist) and HVAC equipment recommended for humidity control and supplemental heat.

Interior Concrete Substrates

- Continue regular maintenance. See below for paint finishes.

Interior Steel Substrates

- Continue regular maintenance. See below for paint finishes.

Interior Paint Finishes

- Maintain historic paint finishes where possible.

In areas that have suffered corrosion, photographically document surviving paint finishes prior to paint removal associated with corrosion mitigation and repair work.

Maintenance Deficiency Priority Ratings (5-Year Rating Period)

Listed as "Priority Ratings" on the Feature Inventory Condition Assessment Tables, these ratings are based on the condition rating of each feature and a priority rating was established. These priority ratings indicate either a critical, serious, or minor deficiency priority rating.

Critical – (Emergency/Immediate)

- This rating defines an advanced state of deterioration which has resulted in the failure of a feature or will result in the failure of a feature if not corrected within 1 year; or
- There is accelerated deterioration of adjacent or related materials or systems as a result of the feature's deficiencies if not corrected within 1 year; or
- There is an immediate threat to the health and/or safety of the user; or
- There is a failure to meet a regulatory requirement.

Serious – (Immediate/Short Term)

- This rating defines a deteriorated conditions that if not corrected within 1 to 3 years will result in the failure of the feature; or
- A threat to the health and/or safety of the user may occur within 1 to 3 years if the ongoing deterioration is not corrected; or
- There is ongoing deterioration of adjacent or related materials and/or features as a result of the feature's deficiency.

Minor – (Short Term/Long Term)

- This rating indicates standard preventative maintenance practices and preservation methods have not been followed; or
- There is reduced life expectancy of affected adjacent or related materials and/or systems within 3 to 5 years and beyond; or
- There is a condition with a long-term impact within 3 to 5 years and beyond.

For the purposes of this report, these definitions were rigorously adhered to as a way to qualitatively assess the current condition of the Delta-09 Launch Facility.

Structural

Delta-09 Soft Support Building Exterior

Priority: Serious

- [BEST OPTION FOR LONG TERM DURABILTY AND SERVICE LIFE] Remove and replace the 2-1/2" concrete wear slab and waterproofing system between the concrete wear slab and the structural concrete slab. Cracks within the structural concrete slab can be injected with a hydrophobic resin to offer additional protection against future moisture infiltration at those locations. Upon completion of the new concrete wear slab over the new waterproofing, an additional layer of protection for the new wear slab can include the installation of a hi-solids polyurethane waterproofing traffic-bearing membrane system across the concrete surface to minimize moisture infiltration and subsequent related concrete damage. Such a membrane system is an opaque coating system that will cover the concrete surface and standard pigmented topcoats generally consist of various gray color options. Alternatively, the polyurethane topcoat material can be tinted to provide a custom color that may provide a better color match to the original concrete.
- [GOOD OPTION WHILE STILL RELYING ON ORIGINAL WEAR SLAB AND WATERPROOFING] Leave the original concrete wear slab in place and perform concrete repairs to address slab delaminations and cracks. Delaminations should be cut out and patched using a concrete repair patching material. Consideration should be given to the concrete repair materials and aggregates selected to blend with the original substrate while not compromising the durability of the patch repair. Cracks are to be routed with a v-notched blade and filled with polyurethane sealant to provide a weathertight detail. The existing sealant installed across the horizontal gap between the concrete slabs should be cut out to reopen the waterproofing plane to permit the existing waterproofing the ability to drain. As the original wear slab would remain in place, likewise the original waterproofing would also remain in place. To account for a 62-year-old waterproofing system that has known deficiencies and to remove any aesthetic inconsistencies between new patches and the original remaining concrete substrate, a hi-solids polyurethane waterproofing traffic-bearing membrane system can be installed across the wear slab concrete. If coated with a membrane system, the original wear slab would also greatly benefit from minimized moisture infiltration.
- [ALTERNATIVE OPTION WITH SHORTER SERVICE LIFE AND LESS PROTECTION] An alternative to installing an opaque, polyurethane membrane system across the concrete wear slab would be to apply a clear, penetrating water repellent sealer with corrosion inhibitor. Penetrating sealers are typically reapplied every 2 years to ensure their effectiveness in protecting the concrete.

Polyurethane membrane systems, when applied in this type of application where foot traffic across the coating is minimal, can provide between 10-15 years of service life before significant maintenance efforts are necessary.

Delta-09 Soft Support Building Interior

Priority: Minor

- The few concrete spalls inside the Soft Support Building can be patched using concrete repair patching materials.
- Refer to the HVAC recommendations regarding treatment for addressing ambient moisture conditions inside the Soft Support Building.
- Paint coatings applied to the concrete surfaces will require attention at damaged locations.

Delta-09 Launch Facility - Exterior

Viewing Structure

Priority: Serious

- Install a clear, penetrating water repellent sealer with corrosion inhibitor across the exposed concrete curb surfaces below the viewing structure to help limit moisture migration through the existing shrinkage cracks.

Closure Door and Tracks

Priority: Serious

- Perform spot repairs to address concrete delaminations and cracks. Delaminations should be cut out and patched using a concrete repair patching material. Consideration should be given to the concrete repair materials and aggregates selected to blend with the original substrate while not compromising the durability of the patch repair.
- Clean corrosion areas on steel substrates. Prepare and apply a high-performance coating system primer and topcoats as needed to maintain a protective seal.
- [BEST COATING OPTION FOR LONG TERM DURABILTY AND SERVICE LIFE] The exposed concrete on the closure door and tracks are susceptible to moisture infiltration and related damage. Installation of a hi-solids polyurethane waterproof traffic-bearing membrane system will provide for a significant reduction in moisture migration through the concrete. Shrinkage cracks in the closer door skyward facing concrete surface are addressed by the waterproof basecoat layer in the membrane system.
- [ALTERNATIVE COATING OPTION WITH SHORTER SERVICE LIFE AND LESS PROTECTION] An alternative to installing an opaque, polyurethane membrane system across the launch facility concrete would be to apply a clear, penetrating water repellent sealer with corrosion inhibitor. The sealer option will protect the concrete from moisture infiltration and maintain the aesthetic appearance of the concrete but is not a waterproofing system and must be reapplied on a regular basis. Many of the narrow shrinkage cracks in the closer door skyward facing concrete surface can be addressed by the penetrating sealer. Wider cracks are to be routed with a v-notched blade and filled with polyurethane sealant to provide a weathertight detail.
- Monitor paint coatings for signs of failure or steel corrosion.

Launch Facility Structure

Priority: Serious

- Inject cracks in the concrete retaining walls using epoxy adhesive. Previous sealant and epoxy repairs spread across the concrete surface have limited effectiveness and should be removed during the crack treatment work.
- Perform horizontal concrete repairs to address concrete delaminations and cracks in the jack and tie down approach slab-on-grade as well as the exposed concrete skyward facing surface of the launch facility structure. Delaminations should be cut out and patched using a concrete repair patching material. Consideration should be given to the concrete repair materials and aggregates selected to blend with the original substrate while not compromising the durability of the patch repair. Cracks are to be routed with a v-notched blade

and filled with polyurethane sealant to provide a weathertight detail. Previous sealant and epoxy repairs spread across the concrete surface have limited effectiveness and should be removed during the crack treatment work.
- Remove and replace all sealant joints in the concrete.
- [BEST COATING OPTION FOR LONG TERM DURABILTY AND SERVICE LIFE] The exposed concrete on the launch facility structure has experienced wide-spread cracking. Installation of a hi-solids polyurethane waterproof membrane system will provide a significant reduction in moisture migration through the exposed concrete surfaces at grade level.
- [ALTERNATIVE COATING OPTION WITH SHORTER SERVICE LIFE AND LESS PROTECTION] An alternative to installing an opaque, polyurethane membrane system across the launch facility concrete would be to apply a clear, penetrating water repellent sealer with corrosion inhibitor. The sealer option will protect the concrete from moisture infiltration and maintain the aesthetic appearance of the concrete, but is not a waterproofing system and must be reapplied on a regular basis.

Delta-09 Launch Facility - Interior

Launcher Access Shaft

Priority: Serious
- The steel plate liner section loss reported by Gecko Robotics in their study (refer to Appendix C) is nearly 40% in isolated locations. The condition of this damage should be monitored through continued testing.
- Continue monitoring the reinforced concrete wall conditions to document changes over time.
- Monitor paint coatings for signs of failure or steel corrosion.

Launcher Equipment Room

First and Second Levels

Priority: Serious
- The steel plate liner section loss reported by Gecko Robotics in their study (refer to Appendix C) is nearly 25% at isolated locations. The condition of this damage should be monitored through continued testing. See below for paint finishes.
- Continue monitoring the reinforced concrete wall conditions to document changes over time.
- Reopen and maintain the drain operation of the neutralizer pit and adjacent floor drain.
- Reopen and maintain the open nature of all weep holes through the launch tube steel wall at the equipment room second level.
- Monitor paint coatings for signs of failure or steel corrosion.
- Clean corrosion areas on steel substrates. Prepare and apply a high-performance coating system primer and topcoats as needed to maintain a protective seal.

Launch Tube

Priority: Serious
- The steel plate liner section loss reported by Gecko Robotics in their study (refer to Appendix C) is nearly 25% at isolated locations. The condition of this damage should be monitored through continued testing.
- Continue monitoring the reinforced concrete wall conditions to document changes over time.
- Additionally, a collaborative effort to superimpose future steel plate liner results with concrete wall testing results can offer any correlation between the steel plate liner section loss damage and the debonding/delaminations found within the reinforced concrete wall.
- Monitor paint coatings for signs of failure or steel corrosion.
- Clean corrosion areas on steel substrates. Prepare and apply a high-performance coating system primer and topcoats as needed to maintain a protective seal.

Plumbing

Delta-09 Soft Support Building

Plumbing – Sump Pump Monitoring

Priority: Serious

- The sump pump serves to remove rainwater that collects in the areaways, which during significant rain events can result in several inches of water. Past flooding of the soft support building occurred when the sump pump failed and did not have an automatic notification.
- Remove and replace the sump pump level controls with electronic level controls with remote monitoring capability. In the event of a pump failure, the high sump level alarm can notify NPS maintenance of the issue before flooding the equipment room. Alarms can be transmitted through telemetry, WIFI, cellular dialer or a hard-wired system.

Delta-09 Launch Facility

Plumbing – Sump Pump Monitoring

Priority: Minor

- The sump pump primarily serves to drain condensate produced by the dehumidifier and any ground water that enters through the weep holes in the launch tube. As a result, the risk of flooding is much less than if it was draining surface water.
- Remove and replace the sump pump level controls with electronic level controls with remote monitoring capability. In the event of a pump failure, the high sump level alarm can notify NPS maintenance of the issue before flooding the equipment room. Alarms can be transmitted through telemetry, WIFI, cellular dialer or a hard-wired system.

HVAC

Delta-09 Soft Support Building & Launch Facility

Heating/Dehumidification.

Priority: Serious

- [BEST OPTION FOR LONG TERM CONTINUITY AND SERVICE LIFE] Rehabilitate and modify the existing brine chiller to operate as a dry cooler to serve new cooling dehumidification equipment to be installed in the Launch Facility. This work would include the following;
    - Pressure test and clean the existing brine piping to be used to circulate a glycol/water mix from the dry cooler to new air handling equipment to be installed in the Launch Facility.
    - Remove the existing centrifugal condenser fan in the Soft Support Building and clean the existing exhaust ductwork, replace the existing dampers and pneumatic actuators with low voltage actuators for the outdoor intake, recirculation damper and exhaust damper.
    - Replace the air-cooled condenser with an indoor centrifugal dry cooler (blower coil unit) and connect the existing brine piping to the coil. Install isolation valves and a stainer.
    - Install several (2 to 3) water source heat pumps of about 2 to 3 tons each (to allow the units to be lowered into the Launch Facility). Each heat pump includes a hot gas reheat coil to use the waste heat for reheat to maintain space temperature and act like a dehumidifier. The reheat is needed because the heat from the launch controller rack is no longer present.
    - Install a new DDC control system to automatically control the equipment in the Soft Support

Building and to interface with the equipment to be installed in the Launch Facility.
    - Replace the existing electric horizontal unit heater in the Soft Support Building to maintain the surface temperature above dewpoint will minimize both corrosion and mold/mildew.
    - Historically, the tube heater serving the Launch Facility operated to maintain a launch tube temperature of 60°F. We recommend adding additional heaters within the launch tube, out of view from the viewing window to keep the temperature of the launch tube walls above dewpoint. The existing tube heater and flexible ductwork should remain as it is part of the historic fabric of the launch facility.
- [GOOD OPTION TO CONTROL HUMIDITY LEVELS] A second means to controlling humidity in the Soft Support Building is the provide thermostatically controlled ventilation. Install an inline exhaust fan in the existing exhaust duct from the brine chiller and extend and intake air duct through the existing intake louver with a gooseneck connection through the capped intake area way. This exhaust fan and dampers can be programed to operate whenever the space temperature is ≥70F or combine it with a humidistat to run whenever the indoor relative humidity is above 50%RH. Humidity control for the Launch Facility is to continue with the planned dehumidification and ventilation project that the NPS is currently planning for construction in 2024.

Electrical

Delta-09 Soft Support Building

Main Distribution and Service Disconnect

Priority: Serious

- [BEST OPTION FOR LONG TERM CONTINUITY AND MAINTAINING HISTORIC INTEGRITY WITH MINIMAL DISTURBANCE] Remove and replace existing 350A service disconnect and relocate to a higher elevation (off the floor) to mitigate the potential of flood water reentering its protective enclosure. Existing protective enclosure to remain and be cleaned to remove dust and corrosion on the interior and exterior sides. Provide paint coatings and touch up paint (matching historic finish) to mitigate future corrosion on existing enclosure. Retrofit existing distribution panel 'LDA' and branch panels 'LDC' and 'LLA'. Circuit breakers for retrofitted panels to match existing distribution entirely, limiting the need to intercept and extend existing branch circuiting serving lighting, receptacles and mechanical equipment. Replace conductors between the service disconnect and retrofitted Main Distribution Panel 'LDA'. Retrofitting includes the replacement of panelboard bussing and overcurrent protection devices.

- [GOOD OPTION FOR LONG TERM CONTINUITY AND MAINTAINING HISTORIC INTEGRITY WITH LIMITED DISTURBANCE] Remove and replace existing 350A service disconnect and relocate to a higher elevation (off the floor) to mitigate the potential of flood water reentering its protective enclosure. Retrofit Distribution Panel 'LDA' with new bussing and overcurrent protection devices to serve existing loads. Intercept and extend existing branch circuiting serving lighting, receptacles, and mechanical equipment back to retrofitted Distribution Panel 'LDA'. Reuse existing branch panelboard enclosures as pull boxes (junction boxes) to extend and route existing branch circuiting.

- Remove dust and corrosion from interior and exterior sides of panel 'LDA', 'LDC' and 'LLA' existing to remain protective

enclosures. Provide paint coatings and touch up paint (matching historic finish) to interior and exterior sides of existing enclosures to mitigate future corrosion/rust build up. Photographically document historic paint finishes prior to application of touch up paint. Remove dust and mold/mildew build up on all existing visible conductors within existing to remain panelboard enclosures.

Static Electrical Equipment

Priority: Serious

- Remove dust and corrosion from interior and exterior sides of existing to remain, abandoned in place automatic transfer switch enclosure. Remove all dust, corrosion and mold/mildew build on internal electrical components including lugs, terminals, and visible conductors and conduit. Return the abandoned in place automatic transfer switch to a refurbished and working condition as if it were to be reenergized and operational. Provide paint coatings and touch up paint (matching historic finish) to interior and exterior sides of existing enclosure to mitigate future corrosion/rust build up. Photographically document historic paint finishes prior to application of touch up paint.

- Remove dust and corrosion from existing to remain, abandoned in place 75KW diesel fired generator set and associated generator controls, battery charging panel and generator cranking panel. Provide paint coatings and touch up paint (matching historic finish) to the abandoned 75KW generator set, battery charging panel and generator cranking panel. Photographically document historic paint finishes prior to application of touch up paint.

- All existing electrical conduits and exposed wiring to be cleaned thoroughly of dust, corrosion, and mold/mildew build up. Conduits to be painted (to match historic finishes) to create a protective barrier and mitigate any potential for future corrosion to reoccur.

- Remove dust and corrosion from existing to remain contactor 'D1' and buck boost transformer enclosures. Interior and exterior portions of enclosures to be cleaned and repainted (to match historic finishes) to mitigate any potential for future corrosion to reoccur.

Lighting

Priority: Minor

- Provide paint coatings (matching original historic finish) to luminaire housings to create a protective barrier and mitigate the potential of corrosion reoccurring.

Delta-09 Launch Facility

Main Distribution

Priority: Minor

- Retrofit existing Distribution Panel 'LDB' with new bussing and overcurrent protection devices to serve LF general lighting, receptacles and mechanical equipment. Although Panel 'LDB' has no visual issues, it is well beyond its service of life and is recommended to be replaced. Circuit breakers for retrofitted panel to match existing distribution entirely, limiting the need to intercept and extend existing branch circuiting serving lighting, receptacles and mechanical equipment.

- Remove dust and corrosion from interior and exterior sides of panel 'LDB' existing to remain protective enclosure. Provide paint coatings and touch up paint (matching historic finish) to interior and exterior sides of existing enclosure to mitigate future corrosion/rust build up. Photographically document historic paint finishes prior to application of touch up paint. Remove dust and mold/mildew build up on all existing visible conductors within existing to remain panelboard enclosure.

Lighting

Priority: Minor

- Provide paint coatings (matching original historic finish) to luminaire housings to create a protective barrier and mitigate the potential of corrosion reoccurring.

Treatment Options Evaluation Table

The following table compares multiple treatment options for specific features. These treatments are rated high, moderate, or low. This table may aid in decision making.

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Launcher Viewing Structure	Option 1: Maintain existing viewing structure	Moderate	Moderate	Moderate	Moderate/ High	This feature is non-historic
Launcher Viewing Structure	Option 2: Replace viewing structure glazing and frame	High	High	High	High	This feature is non-historic
Soft Support Building Concrete Wear Slab	Good Option: Repair existing concrete wear slab to remain in place, cut out caulking at gap between slabs to allow waterproofing to properly drain, existing waterproofing to remain in place, install a waterproof membrane over the wear slab.	High	N/A	Moderate	Moderate	Maintains maximum historic fabric but relies on aged wear slab and waterproofing.
Soft Support Building Concrete Wear Slab	Best Option: Remove and replace the concrete wear slab and waterproofing. Install a protective waterproof membrane over the wear slab.	Moderate	N/A	High	High	Best option for long term durability and service life
Soft Support Building Concrete Wear Slab	Alternative Option: Apply a penetrating water repellent sealer on the wear slab every two to three years	High	N/A	Moderate	High	More economical than a waterproof membrane but requires more periodic maintenance

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Launch Facility Dehumidification	Best Option: Replace the air-cooled condensing section of the brine chiller with a blower coil unit reject heat from new water source heat pump units to be installed in the mechanical level of the Launch Facility	Moderate	Moderate	High	N/A	Allows multiple, smaller heat pumps within the Launch Facility. Air is cooled, removing the moisture and then the "waste heat" is used to reheat the air to maintain temperature. The historic system did not need reheat as the heat from the launch control racks did the heating.
Option 2 - Good Option	Good Option to Control Humidity Levels: A second means to controlling humidity in the Soft Support Building is the provide thermostatically controlled ventilation. Install an inline exhaust fan in the existing exhaust duct from the brine chiller and extend and intake air duct through the existing intake louver with a gooseneck connection through the capped intake area way. This exhaust fan and dampers can be programed to operate whenever the space temperature is ≥70F or combine it with a humidistat to run whenever the indoor relative humidity is above 50%RH. Humidity control for the Launch Facility is to continue with the planned dehumidification and ventilation project that the NPS is currently planning for construction in 2024.	Moderate	Moderate	Moderate	High - The equipment is located on Level 1 and is visible to any visitor accessing Level 1. The equipment does not look "original."	Works similar to Option 1, however, heat is not rejected to water loop - rather directly to surround air. Capacity is limited to the size of the dehumidifier that can fit in the launch tube.

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Delta 09 SSB - Alternate Option 2 to Control Humidity	Provide thermostatically controlled ventilation. Install an inline exhaust fan in the existing exhaust duct from the brine chiller and extend an intake air duct through the existing intake louver with a gooseneck connection through the capped intake area way.	Low	High	High	N/A	This exhaust fan and dampers can be programmed to operate whenever the space temperature is ≥70F or combine it with a humidistat to run whenever the indoor relative humidity is about 50% RH.
Delta 09 SSB Option 1 - Sump Pump Monitoring	Remove and replace the sump pump level controls with wlectronic level controls with remote monitoring capability. In the event of a pump failure, the high sump pump level alarm can notify NPS Maintenance of the issue before flooding the equipment room.	Low	N/A	Moderate	N/A	Alarms can be transmitted through telemetry, WIFI, cellular dialer or a hard-wired system.
Delta-09 LF Option 1 - Sump Pump Montoring	Remove and replace the sump pump level controls with wlectronic level controls with remote monitoring capability. In the event of a pump failure, the high sump pump level alarm can notify NPS Maintenance of the issue before flooding the equipment room.	Low	N/A	Moderate	N/A	Alarms can be transmitted through telemetry, WIFI, cellular dialer or a hard-wired system.

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Delta-09 SSB Option 1 (Best Option) Main Distribution and Service Disconnect	Remove and replace existing 350A service disconnect and relocate to a higher elevation (off the floor) to mitigate the potential of flood water re-entering its protective enclosure. Existing protective enclosure to remain and be cleaned to remove dust and corrosion on the interior and exterior sides. Provide paint coatings and touch up paint (matching historic finish) to mitigate future corrosion on existing enclosure. Retrofit existing distribution panel 'LDA' and branch panels 'LLA.' Circuit breakers for retrofitted panels to match existing distribution entirely, limiting the need to intercept and extend existing branch circuiting serving lighting, receptacles and mechanical equipment. Replace conductors between the service disconnect and retrofitted Main Distribution Panel 'LDA.' Retrofitting includes the replacement of panelboard bussing and overcurrent protection devices.	High	N/A	High	N/A	

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Delta-09 SSB Option 1 (Good Option) Main Distribution and Service Disconnect	Remove and replace existing 350A service disconnect and relocate to a higher elevation (off the floor) to mitigate the potential of flood water reentering its protective enclosure. Retrofit Distribution Panel 'LDA' with new bussing and overcurrent protection devices to serve existing loads. Intercept and extend existing branch circuiting serving lighting, receptacles, and mechanical equipment back to Retrofitted Distribution Panel 'LDA'. Reuse existing branch panelboard enclosures as pull boxes (junction boxes) to extend and route existing branch circuiting. Provide paint coatings and touch up paint (matching historic finish) to mitigate future corrosion/rust build up. Photographically document historic paint finishes prior to application of touchup paint. Remove dust and mold/mildew build up on all existing visible conductors within existing to-remain panelboard enclosures.	Moderate	N/A	High	N/A	

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Delta-09 SSB Static Electrical Equipment	Remove dust and corrosion from interior and exterior sides existing to-remain, abandoned in place, automatic transfer switch enclosure. Remove all dust, corrosion and mold/mildew build up on internal electrical componenets including lugs, terminals, and visible conductors and conduit. Return the abandoned-in-place automatic transfer switch to a refurbushed and working condition as if it were to be reenergized and operational. Provide paint coatings and touch up paint (matchign historic finiah) to interior and exterior sides of existing enclosure to mitigate future corrosion/rust build up. Photographically document historic paint coatings prior to application of touch up paint.	High	N/A	Moderate	N/A	
Delta-09 SSB Static Electrical Equipment (Continued)	Remove dust and corrosion from existing to-remain, abandoned in place 75KW diesel fired generator set and associated generator controls. All existing electrical conduits and exposed wiring to be cleaned thoroughly of dust, corrosion, and mold/ mildew build up. Conduits to be painted (to match historic finishes) to create a protective barrier and mitigate any potential future corrosion to reoccur. Remove dust and corrosion from existing to-remain contactor 'D1' and buck boost transformer enclosures. Interior and exterior portions of enclosures to be cleaned and repainted (to match historic finishes) to mitigate any potential for furure corrosion to reoccur.	HIgh	N/A	Moderate	N/A	

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Delta-09 SSB Lighting	Provide paint coatings (matching original historic finish) to luminaire housings to create a protective barrier and mitigate the potential of corrosion reoccuring.	Moderate	Moderate	Moderate	N/A	
Delta-09 LF - Main Distribution	Retrofit existing Distribution Panel 'LDB' with new bussing and overcurrent protection devices to serve LF general lighting, receptacles and mechanical equipment. Although Panel 'LDB' has no visual issues, it is well beyond its service of life and is recommended to be replaced. Circuit breakers for retrofitted panel to match existing distribution entirely, limiting the need to intercept and extend existing branch circuiting serving lighting, receptacles and mechanical equipment. Remove dust and corrosion from interior and exterior sides of panel 'LDB' existing to-remain protective enclosure. Provide paint coatings and touch up paint (matching historic finish) to interior and exterior sides of existing enclosure to mitigate future corrosion/rust build up. Photographically document historic paint finishes prior to application of touch up paint. Remove dust and mold/mildew build up on all existing visible conductors within existing to-remain panelboard enclosure.	Moderate	Moderate	Moderate	N/A	

Feature	Treatment	Effect on Historic Fabric	Energy Efficiency	Maintenance & Durability	Visitor Experience	Notes
Delta-09 LF - Lighting	Provide paint coatings (matching original historic finish) to luminaire housings to create a protective barrier and mitigate the potential of corrosion reoccuring.	Moderate	N/A	Moderate	N/A	

Page intentionally left blank

List of Figures

Executive Summary and Administrative Data 11

Report Summary 11

Figure 0.1: Minuteman National Historic Site map showing the location of the Visitor Center relative to the Delta-09 and Delta-01 sites. 16

Part 1A. Developmental History 17

Figure 1A.1: Cover Page, HSR, CLR and EA prepared by Quinn Evans Architects in 2010 (Source: Quinn Evans Architects). 17

Part 1B. Character Defining Features 19

Figure 1B.1: [Right Spread] Detail of floorplan of Delta-01 Launch Control Center (LCC), 1961. The angled section at left is the elevator lobby. The elliptical section to the right is the capsule containing the suspended acoustical enclosure. Source: MIMI. 22

Figure 1B.2: [Right Spread] Detail of section of Delta-01 Launch Control Center (LCC), 1961. The L-shaped section at left is the elevator and ladder shaft and elevator lobby. The elliptical section to the right is the capsule containing the suspended acoustical enclosure. Source: MIMI. 24

Figure 1B.3: Elevator enclosure and ladder in elevator lobby of Delta-01. Source: RATIO, 2023. 27

Figure 1B.4: View up shaft in elevator lobby of Delta-01. Source: RATIO, 2023. 27

Figure 1B.5: Morale art on the elevator lobby wall and blast door of Delta-01. The mural at left was painted in 1988 and that on the blast door was painted by Deputy Missile Combat Crew Commander Tony Gatlin (born 1962) in 1990. The "30 minutes or less" was classified information at the time this was painted. Source: RATIO, 2023. 27

Figure 1B.6: Interior of capsule showing interior of blast door opening and platform connecting to acoustical enclosure (off-camera at right). The circular spot above the door is overpainted morale art. Source: RATIO, 2023. 27

Figure 1B.7: View from capsule toward blast door and elevator lobby. Source: RATIO, 2023. 28

Figure 1B.8: Overpainted morale art on the capsule wall above the blast door opening. Park staff report that the Air Force painted over this art shortly before turning the property over to NPS; it is believed to show a skull and crossbones (partially visible through the overpaint) and reportedly included the words "kick ass." Source: RATIO, 2023. 28

Figure 1B.9: View from top of acoustical enclosure showing escape tube door (center), cable protective frame enclosure (right), acoustical enclosure suspension system (right foreground), and historic HVAC equipment and ductwork (bottom left and center). Source: RATIO, 2023. 28

Figure 1B.10: View into acoustical enclosure showing computer cases, built-in equipment, the bunk, chairs, light fixtures, and acoustical treatments. Source: RATIO, 2023. 29

Figure 1B.11: View from the back of the acoustical enclosure toward the door showing computer cases, built-in equipment, the bunk, chairs, light fixtures, and acoustical treatments. Source: RATIO, 2023. 29
Figure 1B.12: Toilet within acoustical enclosure. Source: RATIO, 2023. 29

Part 1C. Physical Description and Condition Assessment – Delta-09 Launch Facility 33

Figure 1C.1. View of the Soft Support Building as seen from grade level. 37
Figure 1C.2. Soft Support Building roof plan showing documented cracks and concrete delaminations. Original plan view adapted from Sheet A-8 created by Parsons-Staven dated June 5, 1961. 38
Figure 1C.3. Repaired cracks in the concrete wear slab that utilized epoxy and sealant material. 39
Figure 1C.4. An example of a cracked and delaminated portion of the concrete wear slab. 39
Figure 1C.5. The perimeter gap between the concrete wear and structural slabs has been sealed tight with sealant. 39
Figure 1C.6. The previous coating material on the exposed portion of the foundation wall has failed. . 39
Figure 1C.7. View of the underside of the Soft Support Building structural slab with an active leaking crack. 40
Figure 1C.8. Close-up view showing the slab crack and stalactite formation resulting from the active moisture migration. 40
Figure 1C.9. Rusted steel surfaces were observed on the removeable cover plate infill structure. 40
Figure 1C.10. Organic growth was visible on the underside painted surface of the structural concrete roof slab. 40
F: Special Construction – Delta-09 Launch Facility 40
Figure 1C.11. Launch Facility grade level plan. Original plan view adapted from Sheet A1 created by The Roybal Corporation dated June 28, 1996. 41
Figure 1C.12. Launch Facility cross-sectional view. Original section view adapted from Sheet S-19 created by Parsons-Staven dated June 5, 1961. 42
Figure 1C.13. View of the concrete curb supporting the viewing structure. 43
Figure 1C.14. Shrinkage cracks were observed within the concrete curb and no delaminations were noted. 43
Figure 1C.15. View of the plug detail on the skyward facing surface of the closure door. The concrete infill within the plug was cracked and delaminated. Concrete beyond the plug along the edge of the steel-framed closure door was also delaminated in limited areas. 44
Figure 1C.16. View of the closure door tracks and middle maintenance track supported by concrete below. 44
Figure 1C.17. View of a small delamination in the concrete below one of the closure door tracks. .. 44
Figure 1C.18. View of the underside surface of the closure door. Corrosion was visible across much of the leading edge of the closure door steel structure. 44
Figure 1C.19. View of the stainless steel debris catch that was anchored to the closure door in the 1970s. 44

Figure 1C.20. View of the concrete retaining wall structure extending to the east from the Launch Facility structure. Cracking was observed within the concrete wall. Some cracks have been previously treated while others have not yet been repaired. 45
Figure 1C.21. Delaminations and spalls were located on the jack and tie down slab-on-grade directly adjacent to the Launch Facility concrete structure. 45
Figure 1C.22. View of the jack and tie down slab with the two jack pads in the foreground. 46
Figure 1C.23. Delaminated concrete, failed previous patching, and epoxy repairs around the jack pads were observed. The sheet metal between the slab and the jack pad was heavily corroded. 46
Figure 1C.24. The exposed skyward facing surface of the Launch Facility concrete structure has widespread cracking. Many of those cracks have been previously repaired. 46
Figure 1C.25. A close-up view of the skyward facing concrete surface showing some cracks that have received an epoxy treatment and others that have not yet been repaired. 46
Figure 1C.26. Delaminated concrete and failed sealant were observed around the launch structure access hatch. 46
Figure 1C.27. Corrosion of the steel floor plate at the second equipment room level was apparent around the fan equipment and adjacent to the electrical room. 47
Figure 1C.28. Moisture damage has resulted in failed coatings and corrosion of the steel. 48
Figure 1C.29. The neutralizer pit and adjacent drain were full of water at the time of our visit. NPS staff vacuumed out the water to expose the inside surfaces of both assemblies. 48
Figure 1C.30. View from the second equipment room level pointing at one of the weep holes through the steel plate liner at the launch tube. 48
Figure 1C.31. View from inside the launch tube showing three weep holes through the steel plate, all with various degrees of corrosion debris on the steel surface below the holes from moisture draining through the weeps. 48
Figure 1C.32. Some of the weep holes were blocked with debris. One example is shown here as viewed from the second equipment room level. 48
Figure 1C.33. View of another blocked weep hole as observed from inside the launch tube. 48
Figure 1C.34. An example of an open, unobstructed weep hole is shown here. 49
Figure 1C.35. View of the inside painted surface of the launch tube steel plate liner. The platform used to access the manlift basket is seen in the upper right corner of the image. 50
Figure 1C.36. Areas of the steel plate liner have greater amounts of corrosion compared to others. Some of this damage can be attributed to moisture while other areas are associated with damage from the manlift basket contacting the coating during operation. 50
Figure 1C.37. Paint flakes that disengaged from the steel plate liner surface collected on horizontal surfaces near the bottom of the launch tube. 50
Figure 1C.38. The acid neutralizing basis located in the battery area was backed up with water, indicating a blocked drain line (Source: H.F. Lenz Company) 51
Figure 1C.39: The submersible sump pump located in the Delta-09 Soft Support Building (Source: H.F. Lenz Company). 51
Figure 1C.40: The vent, manway cover and fill box for the diesel fuel UST remain in place (Source: H.F. Lenz Company). 52

Figure 1C.41: Air-handling unit return air section draws air from the Equipment Room to cool before supplying air to the equipment racks. The black piping is the chilled brine piping from the Delta-09 Soft Support Building. (Source: H.F. Lenz Company) 52
Figure 1C.42: The equipment racks. The ductwork connections are visible at the top of the racks. (Source: H.F. Lenz Company) 52
Figure 1C.43: Perforated air distribution plates supply cool air from the equipment cooling system to the equipment racks. (Source: H.F. Lenz Company) 53
Figure 1C.44: The electric tube heater which maintained a consistent tube temperature of 60°F (Source: H.F. Lenz Company) 53
Figure 1C.45: Flexible ductwork from the tube heater connects to a plenum to discharge heated air into the launch tube. (Source: H.F. Lenz Company) 53
Figure 1C.46: Warm air is discharged up to the viewing structure to minimize condensation and melt snow to provide visitors with a view in the launch tube. (Source: H.F. Lenz Company) 54
Figure 1C.47: A dehumidifier added by the National Park Service to control humidity in the launch tube. (Source: H.F. Lenz Company) 54
Figure 1C.48: A drum louver connected to the dehumidifier to discharge dry air into the launch tube. (Source: H.F. Lenz Company) 54
Figure 1C.49: The air-cooled brine chiller is used to produce chilled brine to cool the equipment racks in the Launch Facility. (Source: H.F. Lenz Company) 55
Figure 1C.50. The damper arrangement for the brine chiller condenser fan allows air to either be exhausted out of the Soft Support Facility or recirculate the air to heat the space. (Source: H.F. Lenz Company) 55
Figure 1C.51. Overhead electric service entering the Delta-09 site just outside the East fence line. (Source: H.F. Lenz Company) 55
Figure 1C.52. Front view of Panel 'LDB', dedicated to serving equipment in the Delta-09 LF. (Source: H.F. Lenz Company) 56
Figure 1C.53. Corrosion and rust setting in on the load of the power line protection filter assembly. (Source: H.F. Lenz Company) 56
Figure 1C.54. Flood damage and onsetting corrosion can be seen on the main service disconnect within its protective enclosure. (Source: Ken Thompson, NPS) 57
Figure 1C.55. Cracking of paint and rust accumulating on Panel 'LDA' protective enclosure. (Source: H.F. Lenz Company) 57
Figure 1C.56. Rust accumulating on Panel 'LDA' overcurrent protection devices. (Source: H.F. Lenz Company) 57
Figure 1C.57: Interior side of Panel 'LDA' protective enclosure. (Source: H.F. Lenz Company) 58
Figure 1C.58: Interior side of Panel 'LDC' protective enclosure. (Source: H.F. Lenz Company) 58
Figure 1C.59: Onsetting corrosion and rust on the Automatic Transfer Switch emergency lugs. (Source: H.F. Lenz Company) 59
Figure 1C.60:. Front view of Generator battery charger and cranking panel. (Source: H.F. Lenz Company) 59

Appendix A. Hazardous Materials

Page intentionally left blank

611 Lunken Park Drive
Cincinnati, OH 45226
P: (513) 321-5816
Terracon.com

October 20, 2023

Seven Generations Architecture & Engineering
600 East Michigan Avenue, Suite B
Kalamazoo, Michigan 49007

Attn: Mr. Alex Hokkanen, AIA, LEED AP BD+C
T: (763) 234-1962
E: ahokkanen@bodwegroup.com

Re: Limited Lead Paint Testing Report
Minuteman Missile Delta-01 and Delta-09
I-90 Exit 116
Wall, South Dakota 57790
Terracon Project No. N1237348

Dear Mr. Hokkanen:

Terracon Consultants, Inc. (Terracon) appreciates the opportunity to submit this letter report to Seven Generations Architecture & Engineering (Client) regarding the lead analytical results for limited paint sampling conducted for the above-referenced project.

Terracon representative Mr. Joshua Vogel conducted the limited paint sampling at the project site on October 4, 2023, concurrent with an asbestos inspection. Bulk paint sample collection was performed using a clean straight-edge razor to remove paint from dominant-type, representative painted surface coatings from the below ground structures at Delta-01 and from the above and below ground support building and missile silo at Delta-09. Collected paint samples were placed in sealable containers, labeled with unique sample numbers, and submitted under chain of custody to Eurofins CEI of Cary, North Carolina. Paint chip samples were submitted for analysis by Atomic Absorption Spectroscopy (AAS) per EPA Method SW846 7000B. Eurofins CEI is accredited for lead in paint analysis under the American Industrial Hygiene Association's (AIHA®) Environmental Lead Laboratory Accreditation Program (ELLAP), accreditation number 103025.

Lead Paint Analytical Results Summary

Terracon collected a total of 31 bulk paint samples for lead-content analysis from dominant-type paint coatings associated with the below ground structures at Delta-01 and from the above and below ground support building and missile silo at Delta-09. The laboratory results indicated that 29 of the 31 collected bulk paint samples contain detectable lead concentrations above the analytical method's reporting limit. Please note that the laboratory reported an insufficient sample weight to analyze sample number L-01, and therefore, this sample had to be assumed as lead containing. A summary table with sample descriptions and results is attached. The laboratory analytical report and sample chain of custody are also attached.

The results correspond to the following painted building components which were **identified by laboratory analysis to contain detectable concentrations of lead** (with the exception of paint sample number L-01 as noted above which has been assumed to contain lead). The results apply to all similar components associated with the below ground structures at Delta-01 and the above and below ground support building and missile silo at Delta-09.

- Delta-01 - Green interior paint on metal computer boxes (corresponding to sample # L-01 as assumed lead-containing)
- Delta-01 - White interior paint on concrete walls of capsule (corresponding to sample # L-03, 292,000 parts per million {ppm} lead)
- Delta-01 – Reddish interior brown paint on concrete walls of capsule (corresponding to sample # L-04, 278,000 ppm lead)
- Delta-01 – Silver interior paint on metal capsule walls (corresponding to sample # L-05, 343,000 ppm lead)
- Delta-01 – Orange interior paint on metal escape hatch (corresponding to sample # L-06, 475,000 ppm lead)
- Delta-01 - Grey interior paint on concrete walls of capsule (corresponding to sample # L-07, 304,000 ppm lead)
- Delta-01 – Brown interior paint on metal on bottom of capsule (corresponding to sample # L-08, 561 ppm lead)
- Delta-01 – Blue interior paint on concrete entry walls to capsule (corresponding to sample # L-09, 1,910 ppm lead)
- Delta-01 – Grey interior paint on concrete entry floor to capsule (corresponding to sample # L-10, 347 ppm lead)
- Delta-01 – Yellow interior paint on concrete entry floor to capsule (corresponding to sample # L-11, 149 ppm lead)
- Delta-01 – Grey interior paint on metal blast door of capsule (corresponding to sample # L-12, 16,500 ppm lead)
- Delta-01 – Green interior paint on metal elevator equipment (corresponding to sample # L-13, 692 ppm lead)
- Delta-09 – White interior paint on metal generator in support building (corresponding to sample # L-14, 1,300 ppm lead)

- Delta-09 - Green interior paint on concrete walls in support building (corresponding to sample # L-15, 498 ppm lead)
- Delta-09 – Light interior green paint on concrete walls in support building (corresponding to sample # L-16, 450 ppm)
- Delta-09 - Grey exterior paint on metal ladder in support building (corresponding to sample # L-17, 59,900 ppm lead)
- Delta-09 – Grey interior paint on metal cap of support building (corresponding to sample # L-18, 88.2 ppm lead)
- Delta-09 – Blue interior paint on metal hoist near support building (corresponding to sample # L-19, 1,330 ppm lead)
- Delta-09 – Orange exterior paint on metal cap track of silo (corresponding to sample # L-20, 121 ppm lead)
- Delta-09 – Blue exterior paint on metal cap track of silo (corresponding to sample # L-21, 846 ppm lead)
- Delta-09 – Blue interior paint on metal rocket support at base of silo (corresponding to sample # L-22, 11,000 ppm lead)
- Delta-09 - Black interior paint on concrete walls of silo (corresponding to sample # L-23, 6,440 ppm lead)
- Delta-09 – White interior paint on concrete walls of silo (corresponding to sample # L-24, 35,700 ppm lead)
- Delta-09 – Green interior paint on metal walls of silo (corresponding to sample # L-25, 2,720 ppm lead)
- Delta-09 – Light interior green paint on metal railing in silo (corresponding to sample # L-26, 74,000 ppm lead)
- Delta-09 - Grey interior paint on metal floor of silo (corresponding to sample # L-27, 24,500 ppm lead)
- Delta-09 - Grey interior paint on metal walls of silo (corresponding to sample # L-28, 102,000 ppm lead)
- Delta-09 – Green interior paint on metal battery bracket on second level of silo (corresponding to sample # L-29, 31,200 ppm lead)
- Delta-09 – Silver interior paint on metal wall in electric cabinet on second level of silo (corresponding to sample # L-30, 114,000 ppm lead)
- Delta-09 - Light grey exterior paint on metal cap of silo (corresponding to sample # L-31, 143 ppm lead)

A paint sample collected from the following component was identified to not contain lead above the analytical method's reporting limit.

- Delta-01 - Grey paint on metal fire suppression system pipe (corresponding to sample # L-02)

Occupational Safety and Health Administration (OSHA) standard, 29 Code of Federal Regulations (CFR) 1926.62 (Lead in Construction), does not reference a specific concentration of lead in a paint surface coating for applicability of the aforementioned regulation. The requirements under OSHA 29 CFR 1926.62 are applicable to any

concentration of lead found above the analytical method's reporting limit. When disturbed, paints containing lead in any concentration represent an airborne exposure hazard that could exceed the OSHA legally enforceable action level (AL) or permissible exposure limit (PEL). Contractors that bid or conduct work activities that will disturb surfaces with lead-containing paint should be made aware of those so that they can plan for proper compliance with the OSHA Lead in Construction standard. Additionally, contractors should be aware that untested paint surfaces, if any, should be assumed to also contain lead unless sampling and analysis refute lead content.

This limited sampling event was conducted as per the direction and request of the Client. The sampling was of a limited nature specific to dominant type components and readily accessible and dominant-type paint coatings and may not have included all painted components. The results are based upon the sampled location and may not necessarily be representative of all painted surfaces of that type. This sampling was not meant to comply with EPA or HUD Guidelines for residential or child-occupied facilities, but rather to provide information for contractors regarding the potential presence of lead relative to dominant-type paint coatings. The sampling was conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the same locale. The results, findings and recommendations expressed in this letter report are based on conditions observed during the limited sampling event. This letter report has been prepared on behalf of and exclusively for use and reliance by the Client and is not a bidding document. Contractors or consultants reviewing this limited sampling report must draw their own conclusions regarding whether further investigation or remediation is deemed necessary. Terracon does not warrant the work of regulatory agencies, laboratories, or other third parties supplying information, which may have been used in the preparation of this report. No warranty, express or implied, is made.

Terracon appreciates the opportunity to provide this service to Seven Generations Architecture & Engineering. If you have questions regarding this letter report or if we can be of further service, please contact the undersigned at (513) 321-5816.

Sincerely,
Terracon Consultants, Inc.

Josh Vogel
Group Manager

Joseph Tussey, CHMM
Principal

Attachments: 1) Paint Sample & Lead Results Summary Table
2) Laboratory Analytical Report & Sample Chain of Custody

Attachment 1

Paint Sample & Lead Results Summary Table

Terracon Sample #	Component	Paint Color (surface)	Substrate	Sample Location	Results (ppm Lead and % Lead by Weight)
L-01	**Interior Computer Box**	**Green**	**Metal**	**Delta-01 Capsule**	**Assumed Lead Containing(Insufficient Sample Weight to Analyze)**
L-02	Interior Fire Suppression System Pipe	Grey	Metal	Delta-01 Capsule	<67.1 ppm or <0.00671%
L-03	**Interior Wall**	**White**	**Concrete**	**Delta-01 Capsule**	**292,000 ppm or 29.2%**
L-04	**Interior Wall**	**Reddish Brown**	**Concrete**	**Delta-01 Capsule**	**278,000 ppm or 27.9%**
L-05	**Interior Capsule**	**Silver**	**Metal**	**Delta-01 Capsule**	**343,000 ppm or 34.3%**
L-06	**Interior Escape Hatch Door**	**Orange**	**Metal**	**Delta-01 Capsule**	**475,000 ppm or 47.5%**
L-07	**Interior Wall**	**Grey**	**Concrete**	**Delta-01 Capsule**	**304,000 ppm or 30.4%**
L-08	**Interior Under Capsule**	**Brown**	**Metal**	**Delta-01 Capsule**	**561 ppm or 0.0561%**
L-09	**Interior Entry Wall**	**Blue**	**Concrete**	**Delta-01 Capsule**	**1,910 ppm or 0.191%**
L-10	**Interior Entry Floor**	**Grey**	**Concrete**	**Delta-01 Capsule**	**347 ppm or 0.0347%**
L-11	**Interior Entry Floor**	**Yellow**	**Concrete**	**Delta-01 Capsule**	**149 ppm or 0.0149%**
L-12	**Interior Blast Door**	**Grey**	**Metal**	**Delta-01 Capsule**	**16,500 ppm or 1.65%**
L-13	**Interior Elevator Equipment**	**Green**	**Metal**	**Delta-01 Capsule**	**692 ppm or 0.0692%**
L-14	**Interior Generator**	**White**	**Metal**	**Delta-09 Support Building**	**1,300 ppm or 0.130%**
L-15	**Interior Wall**	**Green**	**Concrete**	**Delta-09 Support Building**	**498 ppm or 0.0498%**

Terracon Sample #	Component	Paint Color (surface)	Substrate	Sample Location	Results (ppm Lead and % Lead by Weight)
L-16	Interior Wall	Light Green	Concrete	Delta-09 Support Building	450 ppm or 0.0450%
L-17	Exterior Ladder	Grey	Metal	Delta-09 Support Building	59,900 ppm or 5.99%
L-18	Exterior Cap	Grey	Metal	Delta-09 Support Building	88.2 ppm or 0.00882%
L-19	Exterior Hoist	Blue	Metal	Delta-09 Support Building	1,330 ppm or 0.133%
L-20	Exterior Cap Track	Orange	Metal	Delta-09 Silo	121 ppm or 0.0121%
L-21	Exterior Cap Track	Blue	Metal	Delta-09 Silo	846 ppm or 0.0846%
L-22	Interior Rocket Support	Blue	Metal	Delta-09 Silo	11,000 ppm or 1.10%
L-23	Interior Wall	Black	Concrete	Delta-09 Silo	6,440 ppm or 0.644%
L-24	Interior Wall	White	Concrete	Delta-09 Silo	35,700 ppm or 3.57%
L-25	Interior Wall	Green	Concrete	Delta-09 Silo	2,720 ppm or 0.272%
L-26	Interior Railing	Light Green	Metal	Delta-09 Silo	74,000 ppm or 7.43%
L-27	Interior Floor	Grey	Metal	Delta-09 Silo	24,500 ppm or 2.45%
L-28	Interior Silo Wall	Grey	Metal	Delta-09 Silo	102,000 ppm or 10.2%
L-29	Interior Metal Battery Bracket	Green	Metal	Delta-09 Silo	31,200 ppm or 3.12%
L-30	Interior Wall in Electric Cabinet	Silver	Metal	Delta-09 Silo	114,000 ppm or 11.4%
L-31	Exterior Metal Cap	Light Grey	Metal	Delta-09 Silo	143 ppm or 0.0143%

< = less than the limit of detection (no lead present above the limit of analytical method's reporting limit for that particular sample).

Attachment 2

Laboratory Analytical Report & Sample Chain of Custody

eurofins | CEI

2752 Pleasant Rd Suite 100A • Fort Mill, SC 29708

TEL: 803-526-5146

LABORATORY REPORT
LEAD IN PAINT

Client: **Terracon Consultants, Inc.**
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: L230451
Received: 10-09-23
Analyzed: 10-16-23
Reported: 10-16-23

Project: MIMI Missle Silo, N1237348

METHOD: EPA SW846 7000B

CLIENT ID	LAB ID	PPM (µg/g)	CONCENTRATION % BY WEIGHT
L-1 Insufficient sample weight	L2075		
L-2	L2076	<67.1	**<0.00671**
L-3	L2077	292000	**29.2**
L-4	L2078	278000	**27.9**
L-5	L2079	343000	**34.3**
L-6	L2080	475000	**47.5**
L-7	L2081	304000	**30.4**
L-8	L2082	561	**0.0561**
L-9	L2083	1910	**0.191**
L-10	L2084	347	**0.0347**

2752 Pleasant Rd Suite 100A • Fort Mill, SC 29708

TEL: 803-526-5146

Project: MIMI Missle Silo, N1237348

Lab Code: L230451

METHOD: EPA SW846 7000B

CLIENT ID	LAB ID	PPM (µg/g)	CONCENTRATION % BY WEIGHT
L-11	L2085	149	**0.0149**
L-12	L2086	16500	**1.65**
L-13	L2087	692	**0.0692**
L-14	L2088	1300	**0.130**
L-15	L2089	498	**0.0498**
L-16	L2090	450	**0.0450**
L-17	L2091	59900	**5.99**
L-18	L2092	88.2	**0.00882**
L-19 Sample weight below protocol guidelines	L2093	1330	**0.133**
L-20	L2094	121	**0.0121**
L-21	L2095	846	**0.0846**
L-22	L2096	11000	**1.10**
L-23 Sample weight below protocol guidelines	L2097	6440	**0.644**

2752 Pleasant Rd Suite 100A • Fort Mill, SC 29708

TEL: 803-526-5146

Project: MIMI Missle Silo, N1237348

Lab Code: L230451

METHOD: EPA SW846 7000B

CLIENT ID	LAB ID	PPM (µg/g)	CONCENTRATION % BY WEIGHT
L-24	L2098	35700	**3.57**
L-25	L2099	2720	**0.272**
L-26 Sample weight below protocol guidelines	L2100	74000	**7.43**
L-27	L2101	24500	**2.45**
L-28	L2102	102000	**10.2**
L-29 Sample weight below protocol guidelines	L2103	31200	**3.12**
L-30 Sample weight below protocol guidelines	L2104	114000	**11.4**
L-31	L2105	143	**0.0143**

2752 Pleasant Rd Suite 100A • Fort Mill, SC 29708

TEL: 803-526-5146

Project: MIMI Missle Silo, N1237348

Lab Code: L230451

METHOD: EPA SW846 7000B

CLIENT ID	LAB ID	PPM (µg/g)	CONCENTRATION % BY WEIGHT

Reviewed By:

Tianbao Bai, Ph.D.
Laboratory Director

This method has been validated for sample weights of 0.25g or greater. When samples with a weight of less than that are analyzed those results fall outside of the scope of accreditations.
*** The analysis of composite wipe samples as a single samples is not included under AIHA accreditation.**

Minimum reporting limit is 15 µg total lead. Sample results denoted with a "less than" (<) sign contain less than 15.0 µg total lead, based on a 50ml sample volume.

Lead samples are analyzed by Eurofins CEI, an AIHA ELLAP accredited laboratory for lead analysis of air, soil, wipes, and paint samples.
Laboratory results represent the analysis of samples as submitted by the client. Information regarding sample location, description, area, volume, etc., was provided by the client. Unless notified in writing to return samples, Eurofins CEI discards client samples after 30 days. This report shall not be reproduced, except in full, without the written consent of Eurofins CEI.

Information provided by customer includes customer sample ID, location, volume and area as well as date and time of sampling.

REGULATORY LIMITS	OSHA Standard: No safe limit. Consumer Products Safety Standard: Greater than 0.009% lead by weight. Federal Lead Standard / HUD: 0.5% lead by weight.

LEGEND	µg = microgram	ppm = parts per million	g = grams
	ml = milliliter	Pb = lead	wt = weight

End of Report

eurofins | CEI

CHAIN OF CUSTODY (31)

730 SE Maynard Road, Cary, NC 27511
Tel: 866-481-1412; Fax: 919-481-1442

LAB USE ONLY:	
ECEI Lab Code:	L230451
ECEI Lab I.D. Range:	L2075-L2105

COMPANY INFORMATION	PROJECT INFORMATION
ECEI CLIENT #:	Job Contact:
Company: Terracon	Email / Tel:
Address: 611 Lunken Park Drive	Project Name: MJMI Missle Silo
Cincinnati, Ohio 45226	Project ID# N1237348
Billing Email: joshua.vogel@terracon.com	PO #: N1237348
Tel: 513-612-9002	STATE SAMPLES COLLECTED IN: South Dakota

ECEI standard terms are Net 30 days

IF TAT IS NOT MARKED STANDARD 3 DAY TAT APPLIES.

Analyte	METHOD	TURN AROUND TIME					
		4 HR**	8 HR**	1 DAY**	2 DAY	3 DAY	5 DAY
LEAD PAINT	EPA SW846 7000B / 3rd Ed. 7420/3050B				☐	☐	☒
LEAD WIPE	EPA SW846 7000B / 3rd Ed. 7420/3050B				☐	☐	☐
LEAD SOIL	EPA SW846 7000B / 3rd Ed. 7420/3050B				☐	☐	☐
LEAD AIR	EPA SW846 7000B / NIOSH 7082				☐	☐	☐
LEAD TCLP	EPA SW846 7000B / 1311/3010A/7420				☐	☐	☐
RCRA 8 METALS	EPA SW846 6010 C/D				☐	☐	☐
RCRA 8 TCLP	EPA SW846 6010 C/D				☐	☐	☐
OTHER:					☐	☐	☐

TAT IS NOT AVAILABLE. LEAD SAMPLES ARE SUBCONTRACTED FOR ANALYSIS TO AN ELLAP ACCREDITED LAB.

REMARKS:

BMB ☐ Accept Samples
☐ Reject Samples

Relinquished By:	Date/Time	Received By:	Date/Time
[signature]	10/05/23	BMB	10/9/23 9:30

Samples will be disposed of 30 days after analysis
By submitting samples, you are agreeing to ECEI's Terms and Conditions. Standard billing terms are NET 30

VERSION PbCOC.02.21.1/2.LD
Metals COC Page 1 of 2

PAINT CHIP SAMPLE LOG

Page 1 of

Field Date: 10/04/23
Inspector: Josh Vogel
Project: MIMI Missle Silo
Project #: N1237348

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Lab Sample #	Terracon Sample #	Component	Paint Color (surface)	Substrate	Sample Location	Comments / Results
	L-1	computer Box	Green	Metal	DeHa-01	- capsle
	L-2	[illegible] Fire suppresion	Grey	Metal		
	L-3	Wall	White	Concrete		
	L-4	Wall	Redish Brown	Concrete		
	L-5	Capsle	Silver	Metal		
	L-6	Escape Hatch	Orange	Metal		
	L-7	Wall	Grey	concrete		
	L-8	under capsle	Brown	Metal		
	L-9	Entry wall	Blue	concrete		
	L-10	Entry Floor	Grey	Concrete		
	L-11	Entry Floor	Yellow	Concrete		
	L-12	Blast Door	Grey	Metal		
	L-13	Elevator	Green	Metal		
	L-14	Generator	White	Metal	Delta-09	- Support Building
	L-15	support Beam	Green	concrete		
	L-16	Wall	Light Green	Concrete		
	L-17	Ladder	Grey	Metal		
	L-18	Cap	Grey	Metal		
	L-19	hoast	Blue	Metal		
	L-20	cap Track	Orange	Metal	Delta-09	- Silo
	L-21	Cap Track	Blue	Metal		
	L-22	Rocket support	Blue	Metal		
	L-23	Wall	Black	Concrete		
	L-24	Wall	White	Concrete		
	L-25	Wall	Green	Metal		

PAINT CHIP SAMPLE LOG

Page 1 of ____

Field Date: 10/04/23
Inspector: Josh Vogel
Project: MIMI Missle Silo
Project # N1237348

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Lab Sample #	Terracon Sample #	Component	Paint Color (surface)	Substrate	Sample Location	Comments / Results
	L-26	Railing	Light Green	Metal	Delta-09	- Silo
	L-27	Floor	Grey	Metal	↓	
	L-28	Silo Wall	Grey	Metal		
	L-29	Metal Bracket	Green	Metal		
	L-30	Metal Wall	Silver	Metal		
	L-31	Metal Cap	Light Green	Metal		

Asbestos Inspection Report

Minuteman Missile Silo Delta-09
I-90 Exit 116
Wall, South Dakota 57790

October 20, 2023 | Terracon Project Number: N1237348



Prepared for:

Seven Generations Architecture & Engineering
Kalamazoo, Michigan

Prepared by:

Terracon Consultants, Inc.
Cincinnati, Ohio

Terracon

Nationwide
Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials

611 Lunken Park Drive
Cincinnati, OH 45226
P: (513) 321-5816
Terracon.com

October 20, 2023

Seven Generations Architecture & Engineering
600 East Michigan Avenue, Suite B
Kalamazoo, Michigan 49007

Attn: Mr. Alex Hokkanen, AIA, LEED AP BD+C
T: (763) 234-1962
E: ahokkanen@bodwegroup.com

Re: Asbestos Inspection Report
Minuteman Missile Silo – Delta 09
I-90 Exit 116
Wall, South Dakota 57790
Terracon Project No. N1237348

Dear Mr. Hokkanen:

Terracon Consultants, Inc. (Terracon) is pleased to submit the attached asbestos inspection report for the above-referenced project site to Seven Generations Architecture & Engineering (Client). The purpose of this report is to present the results of an asbestos inspection which was performed at the site on October 4, 2023. The asbestos inspection was conducted under Master Service Agreement Task Order September 13, 2023 (Task Order Number 140P6023F0037). We understand that this inspection was requested for the purpose of the future planned renovation of the structures located at the Minuteman Missile Silo - Delta 09 site in Wall, South Dakota.

Asbestos-containing materials (ACM) were identified as a result of this inspection. Please refer to the attached report for further detail.

Terracon appreciates the opportunity to provide this service to Seven Generations Architecture & Engineering. If you have any questions regarding this report, please contact the undersigned at 513-321-5816.

Sincerely,
Terracon Consultants, Inc.

Joshua Vogel
Group Manager

Joseph A. Tussey, CHMM
Principal

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Project Objective 1
1.2 Reliance 1
2.0 SITE DESCRIPTION 2
3.0 FIELD ACTIVITIES 2
3.1 Visual Assessment 2
3.2 Physical Assessment 2
3.3 Sample Collection 3
3.4 Sample Analysis 3
4.0 REGULATORY OVERVIEW 3
5.0 FINDINGS AND RECOMMENDATIONS 5
6.0 LIMITATIONS/GENERAL COMMENTS 6

APPENDICES:

APPENDIX A IDENTIFIED ASBESTOS-CONTAINING MATERIALS BY HOMOGENEOUS AREA (HA)

APPENDIX B ASBESTOS INSPECTION SAMPLE & RESULTS SUMMARY

APPENDIX C ASBESTOS ANALYTICAL LABORATORY DATA

APPENDIX D LICENSES AND CERTIFICATIONS

APPENDIX E SAMPLE LOCATION DIAGRAMS

APPENDIX F PHOTO LOG

ASBESTOS INSPECTION REPORT

Minuteman Missile Silo – Delta 09
I-90 Exit 116
Wall, South Dakota 57790
Terracon Project No. N1237348
October 20, 2023

1.0 INTRODUCTION

Terracon Consultants, Inc. (Terracon) conducted an asbestos inspection regarding the existing Minuteman Missile Silo - Delta 09 site structures located in Wall, South Dakota. The inspection was conducted on October 4, 2023 by a South Dakota Department of Agriculture and Natural Resources certified asbestos inspector. Accessible building components were inspected, and homogeneous areas of suspect accessible asbestos-containing materials (ACM) were visually identified and documented. Although reasonable effort was made to inspect for accessible suspect materials, additional suspect but un-sampled materials could be located in walls, in voids, in equipment, or in other concealed areas. Bulk samples from suspect ACM were collected in general accordance with the sampling protocols outlined in United States Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Part 763, Subpart E, known as the Asbestos Hazard Emergency Response Act (AHERA). Collected bulk samples were delivered to an accredited laboratory for asbestos content analysis by polarized light microscopy (PLM).

1.1 Project Objective

We understand that this inspection was requested for the future planned renovation of the existing Minuteman Missile Silo - Delta 09 site structures located in Wall, South Dakota. Asbestos inspections are required prior to renovation and demolition activities to satisfy requirements of the USEPA 40 CFR Part 61, Subpart M, the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulation and South Dakota regulations.

1.2 Reliance

This report is for the exclusive use of Seven Generations Architecture & Engineering (Client) for the project being discussed. Reliance by any other party on this report is prohibited without written authorization of Terracon and the Client. Reliance on this report by the Client and all authorized parties will be subject to the terms, conditions, and limitations stated in the proposal, this report, and the Agreement between Terracon and the Client. The limitations of liability defined in the Agreement is the aggregate limit of Terracon's liability to the Client.

2.0 SITE DESCRIPTION

The Minuteman Missile Silo - Delta 09 project site is located off of Interstate 90 Exit 116 in Wall, South Dakota and consists of a former nuclear missile silo and below ground support building. The silo structure consists of an 80-foot-deep silo with two approximately 250 square foot below ground support levels. . The site also features a 450 square foot below ground support building. The structures were reportedly constructed in the 1960s by the United States Air Force as part of the Cold War defense. The facility was decommissioned in the 1990s and was created into a National Park site shortly thereafter.

Appendix E includes general floor plan diagrams (not to scale) of the site structures.

3.0 FIELD ACTIVITIES

The inspection was conducted by Mr. Joshua Vogel who is a South Dakota Department of Agriculture and Natural Resources certified asbestos inspector. A copy of Mr. Vogel's current South Dakota Department of Agriculture and Natural Resources credential is attached in **Appendix D**. The inspection was conducted in general accordance with the sample collection protocols established in USEPA 40 CFR Part 763, Subpart E, Section 763.86, AHERA. A summary of inspection activities is provided below.

3.1 Visual Assessment

Inspection activities were initiated with visual observation of the accessible areas of the subject structures to identify homogeneous areas of accessible suspect ACM. A homogeneous area (HA) consists of building materials that appear similar throughout in terms of color and texture with consideration given to the date of application.

Electrical equipment, electrical lines, and active/energized equipment were not included in this inspection as such items presented a safety hazard to the inspector.

3.2 Physical Assessment

A physical assessment of each HA of suspect ACM was conducted to assess the friability and condition of the materials. A friable material is defined by the USEPA as a material which can be crumbled, pulverized, or reduced to powder by hand pressure when dry. Friability was assessed by physically touching suspect materials.

3.3 Sample Collection

Based on results of the visual observation, bulk samples from suspect ACM were collected in general accordance with USEPA AHERA sampling protocols. Samples of suspect materials were collected from randomly selected locations in each homogeneous area. Bulk samples were collected using wet methods as applicable to reduce the potential for fiber release. Samples were placed in sealable containers and labeled with unique sample numbers using an indelible marker.

The selection of sample locations and frequency of sampling were based on Terracon's observations and the assumption that like materials in the same area are homogeneous in content.

Terracon collected a total of 63 bulk samples from 22 homogeneous areas of suspect ACM. A summary table of samples collected from homogenous areas of suspect ACM is included in **Appendix B**. Sample locations are indicated on diagrams included in **Appendix E**.

3.4 Sample Analysis

Bulk samples were submitted under chain of custody to Eurofins CEI of Cary, North Carolina for analysis by PLM with dispersion staining techniques per USEPA methodology 600/R-93/116. The percentage of asbestos, where applicable, was determined by microscopic visual estimation using PLM. Eurofins CEI is accredited for bulk asbestos analysis by PLM under the National Voluntary Laboratory Accreditation Program (NVLAP), accreditation number 101768-0. A summary of results is included with the summary of collected samples in **Appendix B**. The laboratory analytical report is included in **Appendix C**.

4.0 REGULATORY OVERVIEW

The federal asbestos NESHAP (40 CFR Part 61, Subpart M) regulates asbestos fiber emissions and asbestos waste disposal practices. The asbestos NESHAP regulation also requires the identification and classification of existing ACM according to friability prior to demolition or renovation activity. Friable ACM is a material containing more than 1% asbestos that, when dry, can be crumbled, pulverized, or reduced to powder by hand pressure. All friable ACM is considered regulated ACM (RACM).

The federal asbestos NESHAP regulation classifies material subject to demolition or renovation as RACM, Category I nonfriable ACM, or Category II nonfriable ACM. RACM includes all friable ACM (pre-disturbance); Category I nonfriable ACM that becomes friable (during disturbance) or is subject to sanding, grinding, cutting, or abrading; or Category II nonfriable ACM with a high probability of becoming crumbled, pulverized, or reduced to powder by forces expected to act on the material during disturbance. Category I nonfriable ACMs are asbestos-containing packings, gaskets, resilient floor coverings, and asphalt

roofing products that contain more than 1% asbestos. Category II nonfriable ACMs are all other nonfriable materials (other than Category I nonfriable ACM) that contain more than 1% asbestos. Category II nonfriable ACM generally includes (but is not limited to) cementitious material such as cement pipes, cement siding, cement panels, glazing, mortar, and grouts.

RACM must be properly removed by a state-licensed asbestos abatement contractor prior to demolition or renovation activities that will disturb the materials. If the amount of RACM exceeds 260 linear feet of pipe insulation, greater than 160 square feet for other building components, or will generate more than one cubic meter of waste, the owner or operator must provide the State of South Dakota with written notification of planned removal activities at least 10 working days prior to the commencement of asbestos abatement activities. Removal of RACM must be conducted by an appropriately accredited and South Dakota licensed asbestos abatement contractor. For friable abatement projects that are equal to or greater than (≥) 260 linear feet or any combination that is ≥160 square feet and linear feet, third party final clearance air sampling is required following abatement activities. In addition, the landfill receiving the ACM materials must be notified of the asbestos content.

The Asbestos Section of the South Dakota Department of Agriculture and Natural Resources (DANR) is responsible for regulating asbestos abatement projects in the state of South Dakota. The emission standards for asbestos during remodeling or demolition projects are adopted from the federal NESHAP standards in Administrative Rules of South Dakota 74:36:08. The DANR office provides technical assistance, issues worker certifications, receives abatement job notifications, conducts inspections, and conducts complaint investigations. Training and certification rules are found in Administrative Rules of South Dakota 74:31. DANR has the authority to enforce the South Dakota asbestos program in lieu of the USEPA. Both the building owner and the contractor share the responsibility of making sure the federal and state asbestos requirements are met. All RACM must be removed from a structure being demolished or renovated before any activities are carried out that would break up, dislodge or similarly disturb the materials or prevent access to materials for subsequent removal. Under these rules, resilient floor coverings and asphalt roofing materials are defined as Category I nonfriable materials. The term "friable" means that a material can be easily crushed or reduced to powder thereby releasing asbestos fibers into the air. Nonfriable materials, such as floor tile and asphalt roofing, are not easily crumbled and are less likely to release fibers unless mishandled. According to the current regulations, Category I nonfriable materials are not required to be handled or disposed of as regulated asbestos materials as long as they remain nonfriable during removal and handling. Also, nonfriable materials are not required to be handled by certified asbestos workers if they remain nonfriable. Any Category I materials which are not in poor condition and are not made friable during handling can be disposed of as normal waste but may be subject to local landfill requirements. Any friable materials exceeding 160 square feet, or 260 linear feet must be properly removed, handled, and disposed of according to all NESHAP requirements. Projects involving the removal of RACM must be notified to the state and must be postmarked 10 working days prior to the start of any activity that may disturb

RACM. It should be noted that the federal Occupational Safety and Health Administration (OSHA) has additional regulations which may apply to any asbestos projects and the EPA has additional rules regarding asbestos in schools. The South Dakota OSHA regional office number is (720) 264-6550. As stated above, every landfill has the final approval of what types of materials they will accept and how they will accept them, so it is a good practice to check with the landfill operator prior to disposal of any ACM.

The federal OSHA asbestos standard for the construction industry (29 CFR 1926.1101) regulates workplace exposure to asbestos. The OSHA standard requires that employee exposure to airborne asbestos fibers be maintained below the permissible exposure limits (PELs) of 0.1 asbestos fiber per cubic centimeter of air (0.1 f/cc) as an 8-hour time-weighted average (TWA) or 1.0 f/cc as a 30-minute excursion limit. The OSHA standard specifies work practices and precautions that employers must follow when engaging in specific classes of asbestos work.

5.0 FINDINGS AND RECOMMENDATIONS

With respect to this asbestos inspection, asbestos was identified by laboratory analysis in samples collected from the following materials:

ACM Description	Material Location	% and Type Asbestos	EPA NESHAP Category	Estimated Quantity*
Support Building of Delta 09				
White Pipe Insulation Beneath Metal Jacket with Non-Asbestos-Containing Black Paper Wrap	Associated with Generator	15% Amosite	Regulated Asbestos-Containing Material (RACM)	20 Linear Feet (LF)
Black Butyl Tape	Associated with Ductwork	2% Chrysotile	Category II Non-Friable	10 Square Feet (SF)
Black Caulking	Around North and South Exhaust Ducts in Building	3% Chrysotile	Category II Non-Friable	4 SF
Delta 09 Missile Silo				
White Encapsulate Associated with Styrofoam Tank Insulation	Within Silo, First Level Below Ground in Southeast Corner	5% Chrysotile	Category II Non-Friable	100 SF (2 Tanks)
Mastic Beneath Carbon Pads	Within Silo, Ceiling of Second Level from Surface	Assumed ACM (>1%) – Not Sampled Due to Irreparable Damage	Category II Non-Friable	400 SF

***Estimated quantities** listed above are based on a cursory field evaluation, and actual quantities may vary significantly, especially if ACMs are present in hidden and/or inaccessible areas not evaluated as part of this inspection. **This is not a bidding document and**

contractors would be responsible for drawing their own conclusions regarding quantities present.

The identified materials are reiterated in a table included in **Appendix A**. A summary of samples collected along with summarized results is included in **Appendix B.** The laboratory analytical report is attached in **Appendix C.** Sample location diagrams (not to scale) are included in **Appendix E**. A photo log with example photos of each homogeneous material is included in **Appendix F**.

If the identified ACM will be impacted by future renovation activities, the materials will need to be properly removed and disposed by a state-licensed asbestos abatement contractor in accordance with applicable federal, state, and local asbestos regulations prior to commencing with renovation activities.

If any unsampled suspect material are discovered during the course of renovation activities (e.g., materials concealed/hidden in walls; materials not listed in **Appendix B**), these materials must be assumed as asbestos-containing unless sampled by an accredited asbestos inspector and laboratory analysis refutes the positive assumption.

6.0 LIMITATIONS/GENERAL COMMENTS

Reasonable efforts to access suspect materials within known areas of restricted access (e.g., crawl spaces) were made; however, confined spaces or areas which may pose a health or safety risk to Terracon personnel were not sampled. This asbestos inspection was conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing under similar conditions in the same locale. The results, findings, conclusions, and recommendations expressed in this report are based on conditions observed during our inspection of the buildings. The information contained in this report is relevant to the date on which this inspection was performed and should not be relied upon to represent conditions at a later date. This report has been prepared on behalf of and exclusively for use by Seven Generations Architecture & Engineering for specific application to their project as discussed. This report is not a bidding document. **Contractors or consultants reviewing this report must draw their own conclusions regarding quantities and any further investigation or remediation deemed necessary**. Terracon does not warrant the work of regulatory agencies, laboratories, or other third parties supplying information which may have been used in the preparation of this report. No warranty, express or implied is made.

APPENDIX A

Minuteman Missile Silo – Delta 09
I-90 Exit 116
Wall, South Dakota 57790
Terracon Project No. N1237348

HA No's.	ACM Description	Material Location	% and Type Asbestos	EPA NESHAP Classification	Condition/ Friability	Estimated Quantity*
Support Building of Delta 09						
1	White Pipe Insulation Beneath Metal Jacket with Non-Asbestos-Containing Black Paper Wrap	Associated with Generator	15% Amosite	Regulated Asbestos-Containing Material (RACM)	Good/Friable	20 Linear Feet
7	Black Butyl Tape	Associated with Ductwork	2% Chrysotile	Category II Non-Friable	Good/ Non-Friable	10 Square Feet (SF)
9	Black Caulking	Around North and South Exhaust Ducts in Building	3% Chrysotile	Category II Non-Friable	Good/ Non-Friable	4 SF
Delta 09 Missile Silo						
14	White Encapsulate Associated with Styrofoam Tank Insulation	Within Silo, First Level Below Ground in Southeast Corner	5% Chrysotile	Category II Non-Friable	Good/ Non-Friable	100 SF (2 Tanks)
22	Mastic Beneath Carbon Pads	Within Silo, Ceiling of Second Level from Surface	Assumed ACM (>1%) – Not Sampled Due to Irreparable Damage	Category II Non-Friable	Good/ Non-Friable	400 SF

***Estimated quantities** listed above are based on a cursory field evaluation, and actual quantities may vary significantly, especially if ACMs are present in hidden and/or inaccessible areas not evaluated as part of this inspection. **This is not a bidding document and contractors would be responsible for drawing their own conclusions regarding quantities present.**

See **Appendix B** for a summary of samples collected with respective analytical results, **Appendix C** for the laboratory analytical report, **Appendix E** for sample location diagrams, and a photo log with example photos of each homogeneous material is included in **Appendix F.**

It should be noted that inaccessible/concealed suspect materials, other than those identified during this inspection, may exist. Should additional suspect materials be uncovered prior to or during renovation activities, those materials must be assumed asbestos-containing until sampled by a state-licensed asbestos inspector and analysis refutes the positive assumption.

APPENDIX B

Minuteman Missile Silo – Delta 09
I-90 Exit 116
Wall, South Dakota 57790
Terracon Project No. N1237348

ASBESTOS INSPECTION SAMPLE & RESULTS SUMMARY

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	**SEQ. #**				
Support Building of Delta 09					
1	**01**	**White Pipe Insulation Beneath Metal Jacket with Black Paper Wrap**	**Near Pipe Entry to Generator**	**Support Building of Delta 09: Associated with Generator**	Wrap: None Detected (ND) **Insulation: 15% Amosite**
	02		**At Top of Pipe Coming Off Generator**		Wrap: ND **Insulation: 15% Amosite**
	03		**South End of Pipe**		Wrap: ND **Insulation: 15% Amosite**
2	04	Pipe Fitting Insulation Associated HA 1	Near Pipe Entry to Generator	Support Building of Delta 09: Associate with Generator	ND
	05		At Top of Pipe Coming Off Generator		ND
	06		South End of Pipe		ND
3	07	White Flexible Duct Connector	East Side of Duct	Support Building of Delta 09: Associated with Generator	ND
	08		East Side of Duct		ND
	09		West Side of Duct		ND
4	10	White Mastic on Fiberglass Duct Insulation	East Side of Duct	Support Building of Delta 09: Exhaust Duct of Generator	Mastic: ND Insulation: ND
	11		East Side of Duct		Mastic: ND, Insulation: ND

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
	12		West Side of Duct		Mastic: ND, Insulation: ND
5	13	Yellow Flexible Duct Connector	West Side	Support Building of Delta 09: South Middle End of Building	ND
	14		North Side		ND
	15		East End		ND
6	16	2" Cloth Circular Duct	South End of Support Building	Support Building of Delta 09: South End of Building	ND
	17		South End of Support Building		ND
	18		South End of Support Building		ND
7	**19**	**Black Butyl Tape**	**South End of Room**	**Support Building of Delta 09: Associated with Ductwork**	**2% Chrysotile**
	20		**South End of Room**		**2% Chrysotile**
	21		**South End of Room**		**2% Chrysotile**
8	22	Concrete Stabilization	Northwest Corner	Support Building of Delta 09: West Wall of Building	ND
	23		Middle of West Wall		ND
	24		Southwest Corner		ND
9	**25**	**Black Caulking**	**North Exhaust Duct**	**Support Building of Delta 09: Around North and South Exhaust Ducts in Building**	**3% Chrysotile**
	26		**North Exhaust Duct**		**3% Chrysotile**
	27		**South Exhaust Duct**		**3% Chrysotile**

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
10	28	Grey Exterior Caulking	Northeast Corner	Support Building of Delta 09: Concrete Roof of Building	ND
	29		North End		ND
	30		West End		ND
11	31	Black Exterior Caulking	Southeast Corner	Support Building of Delta 09: South End of Concrete Roof of Building	ND
	32		South End		ND
	33		Southwest Corner		ND
12	34	Silver Exterior Caulking	North Side	Support Building of Delta 9: Hoist Outside of Building Near Southeast Corner	ND
	35		South Side		ND
	36		West Side		ND
13	37	Tan Exterior Caulking	Southwest Corner	Support Building of Delta 09: Hoist Outside of Building Near Southeast Corner	ND
	38		Southwest Corner		ND
	39		Southwest Corner		ND
Delta 09 Missile Silo					
14	**40**	**Styrofoam Tank Insulation with White Encapsulate**	**East Side of Tank**	**Delta 09 Missile Silo: Within Silo First Level Below Ground in Southeast Corner**	Encapsulate: ND, Insulation: ND
	41		**East Side of Tank**		**Encapsulate: 5% Chrysotile,** Insulation: ND
	42		**West Side of Tank**		**Encapsulate: 5% Chrysotile,** Insulation: ND

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
15	43	Grey Exterior Window Caulking	North End	Delta 09 Missile Silo: Viewing Window of Silo	ND
	44		Southwest Corner		ND
	45		Southeast Corner		ND
16	46	Black Exterior Window Glazing	North End	Delta 09 Missile Silo: Viewing Window of Silo	ND
	47		Southwest Corner		ND
	48		South End		ND
17	49	Grey Interior Window Caulking	Southeast Corner	Delta 09 Missile Silo: Viewing Window of Silo	ND
	50		Southeast Corner		ND
	51		Southwest Corner		ND
18	52	Exterior Insulation Finishing System	Southeast Corner	Delta 09 Missile Silo: Internal Side of Cap Beneath Viewing Window on South End	ND
	53		Southeast Corner		ND
	54		Southwest Corner		ND
19	55	Black Exterior Window Caulking	Southwest Corner	Delta 09 Missile Silo: Base of Viewing Window on the South Side	ND
	56		South End		ND
	57		Southeast Corner		ND
20	58	Grey Exterior Window Caulking	Top of Window	Delta 09 Missile Silo: Silo Cap	ND

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
	59		Top of Window	Viewing Window on West Side of Cap	ND
	60		Top of Window		ND
21	61	Grey Exterior Caulking	Southeast Corner	Delta 09 Missile Silo: Silo Cap Crack Patches	ND
	62		South End		ND
	63		Southwest Corner		ND
22	**-**	**Mastic Beneath Carbon Pads**	**-**	**Delta 09 Missile Silo: Ceiling of Second Level from Surface**	**Assumed >1% ACM – Not Sampled Due to Irreparable Damage**

APPENDIX C

ASBESTOS ANALYTICAL LABORATORY DATA

eurofins | CEI

October 16, 2023

Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

CLIENT PROJECT: MiMi Missle Silo, N1237348
CEI LAB CODE: B2321553

Dear Customer:

Enclosed are asbestos analysis results for PLM Bulk samples received at our laboratory on October 9, 2023. The samples were analyzed for asbestos using polarizing light microscopy (PLM) per the EPA 600 Method.

Sample results containing >1% asbestos are considered asbestos-containing materials (ACMs) per EPA regulatory requirements. The detection limit for the EPA 600 Method is <1% asbestos by weight as determined by visual estimation.

Thank you for your business and we look forward to continuing good relations.

Kind Regards,

Tianbao Bai, Ph.D., CIH
Laboratory Director

NVLAP® TESTING
NVLAP LAB CODE 101768-0

730 SE Maynard Road • Cary, NC 27511 • 919.481.1413

eurofins | CEI

ASBESTOS ANALYTICAL REPORT
By: Polarized Light Microscopy

Prepared for

Terracon Consultants, Inc.

CLIENT PROJECT: MiMi Missle Silo, N1237348

LAB CODE: B2321553

TEST METHOD: EPA 600 / R93 / 116 and EPA 600 / M4-82 / 020

REPORT DATE: 10/16/23

TOTAL SAMPLES ANALYZED: 63

SAMPLES >1% ASBESTOS: 11

730 SE Maynard Road • Cary, NC 27511 • 919.481.1413

eurofins | CEI

Asbestos Report Summary

By: POLARIZING LIGHT MICROSCOPY

PROJECT: MiMi Missle Silo, N1237348 **LAB CODE: B2321553**

METHOD: EPA 600 / R93 / 116 and EPA 600 / M4-82 / 020

Client ID	Layer	Lab ID	Color	Sample Description	ASBESTOS %
1-01	Layer 1	B2321553.01	Black,Brown	Paper Coating	None Detected
	Layer 2	B2321553.01	White	Pipe Insulation	Amosite 15%
1-02	Layer 1	B2321553.02	Black,Brown	Paper Coating	None Detected
	Layer 2	B2321553.02	White	Pipe Insulation	Amosite 15%
1-03	Layer 1	B2321553.03	Black,Brown	Paper Coating	None Detected
	Layer 2	B2321553.03	White	Pipe Insulation	Amosite 15%
2-04		B2321553.04	White	Fittings	None Detected
2-05		B2321553.05	White	Fittings	None Detected
2-06		B2321553.06	White	Fittings	None Detected
3-07		B2321553.07	White	Flexible Duct Connector	None Detected
3-08		B2321553.08	White	Flexible Duct Connector	None Detected
3-09		B2321553.09	White	Flexible Duct Connector	None Detected
4-10	Layer 1	B2321553.10	White,Black	Mastic	None Detected
	Layer 2	B2321553.10	Tan	Duct Insulation	None Detected
4-11	Layer 1	B2321553.11	White,Black	Mastic	None Detected
	Layer 2	B2321553.11	Tan	Duct Insulation	None Detected
4-12	Layer 1	B2321553.12	White,Black	Mastic	None Detected
	Layer 2	B2321553.12	Tan	Duct Insulation	None Detected
5-13		B2321553.13	Yellow	Flexible Duct Connector	None Detected
5-14		B2321553.14	Yellow	Flexible Duct Connector	None Detected
5-15		B2321553.15	Yellow	Flexible Duct Connector	None Detected
6-16		B2321553.16	Black	Cloth	None Detected
6-17		B2321553.17	Black	Cloth	None Detected
6-18		B2321553.18	Black	Cloth	None Detected
7-19		B2321553.19	Black	Butyl Tape	Chrysotile 2%
7-20		B2321553.20	Black	Butyl Tape	Chrysotile 2%
7-21		B2321553.21	Black	Butyl Tape	Chrysotile 2%
8-22		B2321553.22	Gray,White	Concrete Stabilization	None Detected
8-23		B2321553.23	Gray,White	Concrete Stabilization	None Detected
8-24		B2321553.24	Gray,White	Concrete Stabilization	None Detected
9-25		B2321553.25	Black	Caulking	Chrysotile 3%

eurofins | CEI

Asbestos Report Summary

By: POLARIZING LIGHT MICROSCOPY

PROJECT: MiMi Missle Silo, N1237348 **LAB CODE: B2321553**

METHOD: EPA 600 / R93 / 116 and EPA 600 / M4-82 / 020

Client ID	Layer	Lab ID	Color	Sample Description	ASBESTOS %
9-26		B2321553.26	Black	Caulking	Chrysotile 3%
9-27		B2321553.27	Black	Caulking	Chrysotile 3%
10-28		B2321553.28	Gray	Caulking	None Detected
10-29		B2321553.29	Gray	Caulking	None Detected
10-30		B2321553.30	Gray	Caulking	None Detected
11-31		B2321553.31	Black	Caulking	None Detected
11-32		B2321553.32	Black	Caulking	None Detected
11-33		B2321553.33	Black	Caulking	None Detected
12-34		B2321553.34	Silver	Caulking	None Detected
12-35		B2321553.35	Silver	Caulking	None Detected
12-36		B2321553.36	Silver	Caulking	None Detected
13-37		B2321553.37	Tan	Caulking	None Detected
13-38		B2321553.38	Tan	Caulking	None Detected
13-39		B2321553.39	Tan	Caulking	None Detected
14-40	Layer 1	B2321553.40	Tan	Encapsulate	None Detected
	Layer 2	B2321553.40	White	Insulation	None Detected
14-41	Layer 1	B2321553.41	Tan,Gray	Encapsulate	Chrysotile 5%
	Layer 2	B2321553.41	White	Insulation	None Detected
14-42	Layer 1	B2321553.42	Tan,Gray	Encapsulate	Chrysotile 5%
	Layer 2	B2321553.42	White	Insulation	None Detected
15-43		B2321553.43	Gray	Window Caulking	None Detected
15-44		B2321553.44	Gray	Window Caulking	None Detected
15-45		B2321553.45	Gray	Window Caulking	None Detected
16-46		B2321553.46	Black	Window Glazing	None Detected
16-47		B2321553.47	Black	Window Glazing	None Detected
16-48		B2321553.48	Black	Window Glazing	None Detected
17-49		B2321553.49	Gray	Window Caulking	None Detected
17-50		B2321553.50	Gray	Window Caulking	None Detected
17-51		B2321553.51	Gray	Window Caulking	None Detected
18-52		B2321553.52	Gray,White	Stucco	None Detected
18-53		B2321553.53	Gray,White	Stucco	None Detected

eurofins | CEI

Asbestos Report Summary

By: POLARIZING LIGHT MICROSCOPY

PROJECT: MiMi Missle Silo, N1237348 **LAB CODE: B2321553**

METHOD: EPA 600 / R93 / 116 and EPA 600 / M4-82 / 020

Client ID	Layer	Lab ID	Color	Sample Description	ASBESTOS %
18-54		B2321553.54	Gray,White	Stucco	None Detected
19-55		B2321553.55	Black	Caulking	None Detected
19-56		B2321553.56	Black	Caulking	None Detected
19-57		B2321553.57	Black	Caulking	None Detected
20-58		B2321553.58	Gray	Window Caulking	None Detected
20-59		B2321553.59	Gray	Window Caulking	None Detected
20-60		B2321553.60	Gray	Window Caulking	None Detected
21-61		B2321553.61	Gray	Caulking	None Detected
21-62		B2321553.62	Gray	Caulking	None Detected
21-63		B2321553.63	Gray	Caulking	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID / Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous		Non-Fibrous		ASBESTOS %
1-01 Layer 1 B2321553.01	Paper Coating	Heterogeneous Black,Brown Fibrous Bound	80%	Cellulose	20%	Tar	None Detected
Layer 2 B2321553.01	Pipe Insulation	Homogeneous White Fibrous Loosely Bound			85%	Binder	15% Amosite
1-02 Layer 1 B2321553.02	Paper Coating	Heterogeneous Black,Brown Fibrous Bound	80%	Cellulose	20%	Tar	None Detected
Layer 2 B2321553.02	Pipe Insulation	Homogeneous White Fibrous Loosely Bound			85%	Binder	15% Amosite
1-03 Layer 1 B2321553.03	Paper Coating	Heterogeneous Black,Brown Fibrous Bound	80%	Cellulose	20%	Tar	None Detected
Layer 2 B2321553.03	Pipe Insulation	Homogeneous White Fibrous Loosely Bound			85%	Binder	15% Amosite
2-04 B2321553.04	Fittings	Heterogeneous White Fibrous Bound	35%	Fiberglass	65%	Binder	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID / Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous		Non-Fibrous		ASBESTOS %
2-05 B2321553.05	Fittings	Heterogeneous White Fibrous Bound	35%	Fiberglass	65%	Binder	None Detected
2-06 B2321553.06	Fittings	Heterogeneous White Fibrous Bound	35%	Fiberglass	65%	Binder	None Detected
3-07 B2321553.07	Flexible Duct Connector	Heterogeneous White Fibrous Bound	30%	Fiberglass	70%	Rubber	None Detected
3-08 B2321553.08	Flexible Duct Connector	Heterogeneous White Fibrous Bound	30%	Fiberglass	70%	Rubber	None Detected
3-09 B2321553.09	Flexible Duct Connector	Heterogeneous White Fibrous Bound	30%	Fiberglass	70%	Rubber	None Detected
4-10 Layer 1 B2321553.10	Mastic	Heterogeneous White,Black Non-fibrous Bound	<1%	Fiberglass	100%	Mastic	None Detected
Layer 2 B2321553.10	Duct Insulation	Homogeneous Tan Fibrous Loose	100%	Fiberglass			None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous		 Non-Fibrous		ASBESTOS %
4-11 Layer 1 B2321553.11	Mastic	Heterogeneous White,Black Non-fibrous Bound	<1%	Fiberglass	100%	Mastic	None Detected
Layer 2 B2321553.11	Duct Insulation	Homogeneous Tan Fibrous Loose	100%	Fiberglass			None Detected
4-12 Layer 1 B2321553.12	Mastic	Heterogeneous White,Black Non-fibrous Bound	<1%	Fiberglass	100%	Mastic	None Detected
Layer 2 B2321553.12	Duct Insulation	Homogeneous Tan Fibrous Loose	100%	Fiberglass			None Detected
5-13 B2321553.13	Flexible Duct Connector	Homogeneous Yellow Fibrous Bound	30%	Fiberglass	70%	Rubber	None Detected
5-14 B2321553.14	Flexible Duct Connector	Homogeneous Yellow Fibrous Bound	30%	Fiberglass	70%	Rubber	None Detected
5-15 B2321553.15	Flexible Duct Connector	Homogeneous Yellow Fibrous Bound	30%	Fiberglass	70%	Rubber	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous		Non-Fibrous		ASBESTOS %
6-16 B2321553.16	Cloth	Homogeneous Black Fibrous Bound	80%	Fiberglass	20%	Binder	None Detected
6-17 B2321553.17	Cloth	Homogeneous Black Fibrous Bound	80%	Fiberglass	20%	Binder	None Detected
6-18 B2321553.18	Cloth	Homogeneous Black Fibrous Bound	80%	Fiberglass	20%	Binder	None Detected
7-19 B2321553.19	Butyl Tape	Homogeneous Black Fibrous Bound			98%	Caulk	2% Chrysotile
7-20 B2321553.20	Butyl Tape	Homogeneous Black Fibrous Bound			98%	Caulk	2% Chrysotile
7-21 B2321553.21	Butyl Tape	Homogeneous Black Fibrous Bound			98%	Caulk	2% Chrysotile
8-22 B2321553.22	Concrete Stabilization	Heterogeneous Gray,White Non-fibrous Tightly Bound			5% 80% 15%	Paint Binder Silicates	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous	 Non-Fibrous	ASBESTOS %
8-23 B2321553.23	Concrete Stabilization	Heterogeneous Gray,White Non-fibrous Tightly Bound	5% 80% 15%	Paint Binder Silicates	None Detected
8-24 B2321553.24	Concrete Stabilization	Heterogeneous Gray,White Non-fibrous Tightly Bound	5% 80% 15%	Paint Binder Silicates	None Detected
9-25 B2321553.25	Caulking	Homogeneous Black Non-fibrous Bound	97% <1%	Caulk Paint	**3% Chrysotile**
9-26 B2321553.26	Caulking	Homogeneous Black Non-fibrous Bound	97% <1%	Caulk Paint	**3% Chrysotile**
9-27 B2321553.27	Caulking	Homogeneous Black Non-fibrous Bound	97% <1%	Caulk Paint	**3% Chrysotile**
10-28 B2321553.28	Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
10-29 B2321553.29	Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous	 Non-Fibrous	ASBESTOS %
10-30 B2321553.30	Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
11-31 B2321553.31	Caulking	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
11-32 B2321553.32	Caulking	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
11-33 B2321553.33	Caulking	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
12-34 B2321553.34	Caulking	Homogeneous Silver Non-fibrous Bound	100%	Caulk	None Detected
12-35 B2321553.35	Caulking	Homogeneous Silver Non-fibrous Bound	100%	Caulk	None Detected
12-36 B2321553.36	Caulking	Homogeneous Silver Non-fibrous Bound	100%	Caulk	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID / Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous		Non-Fibrous		ASBESTOS %
13-37 B2321553.37	Caulking	Homogeneous Tan Non-fibrous Bound			100%	Caulk	None Detected
13-38 B2321553.38	Caulking	Homogeneous Tan Non-fibrous Bound			100%	Caulk	None Detected
13-39 B2321553.39	Caulking	Homogeneous Tan Non-fibrous Bound			100%	Caulk	None Detected
14-40 Layer 1 B2321553.40	Encapsulate	Homogeneous Tan Non-fibrous Bound			100%	Binder	None Detected
Layer 2 B2321553.40 No foam present	Insulation	Homogeneous White Fibrous Loose	100%	Fiberglass			None Detected
14-41 Layer 1 B2321553.41	Encapsulate	Homogeneous Tan,Gray Non-fibrous Bound			95%	Binder	**5% Chrysotile**
Layer 2 B2321553.41	Insulation	Homogeneous White Non-fibrous Bound			100%	Foam	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID / Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous	Non-Fibrous		ASBESTOS %
14-42 Layer 1 B2321553.42	Encapsulate	Homogeneous Tan,Gray Non-fibrous Bound		95%	Binder	5% Chrysotile
Layer 2 B2321553.42	Insulation	Homogeneous White Non-fibrous Bound		100%	Foam	None Detected
15-43 B2321553.43	Window Caulking	Homogeneous Gray Non-fibrous Bound		100%	Caulk	None Detected
15-44 B2321553.44	Window Caulking	Homogeneous Gray Non-fibrous Bound		100%	Caulk	None Detected
15-45 B2321553.45	Window Caulking	Homogeneous Gray Non-fibrous Bound		100%	Caulk	None Detected
16-46 B2321553.46	Window Glazing	Homogeneous Black Non-fibrous Bound		100%	Caulk	None Detected
16-47 B2321553.47	Window Glazing	Homogeneous Black Non-fibrous Bound		100%	Caulk	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous	 Non-Fibrous	ASBESTOS %
16-48 B2321553.48	Window Glazing	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
17-49 B2321553.49	Window Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
17-50 B2321553.50	Window Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
17-51 B2321553.51	Window Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
18-52 B2321553.52	Stucco	Heterogeneous Gray,White Non-fibrous Tightly Bound	10% 35% 55%	Paint Binder Silicates	None Detected
18-53 B2321553.53	Stucco	Heterogeneous Gray,White Non-fibrous Tightly Bound	10% 35% 55%	Paint Binder Silicates	None Detected
18-54 B2321553.54	Stucco	Heterogeneous Gray,White Non-fibrous Tightly Bound	10% 35% 55%	Paint Binder Silicates	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous	 Non-Fibrous	ASBESTOS %
19-55 B2321553.55	Caulking	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
19-56 B2321553.56	Caulking	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
19-57 B2321553.57	Caulking	Homogeneous Black Non-fibrous Bound	100%	Caulk	None Detected
20-58 B2321553.58	Window Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
20-59 B2321553.59	Window Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
20-60 B2321553.60	Window Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
21-61 B2321553.61	Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected

eurofins | CEI

ASBESTOS BULK ANALYSIS

By: POLARIZING LIGHT MICROSCOPY

Client: Terracon Consultants, Inc.
611 Lunken Park Drive
Cincinnati, OH 45226

Lab Code: B2321553
Date Received: 10-09-23
Date Analyzed: 10-16-23
Date Reported: 10-16-23

Project: MiMi Missle Silo, N1237348

ASBESTOS BULK PLM, EPA 600 METHOD

Client ID Lab ID	Lab Description	Lab Attributes	NON-ASBESTOS COMPONENTS Fibrous	 Non-Fibrous	ASBESTOS %
21-62 B2321553.62	Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected
21-63 B2321553.63	Caulking	Homogeneous Gray Non-fibrous Bound	100%	Caulk	None Detected

eurofins | CEI

LEGEND:	Non-Anth	= Non-Asbestiform Anthophyllite
	Non-Trem	= Non-Asbestiform Tremolite
	Calc Carb	= Calcium Carbonate

METHOD: EPA 600 / R93 / 116 and EPA 600 / M4-82 / 020

REPORTING LIMIT: <1% by visual estimation

REPORTING LIMIT FOR POINT COUNTS: 0.25% by 400 Points or 0.1% by 1,000 Points

REGULATORY LIMIT: >1% by weight

Due to the limitations of the EPA 600 method, nonfriable organically bound materials (NOBs) such as vinyl floor tiles can be difficult to analyze via polarized light microscopy (PLM). EPA recommends that all NOBs analyzed by PLM, and found not to contain asbestos, be further analyzed by Transmission Electron Microscopy (TEM). Please note that PLM analysis of dust and soil samples for asbestos is not covered under NVLAP accreditation. *Estimated measurement of uncertainty is available on request.*

This report relates only to the samples tested or analyzed and may not be reproduced, except in full, without written approval by Eurofins CEI. Eurofins CEI makes no warranty representation regarding the accuracy of client submitted information in preparing and presenting analytical results. Interpretation of the analytical results is the sole responsibility of the client. Samples were received in acceptable condition unless otherwise noted. This report may not be used by the client to claim product endorsement by NVLAP or any other agency of the U.S. Government.

Information provided by customer includes customer sample ID and sample description.

ANALYST: _____ Greg Ruff

APPROVED BY: _____ Tianbao Bai, Ph.D., CIH
Laboratory Director

NVLAP® TESTING
NVLAP LAB CODE 101768-0

eurofins | CEI

CHAIN OF CUSTODY (63)

730 SE Maynard Road, Cary, NC 27511
Tel: 866-481-1412; Fax: 919-481-1442

LAB USE ONLY:
CEI Lab Code: B2321553
CEI Lab I.D. Range:

COMPANY INFORMATION	PROJECT INFORMATION
CEI CLIENT #:	Job Contact:
Company: Terracon Consultants	Email / Tel:
Address: 611 Lunkenpark Dr. Cincinnati, OH	Project Name: MZMI Missle Silo
	Project ID#: N1237348
Email: Joshua.Vogel@Terracon.com	PO #: N1237348
Tel: (513) 612-9002 Fax:	STATE SAMPLES COLLECTED IN: South Dakota

IF TAT IS NOT MARKED STANDARD 3 DAY TAT APPLIES.

ASBESTOS	METHOD	TURN AROUND TIME					
		4 HR	8 HR	1 DAY	2 DAY	3 DAY	5 DAY
PLM BULK	EPA 600	☐	☐	☐	☐	☐	☒
PLM POINT COUNT (400)	EPA 600	☐	☐	☐	☐	☐	☐
PLM POINT COUNT (1000)	EPA 600	☐	☐	☐	☐	☐	☐
PLM GRAV w POINT COUNT	EPA 600		☐	☐	☐	☐	☐
PLM BULK	CARB 435		☐	☐	☐	☐	☐
PCM AIR	NIOSH 7400	☐	☐	☐	☐	☐	☐
TEM AIR	EPA AHERA	☐	☐	☐	☐	☐	☐
TEM AIR	NIOSH 7402	☐	☐	☐	☐	☐	☐
TEM AIR (PCME)	ISO 10312	☐	☐	☐	☐	☐	☐
TEM AIR	ASTM 6281-15	☐	☐	☐	☐	☐	☐
TEM BULK	CHATFIELD		☐	☐	☐	☐	☐
TEM DUST WIPE	ASTM D6480-05 (2010)	☐	☐	☐	☐	☐	☐
TEM DUST MICROVAC	ASTM D5755-09 (2014)	☐	☐	☐	☐	☐	☐
TEM SOIL	ASTM D7521-16			☐	☐	☐	☐
TEM VERMICULITE	CINCINNATI METHOD			☐	☐	☐	☐
TEM QUALITTATIVE	IN-HOUSE METHOD		☐	☐	☐	☐	☐
OTHER:		☐	☐	☐	☐	☐	☐

REMARKS / SPECIAL INSTRUCTIONS:

BMB ☐ Accept Samples
☐ Reject Samples

Relinquished By:	Date/Time	Received By:	Date/Time
Josh Vogel	10/06/23	BMB	10/9/23 9:30

Samples will be disposed of 30 days after analysis

Page ____ of ____
Version: CCOC.01.18.1/2.LD

8181 2959 0946

SUSPECT ACM - BULK MATERIAL SAMPLE LOG

Date: 10/04/23
Inspector: Josh Vogel
Project: MIMT Missle Silo
Project #: N1237348

Page ____ of ____

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
1	01	White Pipe Insulation	Near entry to Generator	Support Building	
1	02	Beneath Metal Jacket with	At Top of pipe coming off generator	Around Generator	
1	03	Paper coating	South end of pipe	↓	
2	04	Fittings Associated With HA 1	Near entry to Generator	support Building	
2	05	↓	At top of pipe coming off generator	Around Generator	
2	06	↓	South end of Pipe	↓	
3	07	White Flexible Duct connector	East side of Duct	Support Building Generator	
3	08	↓	East side of Duct	↓	
3	09	↓	East side of Duct	↓	
4	10	White MASTIC on Fiberglass	East side of Duct	Exhaust Duct of	
4	11	Duct Insulation	East side of Duct	generator	
4	12	↓	West side of Duct	↓	
5	13	Yellow Flexible Duct	West side	South end of support	
5	14	connector	North Side	Building	
5	15	↓	East Side	↓	

SUSPECT ACM - BULK MATERIAL SAMPLE LOG

Date: 10/04/23
Inspector: Josh Vugol
Project: MIMI Missle Silo
Project #: N1237348

Page ____ of ____

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
6	16	Cloth 2" Circular Duct	South End of Building	support Building	
6	17	↓	↓	↓	
6	18	↓	↓	↓	
7	19	Black Butyl Tape	South end of room	Associated With Duct	
7	20	↓	South end of room	work of support	
7	21	↓	South end of room	Building ↓	
9	22	Concrete stablization	Northwest Corner	Walls of support	
8	23	↓	middle of West Wall	Building ↓	
8	24	↓	Southwest Corner	↓	
9	25	Black Caulking	North exhaust Duct	Duct work exiting the building in support Building	
9	26	↓	↓	↓	
9	27	↓	South Exhaust Duct	↓	
10	28	Grey Caulking	Northeast corner	Cap or support building	
10	29	↓	North end	↓	
10	30	↓	West end	↓	

.18

SUSPECT ACM - BULK MATERIAL SAMPLE LOG

Date: 10/04/23
Inspector: Josh Uygol
Project: MIMI Missle Silo
Project #: N1237348

Page ____ of ____

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
11	31	Black caulking	SOutheast corner	support Building cap at	
11	32	↓	South end	south end	
11	33	↓	SOuth West corner	↓	
12	34	Silver caulking	North side	Support Building	
12	35	↓	South side	hoest	
12	36	↓	West Side	↓	
13	37	Tan Caulking	South west corner	Base of support	
13	38	↓	↓	building hoest	
13	39	↓	↓	↓	
14	40	Sterofoam Tank Insulation with Encapsulate	East side of Tank	Within Silo Top	
14	41	↓	↓	level in SEC	
14	42	↓	West side of tank	↓	
15	43	Grey Exterior	North end	Viewing window of Silo	
15	44	Window caulking	SOuthwest Corner		
15	45	↓	Southeast corner		

.42

Page intentionally left blank

SUSPECT ACM - BULK MATERIAL SAMPLE LOG

Date: 10/04/23
Inspector: Josh Vogel
Project: MIMI Missle Silo
Project #: N1237348

Page ____ of ____

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
16	46	Black Exterior window	North End	Viewing Window of	
16	47	Glazing	Southwest Corner	Silo	
16	48	↓	South end	↓	
17	49	Grey Interior window	Southeast corner	Viewing Window	
17	50	caulking	↓	of Silo	
17	51	↓	Southwest Corner	↓	
18	52	Stucco	Southeast Corner	Interior Side of	
18	53	↓	Southwest Corner	Viewing Window	
18	54	↓	↓	Base	
19	55	Black caulking	Southwest Corner	Base of Viewing	
19	56	↓	South End	Window on South	
19	57	↓	Southeast Corner	Side	
20	58	Grey Exterior window	Top of window	Cap Viewing window	
20	59	Caulking	↓		
20	60	↓	↓	↓	

SUSPECT ACM - BULK MATERIAL SAMPLE LOG

Page ____ of ____

Date: 10/04/23
Inspector: Josh Vogel
Project: MIMI Missile Silo
Project #: M1237348

Terracon
611 Lunken Park Drive
Cincinnati, Ohio 45226
(513) 321.5816

Sample #		Sample Material Description	Sample Location	HA Location(s)	Results (% / Type of Asbestos)
HA #	SEQ. #				
21	61	Grey Caulking	Southeast corner	Silo	
21	62	↓	South end	Cap	
21	63		Southwest corner	↓	

63

APPENDIX D

LICENSES AND CERTIFICATIONS



South Dakota
Department of Agriculture & Natural Resources

ASBESTOS CERTIFICATION

Joshua Vogel

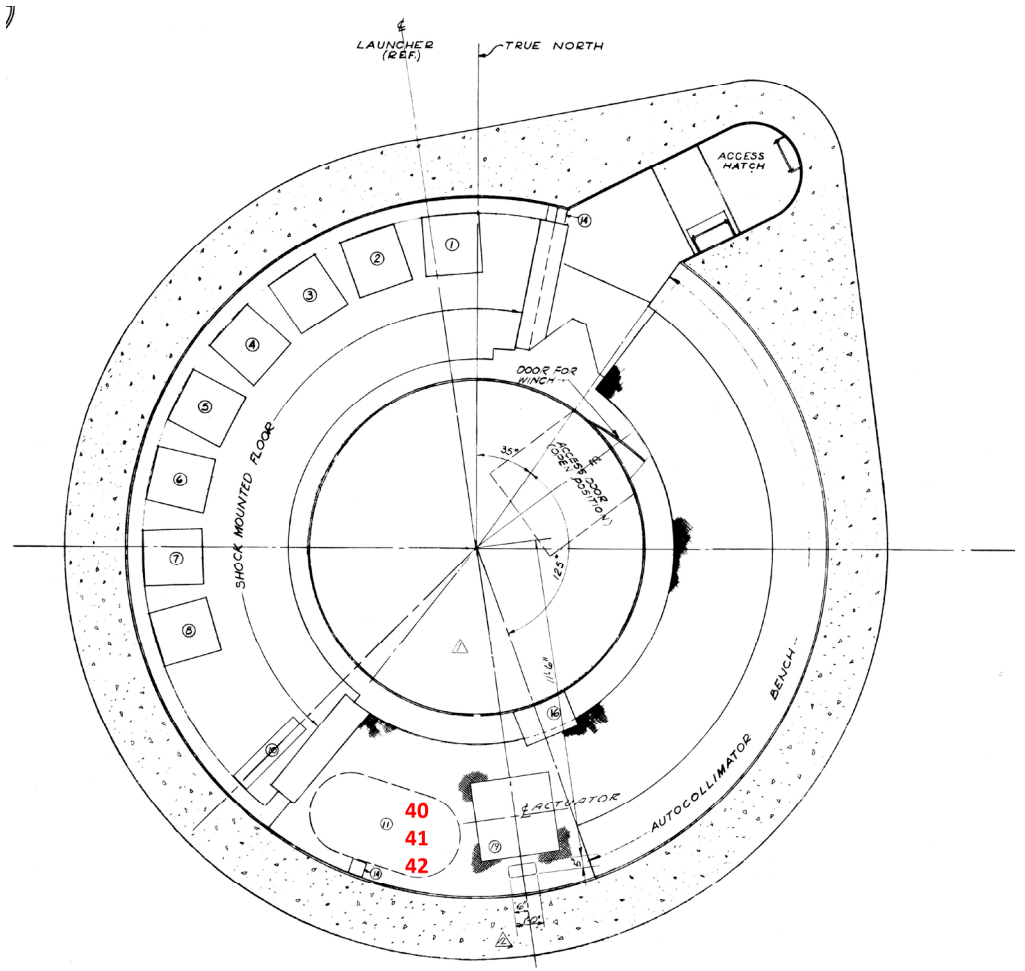
has successfully completed the appropriate training in accordance with ARSD 74:31 and is certified in South Dakota as an:

✓ Inspector	Expires: 11/16/2023
✓ Management Planner	Expires: 11/16/2023
✓ Abatement Designer	Expires: 12/01/2023
__Contractor/Supervisor	Expires:
__Worker	Expires:

Certificate No. 9544

APPENDIX E

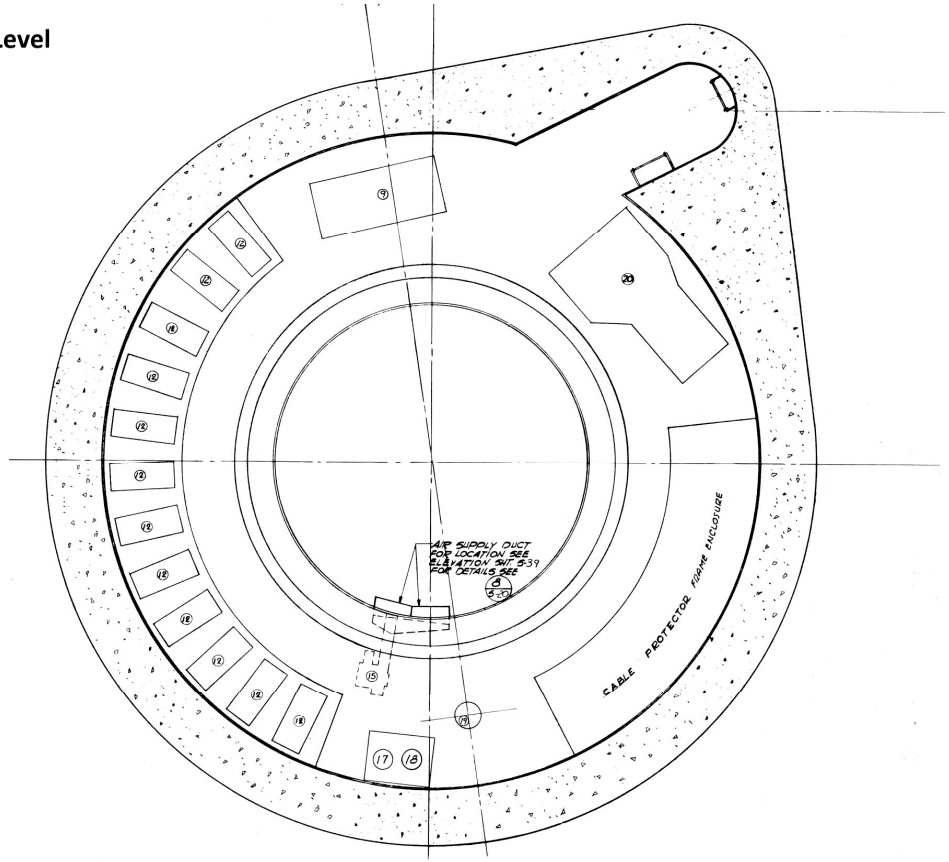
SAMPLE LOCATION DIAGRAMS



LAUNCHER EQUIPMENT LAYOUT
FIRST LEVEL
½" = 1'-0"

Project No. N1237348	Terracon Consulting Engineers and Scientists 611 Lunken Park Drive Cincinnati, Ohio 45226 PH. (513) 321-05816 FAX (513) 321-0294	**Delta 09 Silo 1st Level - Interior Sample Location Diagram**	**Exhibit**
Inspection Date: October 4, 2023		Minuteman Missile Silo – Delta 09 I-90 Exit 116 Wall, South Dakota	1
Project Manager: Josh Vogel			
APR: Joe Tussey			

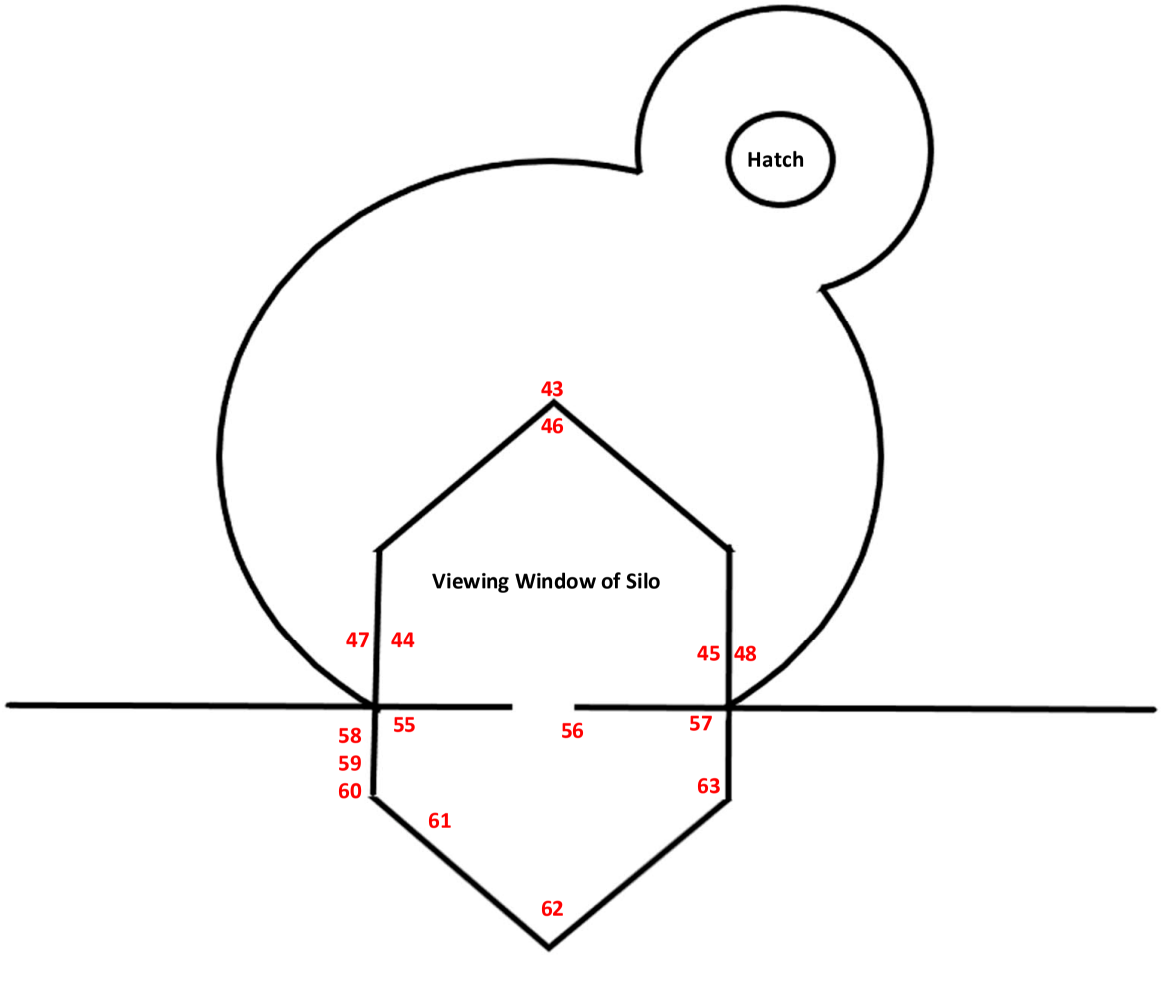
No Samples Collected on This Level



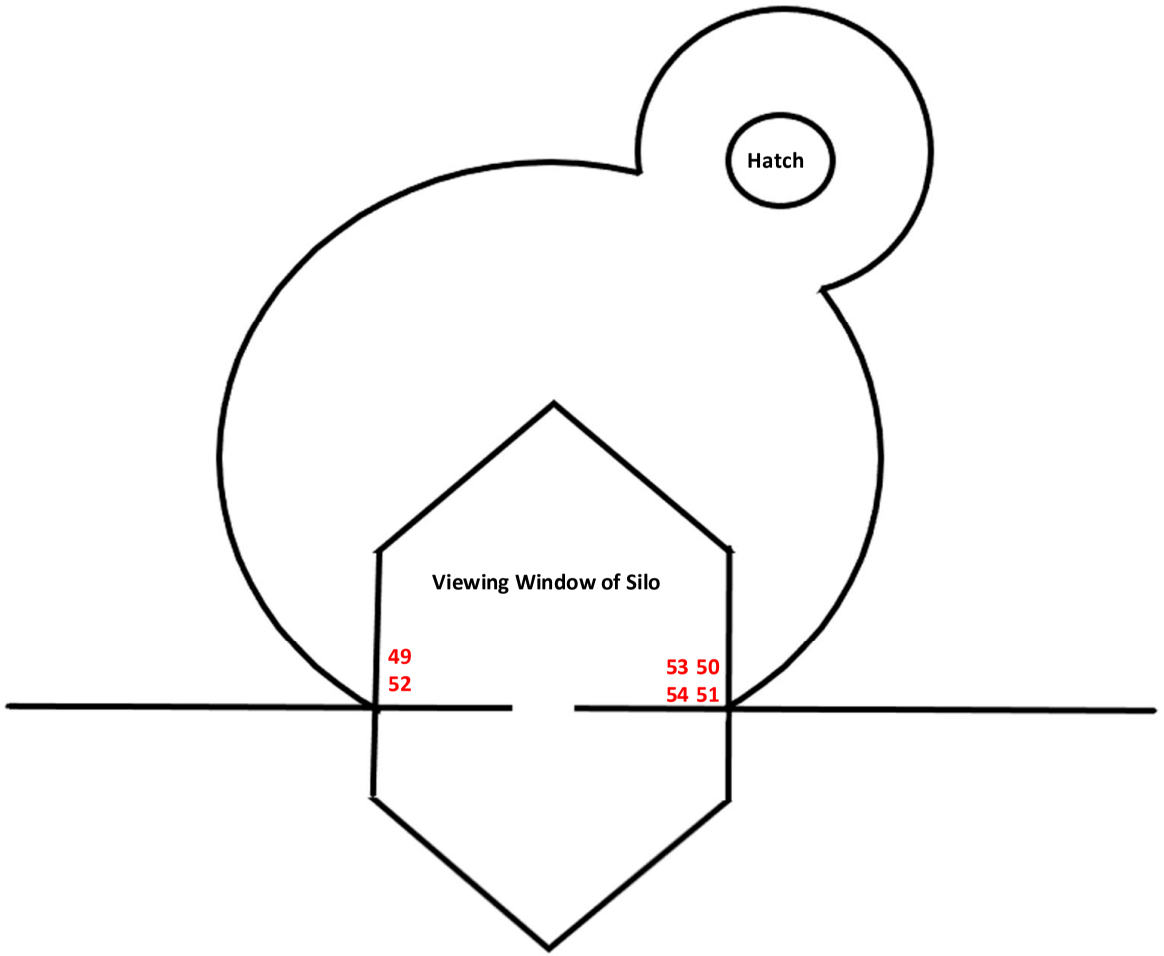
LAUNCHER EQUIPMENT LAYOUT
SECOND LEVEL

N

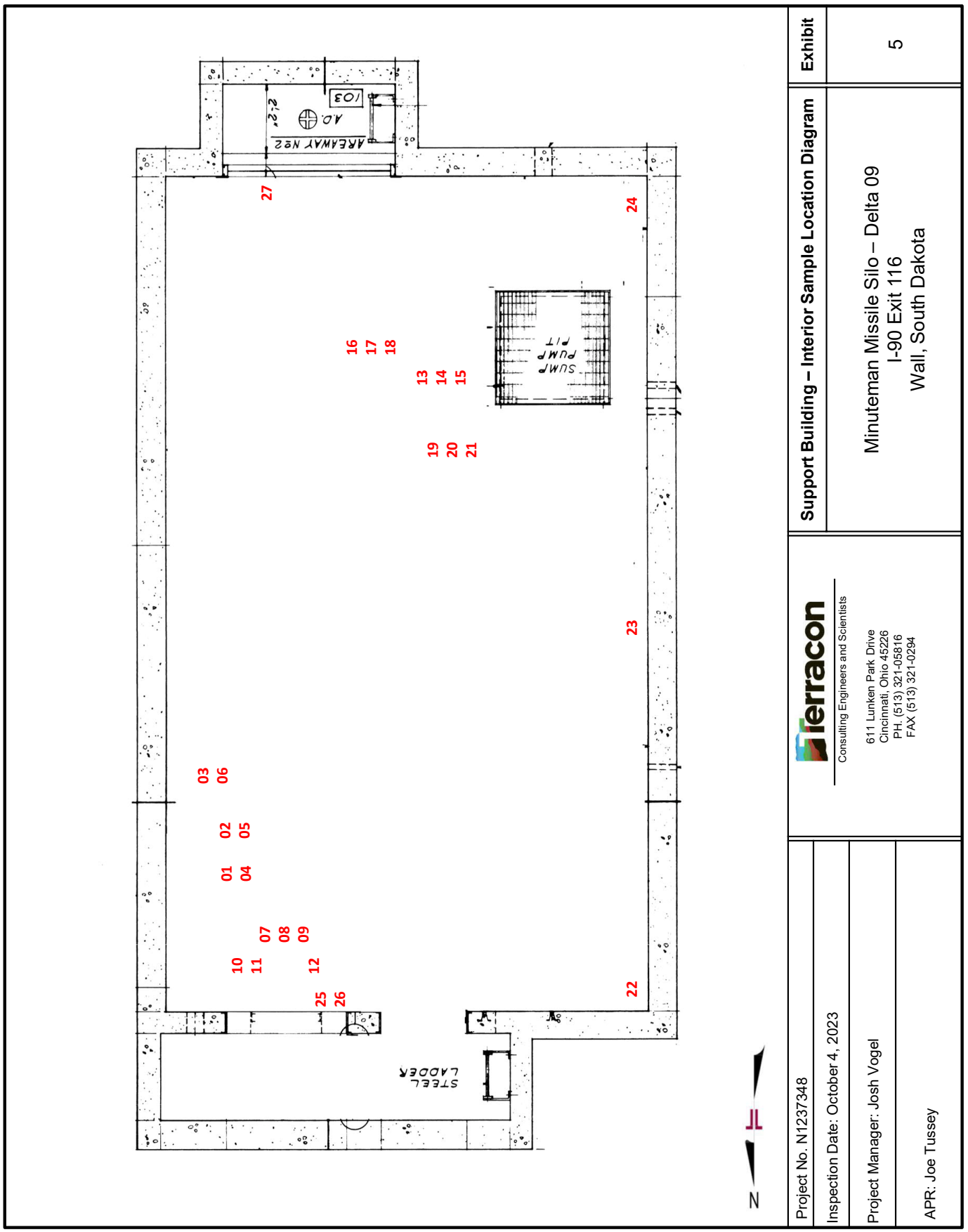
Project No. N1237348	Terracon Consulting Engineers and Scientists 611 Lunken Park Drive Cincinnati, Ohio 45226 PH. (513) 321-05816 FAX (513) 321-0294	**Delta 09 Silo 2nd Level - Interior Sample Location Diagram**	**Exhibit**
Inspection Date: October 4, 2023		Minuteman Missile Silo – Delta 09 I-90 Exit 116 Wall, South Dakota	2
Project Manager: Josh Vogel			
APR: Joe Tussey			

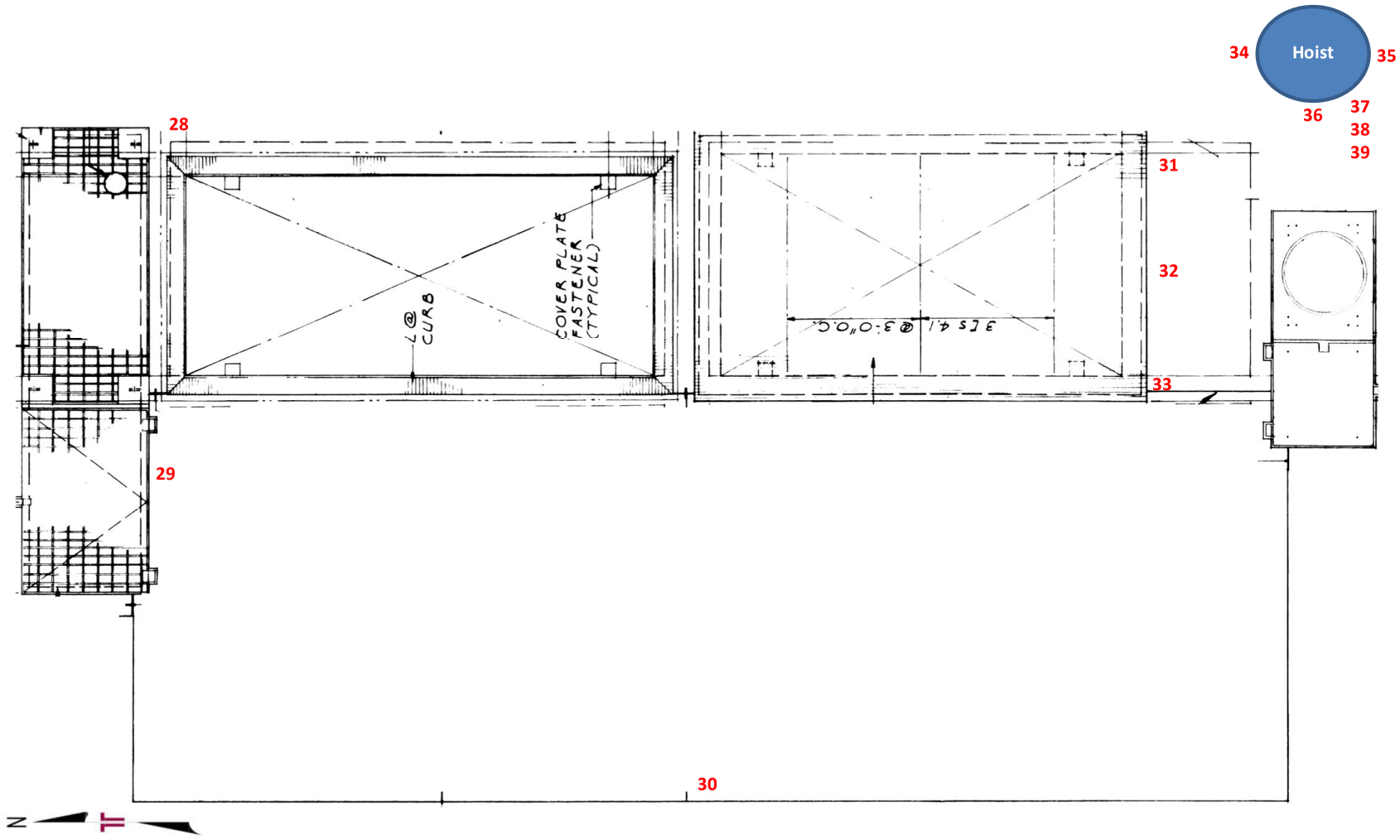


Project No. N1237348	Terracon Consulting Engineers and Scientists 611 Lunken Park Drive Cincinnati, Ohio 45226 PH. (513) 321-05816 FAX (513) 321-0294	**Delta 09 Silo Exterior Sample Location Diagram**	**Exhibit**
Inspection Date: October 4, 2023		Minuteman Missile Silo – Delta 09 I-90 Exit 116 Wall, South Dakota	3
Project Manager: Josh Vogel			
APR: Joe Tussey			



Project No. N1237348	Terracon Consulting Engineers and Scientists 611 Lunken Park Drive Cincinnati, Ohio 45226 PH. (513) 321-05816 FAX (513) 321-0294	**Delta 09 Top of Silo Interior Sample Location Diagram**	**Exhibit**
Inspection Date: October 4, 2023		Minuteman Missile Silo – Delta 09 I-90 Exit 116 Wall, South Dakota	4
Project Manager: Josh Vogel			
APR: Joe Tussey			

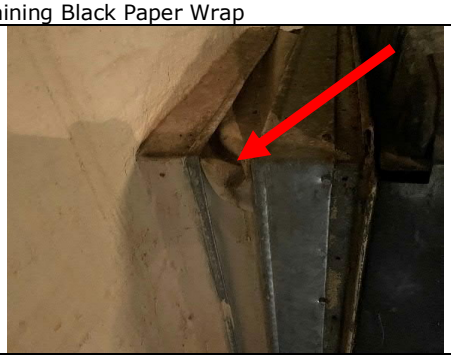
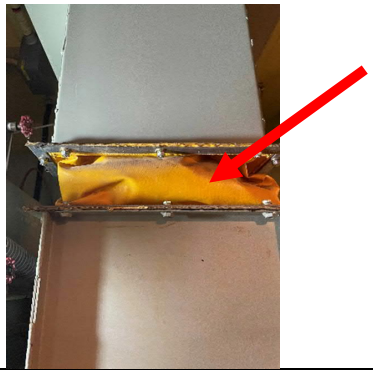

AREAWAY N°2
103
A.D.
2'-2"
SUMP PUMP PIT
STEEL LADDER
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
N
Support Building – Interior Sample Location Diagram
Exhibit
5
Minuteman Missile Silo – Delta 09
I-90 Exit 116
Wall, South Dakota
terracon
Consulting Engineers and Scientists
611 Lunken Park Drive
Cincinnati, Ohio 45226
PH. (513) 321-05816
FAX (513) 321-0294
Project No. N1237348
Inspection Date: October 4, 2023
Project Manager: Josh Vogel
APR: Joe Tussey



Project No. N1237348	Terracon Consulting Engineers and Scientists 611 Lunken Park Drive Cincinnati, Ohio 45226 PH. (513) 321-05816 FAX (513) 321-0294	**Support Building – Exterior Sample Location Diagram**	**Exhibit**
Inspection Date: October 4, 2023			
Project Manager: Josh Vogel		Minuteman Missile Silo – Delta 09 I-90 Exit 116 Wall, South Dakota	6
APR: Joe Tussey			

APPENDIX F

PHOTO LOG

		
Photo 1 HA 01: Asbestos-Containing White Pipe Insulation Beneath Metal Jacket with Non-Asbestos-Containing Black Paper Wrap		**Photo 2 HA 02:** Non-Asbestos-Containing Pipe Fitting Insulation Associated HA 1
		
Photo 3 HA 03: Non-Asbestos-Containing White Flexible Duct Connector		**Photo 4 HA 04:** Non-Asbestos-Containing White Mastic on Fiberglass Duct Insulation
		
Photo 5 HA 05: Non-Asbestos-Containing Yellow Flexible Duct Connector		**Photo 6 HA 06:** Non-Asbestos-Containing 2” Cloth Circular Duct

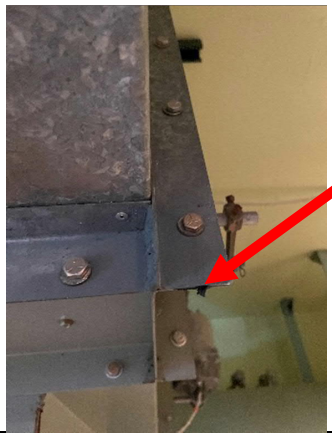
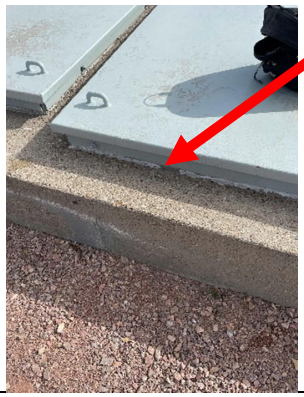
		
Photo 7 HA 07: Asbestos-Containing Black Butyl Tape		**Photo 8 HA 08:** Non-Asbestos-Containing Concrete Stabilization
		
Photo 9 HA 09: Asbestos-Containing Black Caulking		**Photo 10 HA 10:** Non-Asbestos-Containing Grey Exterior Caulking
		
Photo 11 HA 11: Non-Asbestos-Containing Black Exterior Caulking		**Photo 12 HA 12:** Non-Asbestos-Containing Silver Exterior Caulking



Photo 13 HA 13: Non-Asbestos-Containing Tan Exterior Caulking



Photo 14 HA 14: Asbestos-Containing White Encapsulate associated with Styrofoam Tank Insulation



Photo 15 HA 15: Non-Asbestos-Containing Grey Exterior Window Caulking



Photo 16 HA 16: Non-Asbestos-Containing Black Exterior Window Glazing



Photo 17 HA 17: Non-Asbestos-Containing Grey Interior Window Caulking



Photo 18 HA 18: Non-Asbestos-Containing Exterior Insulation Finishing System

	
Photo 19 HA 19: Non-Asbestos-Containing Black Exterior Caulking	**Photo 20 HA 20:** Non-Asbestos-Containing Grey Exterior Window Caulking
	
Photo 21 HA 21: Non-Asbestos-Containing Grey Exterior Caulking	**Photo 22 HA 22:** Assumed Asbestos-Containing Mastic Beneath Carbon Pads

Appendix B. Paint Conservation Analysis

Minuteman Missile National Historic Site

Phillip, South Dakota



Delta-01 and Delta-09 Paint Analysis

June 2024

BCA

BUILDING CONSERVATION ASSOCIATES INC.

Minuteman Missile National Historic Site

Phillip, South Dakota

Delta-01 and Delta-09 Paint Analysis

Prepared For
Seven Generations Architecture + Engineering
Kalamazoo, Michigan

Prepared By
Building Conservation Associates, Inc.
242 Cherry Street
Philadelphia, PA 19106

BCA Team
Dorothy Krotzer
Wei (Melissa) Luo-Hita
Drew Barnhart

June 2024

BCA

BUILDING CONSERVATION ASSOCIATES INC.

CONTENTS

1.0 INTRODUCTION 1
2.0 BACKGROUND INFORMATION 5
3.0 METHODOLOGY 11
3.1 Field Microscopy 11
3.2 Laboratory Analysis of Paint Samples 11
3.3 Color Names 12
4.0 SUMMARY OF FINDINGS 13
4.1 Delta-01 Launch Control Center 13
4.2 Delta-09 Exterior 18
4.3 Delta-09 Launch Facility Interior 23
4.4 Delta-09 Soft Support Building Interior 26
5.0 CONCLUSIONS AND RECOMMENDATIONS 29

APPENDICES
Appendix A: Sample Location Key
Appendix B: Sample Stratigraphy Sheets

1.0 INTRODUTION

At the request of Seven Generations Architecture + Engineering (Seven Generations A + E), Building Conservation Associates, Inc. (BCA) performed paint analysis at the Minuteman Missile National Historic Site (MIMI). The site includes Delta-01 and Delta-09, two Minuteman Missile facilities active from 1963 to early 1990s in western South Dakota (Figure 1 - Figure 6).

BCA's paint analysis is part of the Historic Structure Report (HSR) Update for Delta-01 and Delta-09. As requested by the National Park Service (NPS), the goal of the finishes analysis is to identify the paint schemes dating to early 1990s when the facilities were deactivated, as well as to document the overall paint history. For Delta-01, the paint analysis includes the Launch Control Center, an underground facility. For Delta-09, the scope includes the aboveground elements, the underground Launch Facility, and the underground Soft Support Building. BCA removed paint samples from select exterior and interior elements based on direction provided by NPS, RATIO Architects, LLC (RATIO), as well as BCA's field investigation.

The following report summarizes the findings of the paint analysis. A brief site history and relevant building chronology is discussed in *2.0 Background Information*, followed by BCA's methodology in *Section 3.0*. Details of BCA's findings are presented in *4.0 Summary of Findings*. *5.0 Conclusions and Recommendations* summarizes the report and provides color matches for paint layers dating to the site's deactivation in 1993.

All work required for the execution of this study was performed by Dorothy S. Krotzer, BCA Regional Director/Architectural Conservator and Wei (Melissa) Luo-Hita, Architectural Conservator, with assistance from Drew Barnhart, Architectural Conservator. All photographs are taken by BCA in 2024 unless noted otherwise.

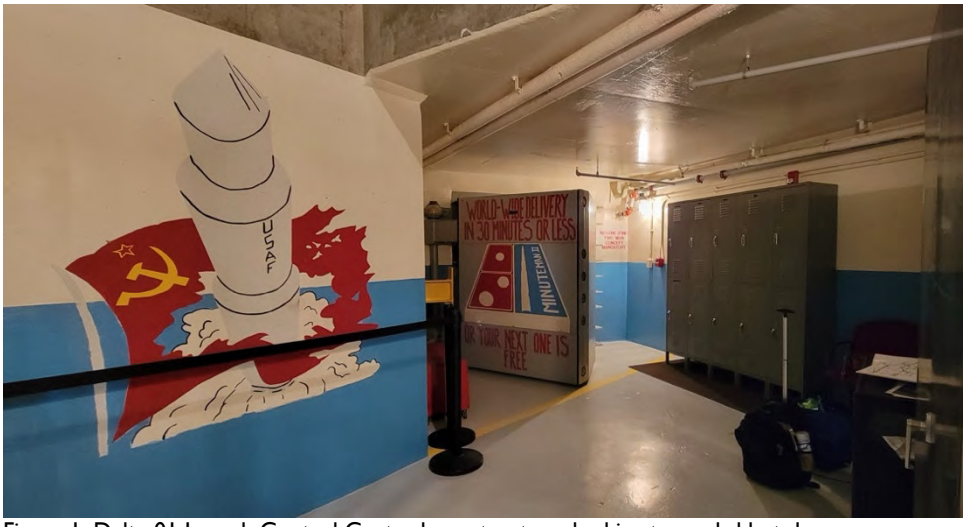


Figure 1. Delta-01 Launch Control Center base structure, looking towards blast door.


Figure 2. Delta-01 LLC, looking into capsule and acoustical enclosure.



Figure 3. Delta-01 acoustical enclosure.



Figure 4. Delta-09 aboveground elements, looking towards viewing enclosure with the access hatch to its left and the ultra-high frequency antenna to its right.



Figure 5. Delta-09 aboveground elements: closure door and tracks (foreground), Soft Support Building roof (background).



Figure 6. Soft Support Building interior.

2.0 BACKGROUND INFORMATION

Delta-01 and Delta-09 were constructed from 1961 to 1962, along with other Minuteman Missile facilities in the region. They were active under the operations of United States Air Force from 1963 to early 1990s.

Relevant building chronology for the paint analysis was extracted from the 2010 Minuteman Missile National Historic Site Historic Structure Report, the 80% draft of the current HSR, and NPS project documents provided by Seven Generations A + E.

Relevant Building Chronology (Figure 7 - Figure 13)

1961 – 1962	Construction
1963	Delta-01 and Delta-09 fully operational
1968	Ultra-High Frequency Antenna installed at Delta-09
1971	Modifications made to accommodate Minuteman II missiles, facilities repainted – "it appears that the facilities all underwent a complete new interior paint campaign, consisting chiefly of shades of green, grey, and white."[1]
1980s	Various interior painting documented in 2010 HSR, include: "At the blast door, the exterior was painted with a figure known to crewmembers at the time as the "Delta Dog" … as well as the words "Welcome – Delta Launch Control Center." The side of the blast door was painted blue with white stars, and the wide jamb of the door had a silhouette of a Minute Man soldier. On the wall above the blast door, "Peace is our Profession" was stenciled above the door, and to the right of the blast door was a sign noting that "No Lone Zone – Two Man Policy Applies". On the southwest wall of the vestibule adjacent to the elevator, several "leadership" quotes by generals were painted within red, white and blue bordered boxes."[2] Only the "No Lone Zone" sign is currently visible, others have been overpainted.
1990	Photograph of the blast door and part of the base structure of Delta-01 shows the walls in white and blue, likely the same colors as they are today. The blast door is medium gray but with a different mural. The photograph of the capsule captures a paint scheme of various shades of green. The "Kick Ass" morale art and the emblem of the 44th Missile Wing on the side of the blast door was overpainted.
1990 – 1993	The blast door in Delta-01 painted with the current Domino's pizza box mural. The missile blasting through Soviet flag on the wall also remains today.

[1] Quinn Evans Architect, and Woolpert, Inc. "Minuteman Missile National Historic Site Historic Structure Report, Cultural Landscape Report and Environmental Assessment," October 2010. 2.12
[2] Ibid. 2.15.

1993	Delta-01 and Delta-09 to be deactivated and converted to museums. Some materials and equipment were removed. Non-functioning radio control panels were installed but all other equipment and furnishing remained.
1999	Minuteman Missile National Historic Site was established by the Congress, but the Air Force retained ownership until 2002.
2001	A training model of missile was placed in the Delta-09 silo and the current viewing enclosure was built.
2002	Operation of Delta-01 and Delta-09 transferred from Air Force to National Park Service.
2006	NPS painted Delta-09's access hatch tube (from the top of the hatch to the bottom of the shaft) and Soft Support Building interiors.
2012	NPS painted parts of Delta-01 Launch Control Center, including the floor of the base structure (2/part Epoxy Pratt & Lambert paint color shade Gig's Gray 28-26), the catwalk (in 26118 Federal Standard), the lower half of the capsule (Pratt & Lambert light gray). The upper part of the capsule was not painted to preserve the historic graffiti.



Figure 7. C.1975 photograph of Delta-09 access hatch, courtesy of NPS. (Photographed by Alonzo Hall, MIMI 2941)



Figure 8. C. 1982 image of Delta-01 blast door and base structure, extracted from 2010 HSR. (source: Minuteman Missile archives, Wilderman Collection, MIMI 2363).

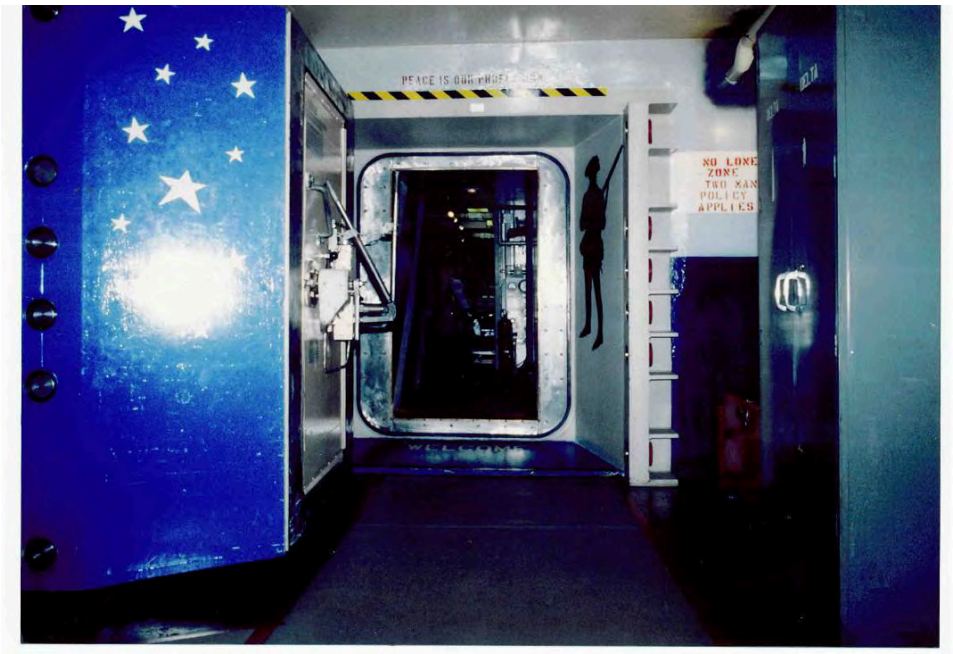


Figure 9. C. 1982 image of Delta-01 blast door looking towards the capsule, extracted from 2010 HSR. (source: Minuteman Missile archives, Wilderman Collection, MIMI 2363).



Figure 10. C. 1982 image of Delta-01 base structure looking towards elevator, extracted from 2010 HSR. (source: Minuteman Missile archives, Wilderman Collection, MIMI 2363).



Figure 11. C. 1982 image inside Launch Control capsule, extracted from 2010 HSR. (source: Minuteman Missile archives, Wilderman Collection, MIMI 2363).

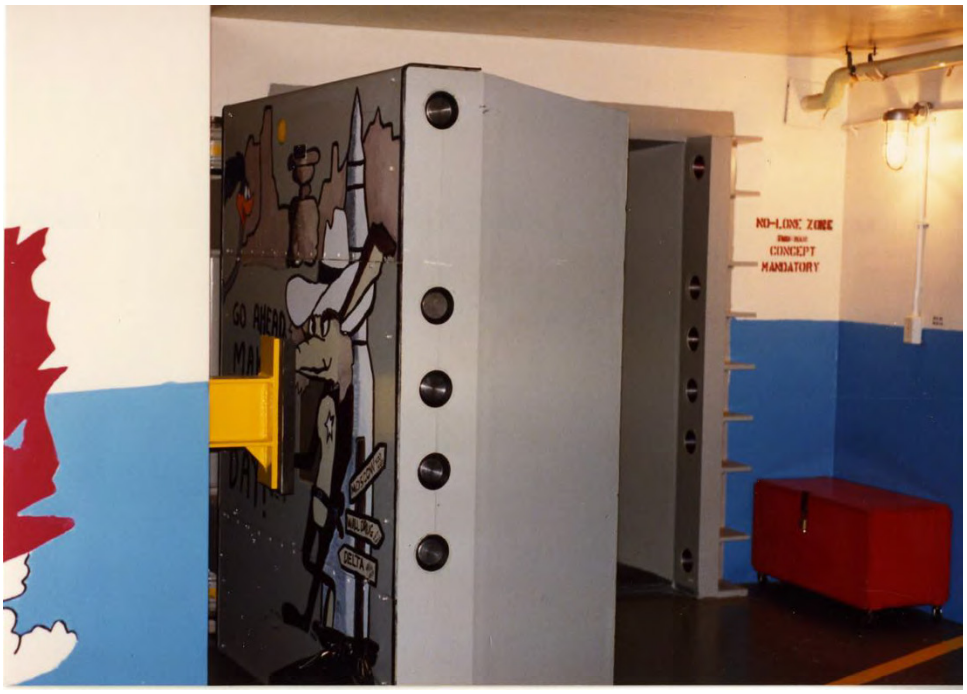


Figure 12. C.1990 image capturing part of the base structure and the blast door, extracted from 2010 HSR. (source: Minuteman Missile Digital Collection, Loughney Collection).



Figure 13. C.1990 photograph of the capsule, extracted from 2010 HSR. (source: Minuteman Missile Digital Collection, Loughney Collection).

3.0 METHODOLOGY

Prior to the site visit, BCA reviewed background information provided by Seven Generations A + E and RATIO, including the 2010 HSR, the 80% draft of the current HSR, and relevant findings from RATIO's investigation, identifying elements of interest for sampling. While on site, BCA discussed the sample locations with NPS.

3.1 Field Microscopy

In-situ field microscopy was performed in each area of investigation. With the aid of X-ACTO blades and a Dermlite for magnification, small craters were made to examine the existing paint layer sequencing. Cratering provides the conservator with a general sense of how many finish layers exist, their approximate colors, and the condition of the substrate. Various craters can then be quickly compared to each other to help determine whether an area has been overpainted, repaired and/or restored, whether early finishes may exist, how one area appears in relation to another, and which areas should be sampled for laboratory analysis. Architectural elements where no paint sample was removed were examined with field microscopy.

3.2 Laboratory Analysis of Paint Samples

BCA removed a total of 62 samples from metal and concrete elements using X-ACTO blades and other hand tools. Each finish sample was bagged, labeled with its sample number and returned to BCA's Philadelphia conservation laboratory. Sample locations were guided by field investigation, substrate quality, current condition of the painted surface, and NPS's input. Subsequently, BCA met with NPS and selected 35 samples to analyze as part of the current project in order to stay within the project budget. The locations of the 35 samples are documented in *Appendix A*.

Each sample was embedded in Extec Polyester Clear Resin® and sectioned on a Buehler IsoMet® low-speed saw. The sectioned samples were then dry polished using a series of fine Micromesh® cloths ranging from 6,000 to 12,000 grit. Sectioned samples were observed under a Nikon Eclipse E200® compound microscope in both visible light passed through a daylight correction filter and ultraviolet light. The ultraviolet light was generated by a mercury illumination system filtered through a violet filter cube (V-2A Ex380/420 Dm430 Bar 450M). Photomicrographs of paint samples were taken using Nikon DS-Fi3® color digital camera system and are included in this report to illustrate specific observations. Photomicrographs for all analyzed samples are included in *Appendix B*.

BCA performed color matches for paint layers identified as early 1990s by visually matching the paint to the Munsell color system and Federal Standard 595 Colors, viewed in simulated natural light under magnification. Some layers required mechanical exposure using X-ACTO blades to remove the overpaint, other 1990s paint layers were identified as the current presentation finish. All available color matches are documented in *Section 5.1* and *Appendix B*.

3.3 Color Names

All color names for paint layers were assigned following the ISCC-NBS Color System. The ISCC-NBS system specifies 267 color categories with non-technical names such as "light yellowish green." The system was developed by the Inter-Society Color Council (ISCC) and the National Bureau of Standards (NBS) in 1955 to provide a standard for specifying colors with common words.[3]

[3] Centore, Paul. "sRGB Centroids for the ISCC-NBS Colour System," May 4, 2016. 1.

4.0 SUMMARY OF FINDINGS

BCA's findings are presented in the following section, which is organized by structure (Delta-01 and Delta-09). Delta-09 is further subdivided into *Exterior, Delta-09 Launch Facility Interior,* and *Soft Support Building Interior.*

4.1 Delta-01 Launch Control Center (Figure 14 - Figure 18)

The Launch Control Center (LLC) of Delta-01 is subterranean. It is accessed via an elevator located in the aboveground Launch Control Facility. The elevator opens to a concrete base structure with a blast door leading to the capsule. The capsule is constructed of metal, protecting the acoustical enclosure that houses the missile controls and other systems.

BCA analyzed the following samples from Delta-01: catwalk railing (sample # D1.1); lower capsule wall (D1.7); upper capsule wall (D1.8); gray ramp to the blast door (D1.9); concrete base structure floor (D1.10); lower base structure wall (D1.14); upper base structure wall (D1.15); door frame to acoustical enclosure (D1.17); control panel in acoustical enclosure (D1.23); acoustical enclosure wall (D1.27); acoustical enclosure ceiling (D1.28). Photographs of all sample locations are included in *Appendix A.*

Most of the existing finishes (i.e., current presentation finishes) from the elements sampled by BCA likely date to the period of significance (the early 1990s), except the elements documented as having been repainted in 2012 (see c.1990 paint scheme in Figure 12 and Figure 13).[4] As discussed in *Section 2.0*, the base structure floor, catwalk (possibly include the gray ramp), and lower capsule wall were repainted in 2012. The paint used in 2012 has a distinctive elastic quality, so it is easy to identify. Since the concrete floor was stripped in 2012, the 1990s finish cannot be determined based on physical evidence. However, the historic photographs show the floor was either painted dark gray or unpainted. Earlier paint layers were found on the sample removed from the gray ramp to the blast door. The 1990s finish for the ramp is likely a dark gray or bluish yellow gray. The lower capsule wall has been repainted approximately four times, the presentation finish for 1990s is either the light gray under the 2012 paint layer or the preceding dark bluish gray.

When operations began in Delta-01 in the 1960s, the base structure had a yellowish gray lower wall and a pale yellow upper wall. The concrete floor appears to have been unpainted and possibly polished. The ramp, catwalk, and railing were painted in the same grayish green as the current railing finish. The upper wall of the capsule was white[5] and the bottom silver. The control panel, the door frame, and the wall in the acoustical enclosure was pale green, the acoustical enclosure ceiling was yellowish white.

The second paint scheme dating to the 1970s and 1980s was similar to the first, consisting of grays and pale greens, although the colors were deeper in the later paint schemes (see c.1982 paint scheme in Figure 8 - Figure 11.) The lower wall of the base structure was painted in dark, vivid blues with white upper wall. The concrete floor was either painted dark gray or remained unpainted. The ramp and catwalk were medium to dark gray, and the railing remained grayish green. The door frame was painted in more saturated grayish blue then yellow green. The

[4] National Park Service. "PMIS_130693_MIMI Repaint Delta 01 LCC Capsule and Tunnel Junction_2012PMIS_130693_MIMI Repaint Delta 01 LCC Capsule and Tunnel Junction_2012,"
[5] Paint evidence suggests that the upper capsule wall may have never been repainted.

control panel remained various pale blue greens. The acoustical enclosure wall was painted pale green a few more times before it was painted in the same yellowish white as the ceiling. The ceiling has always been yellowish white.

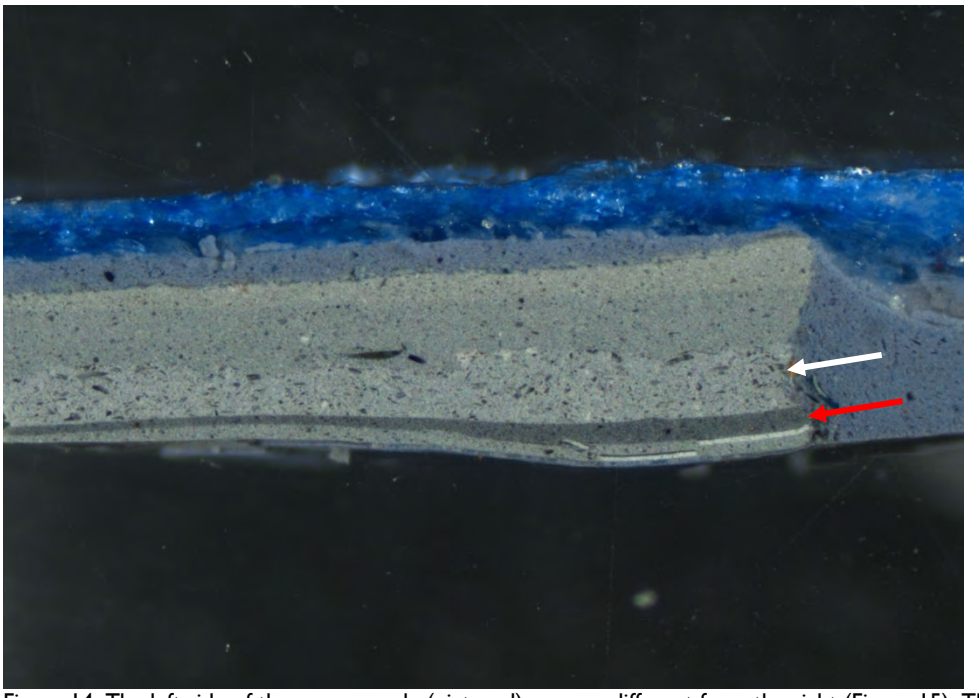


Figure 14. The left side of the ramp sample (pictured) appears different from the right (Figure 15). This is likely the result of the paint layers on the ramp being in poor condition or the ramp had different patterns in the past. This condition complicates the identification of the 1990s finish, but the most likely layers are the dark gray (red arrow) or the bluish yellowish gray (white arrow). *D9.9, left side of sample, visible light, 40x magnification.*

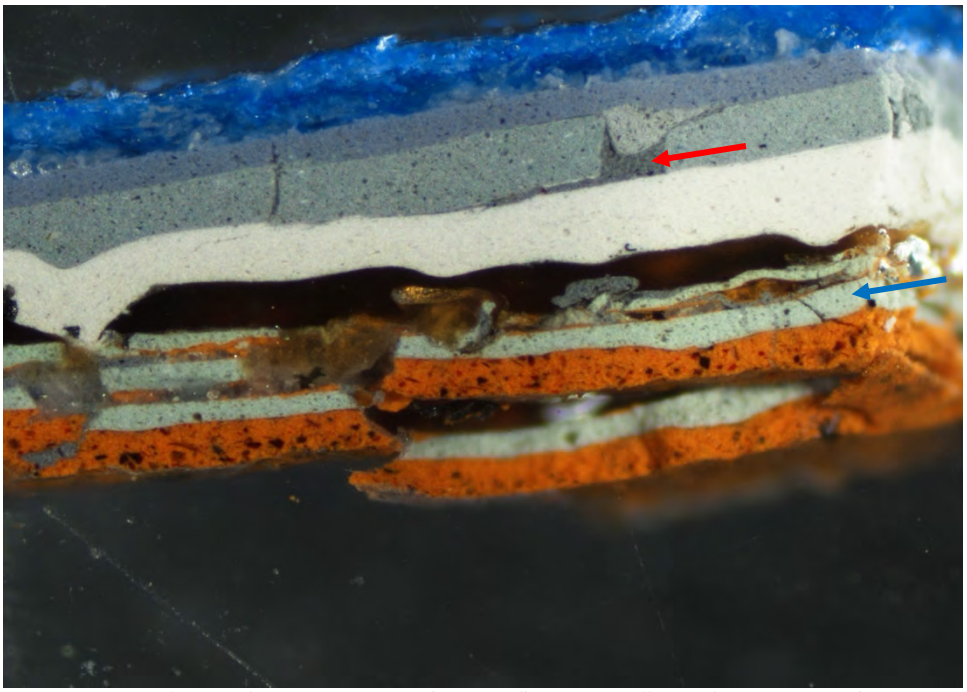


Figure 15. The left side of the ramp sample (Figure 14) appears different from the right (pictured above). This is likely the result of the paint layers on the ramp being in poor condition or the ramp had different patterns in the past. This condition complicates the identification of the 1990s finish, but the most likely layers are the dark gray (red arrow) or the bluish yellowish gray (captured in Figure 14 only). The original 1960s finish is identified by a blue arrow. *D9.9, right side of sample, visible light, 40x magnification.*

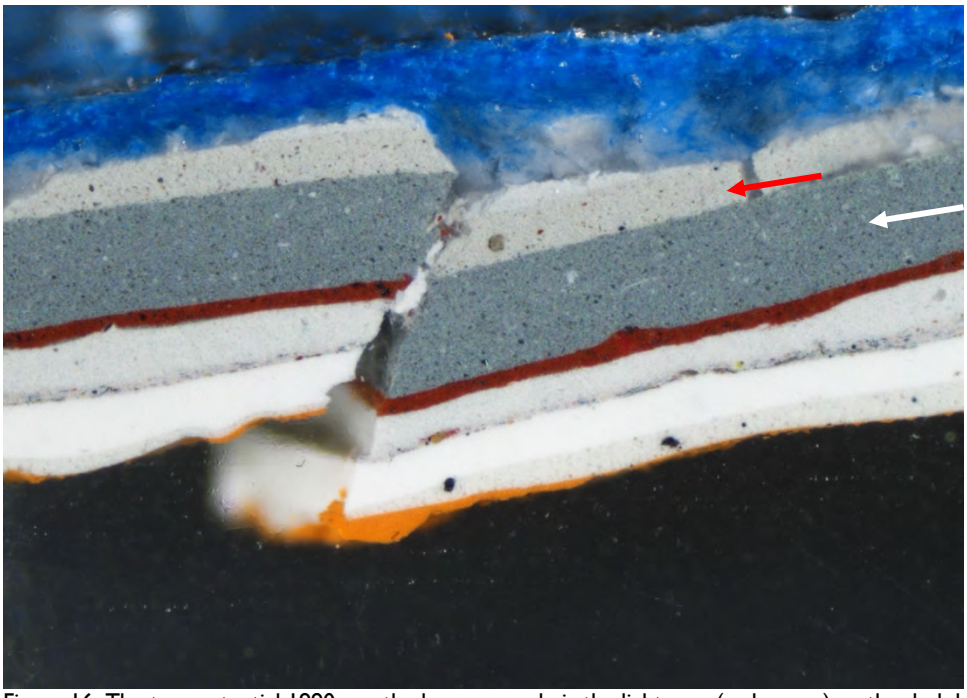


Figure 16. The two potential 1990s on the lower capsule is the light gray (red arrow) or the dark bluish gray (white arrow). *D9.7, visible light, 40x magnification.*

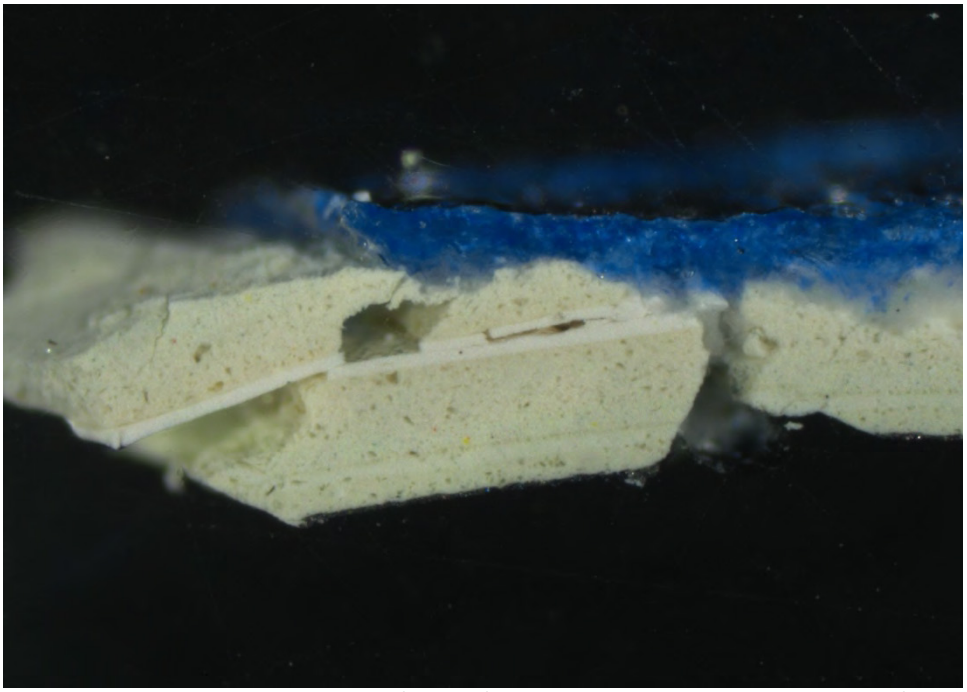


Figure 17. The acoustical enclosure wall (pictured) was painted pale green, while the ceiling (Figure 18) was painted yellowish white in all of the past paint schemes except the current, where they are both painted yellowish white D1.27 Acoustical enclosure wall. *D9.7, visible light, 40x magnification.*

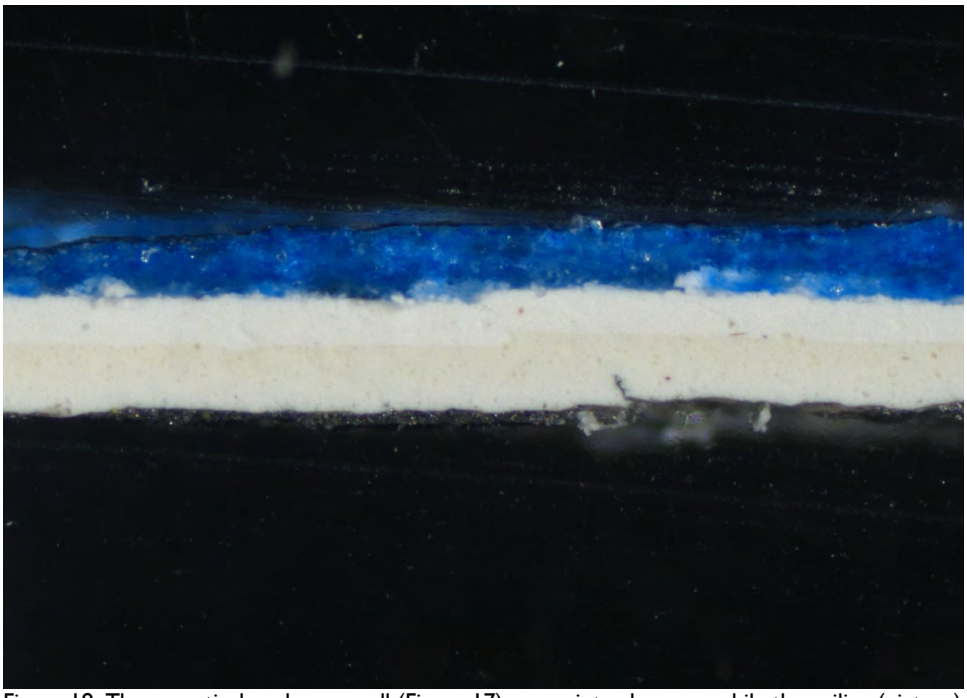


Figure 18. The acoustical enclosure wall (Figure 17) was paint pale green while the ceiling (picture) was painted yellowish white in all the past paint schemes except the current, where they are both painted yellowish white D1.27 Acoustical enclosure wall. *D9.28, visible light, 40x magnification.*

4.2 Delta-09 Exterior (Figure 19 - Figure 24)

At the surface of Delta-09, a glass and metal viewing enclosure was built in 2001, covering the missile silo. A hatch provides access to the below ground Launch Facility. The closure door and its tracks are behind the viewing enclosure. The roof of the Soft Support Building is located to the east of the viewing enclosure and the ultra-high frequency on the northwest.

The aboveground elements that BCA sampled at Delta-09 include: the metal bolt of the viewing enclosure (D9.21); the interior of the access hatch (D9.22); the metal cap of the access hatch controls (D9.23); the metal plate covering the Soft Support Building (D9.28); the closure door wall (D9.31), base (D9.32) and track (D9.33); and the antenna base (D9.35).

According to the oral history from NPS, many of the exterior elements were repainted by the NPS in recent years with colors matching the existing finishes at the time. In addition, the access hatch interior was repainted in 2006, according to NPS project records.[6] The most recent paint layers have a distinctive elastic quality.

In the 1990s, the elements were painted with colors similar to the current colors. The access hatch interior was pale bluish green, the cap was dark grayish blue, the antenna base was medium bluish gray. The metal plate on the Soft Support Building, the closure door wall, base, and track were painted in almost identical colors as their current colors.

Based on the cross-section analysis, the paint layer directly below the current finish is likely original (1960s) on the metal plate, the antenna base, and all the closure door elements. As mentioned above, the 1960s colors on these elements are nearly identical to the current color. Although the closure door wall currently appears to be a lighter gray than its base, the current finish and the original finish for both elements are all the same medium gray when observed under magnification. The visual color difference may be caused by dissimilar substrate textures or the two architectural elements catching light differently due to the slope of the closure door. The hatch interior and cap have been painted many times. The original finish on the access hatch is a very light bluish green, follow by dark gray, silver, then back to pale greens and blues. The original finish on the metal cap is grayish blue, then grayish blue, silver, followed by the 1990s dark grayish blue. The 2001 viewing enclosure bolt has also been repainted frequently. Its original finish is a light yellow brown. Subsequently, it was painted in light grays and blues.

[6] National Park Service. "PMIS_111093_MIMI Paint Delta 09 Access Hatch and Support Bldg Interior_2006."

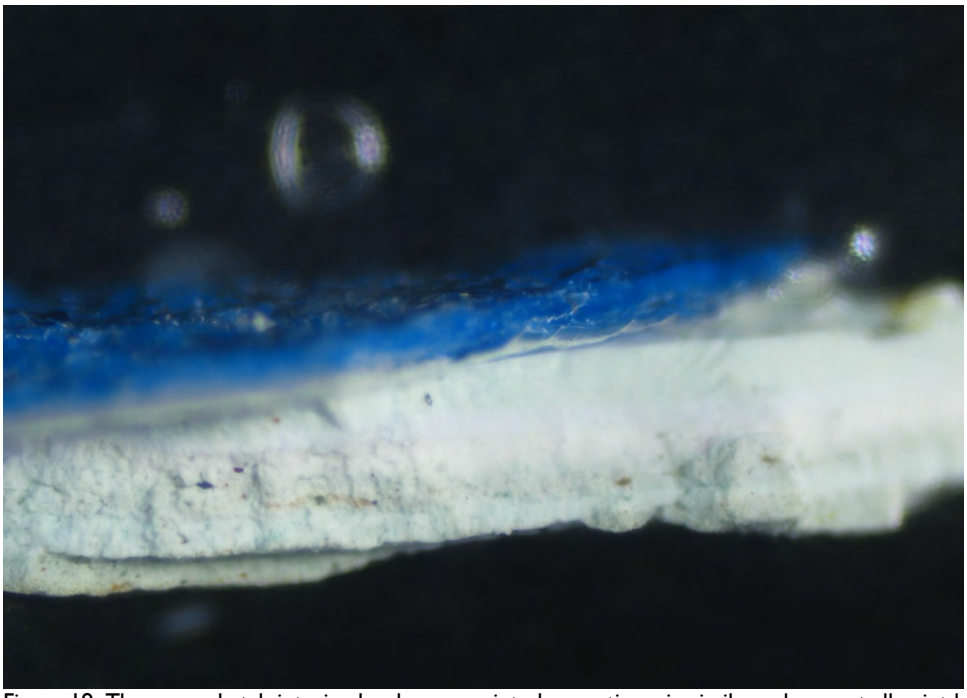


Figure 19. The access hatch interior has been repainted many times in similar colors, not all paint layers were captured in this cross-section. *D9.22, visible light, 40x magnification.*

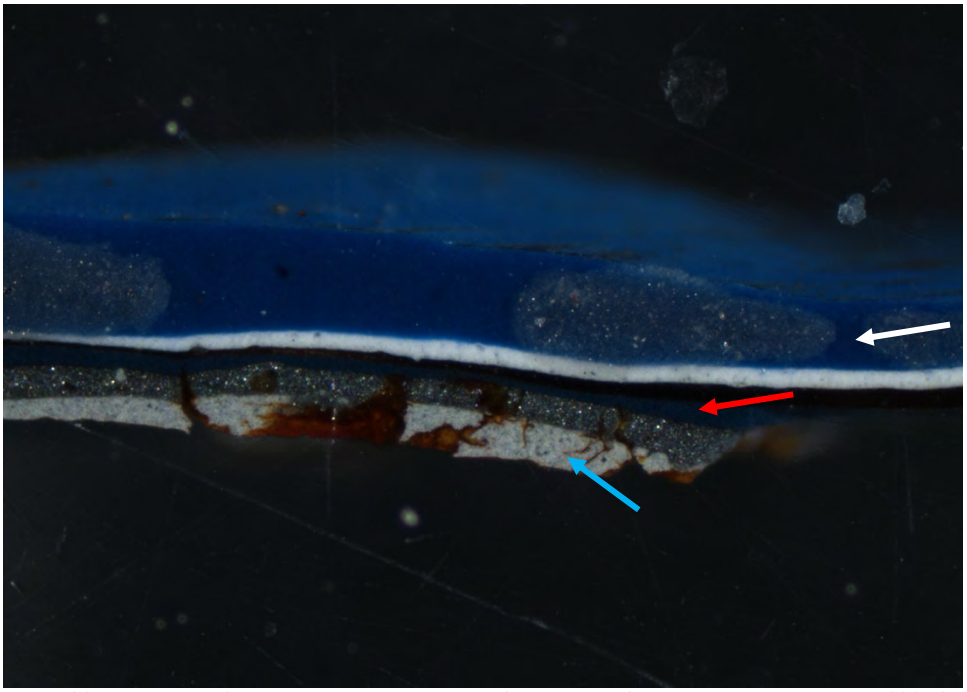


Figure 20. The color of the most recent repainting (white arrow) is nearly identical to its 1990s finish (red arrow) on the cap. The original (1960s) grayish blue is indicated by a blue arrow. *D9.23, visible light, 40x magnification.*



Figure 21. The wall (red arrow) and the base (white arrow) of the closure door appears to be different grays, but the colors are identical under magnification. See their bulk samples in Figure 22 and their cross-sections in Figure 23 and Figure 24.

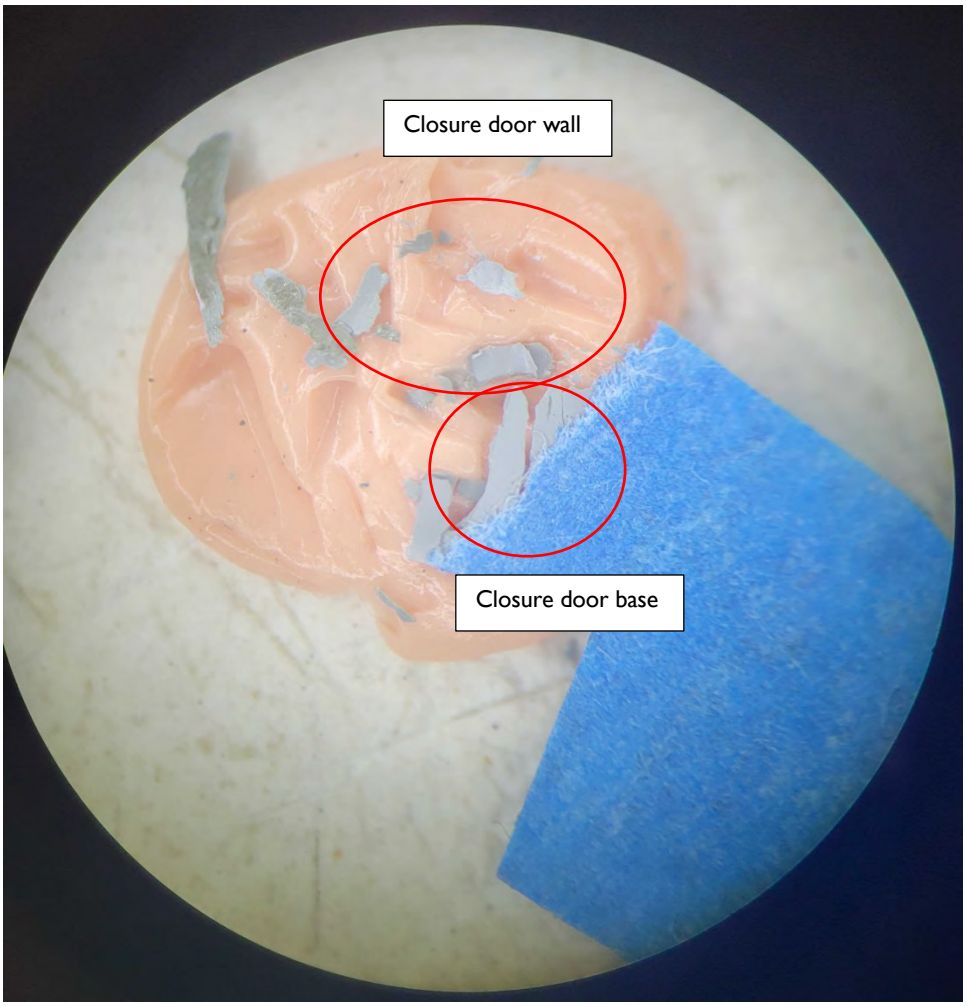


Figure 22. The bulk sample from closure door wall and closure door base appear to be the same color under magnification.

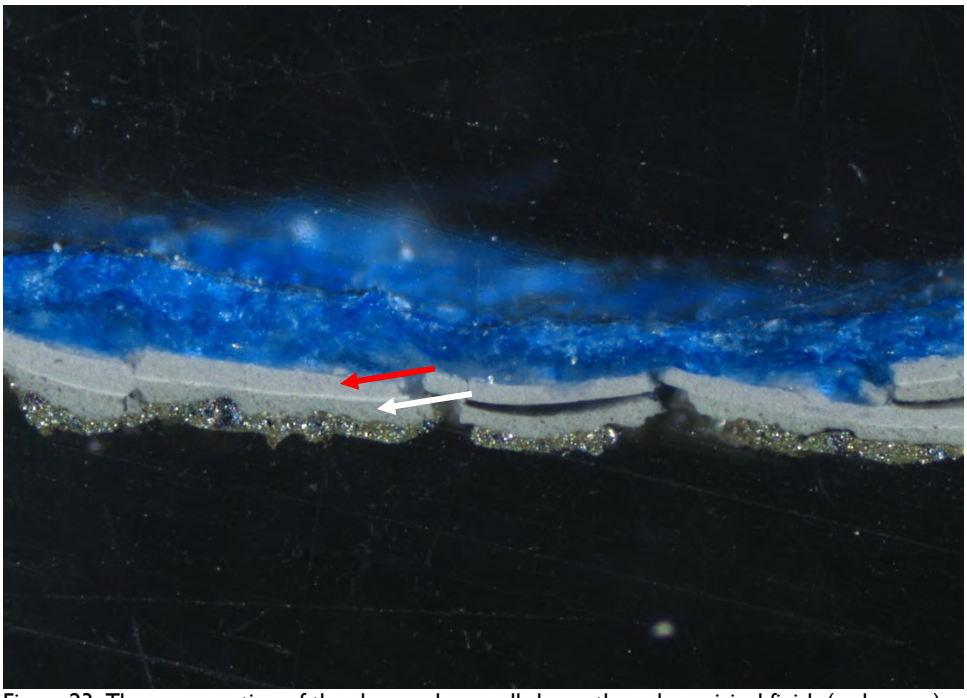


Figure 23. The cross-section of the closure door wall shows the color original finish (red arrow) under the 2000s repainting (white arrow) are identical. *D9.31, visible light, 40x magnification.*

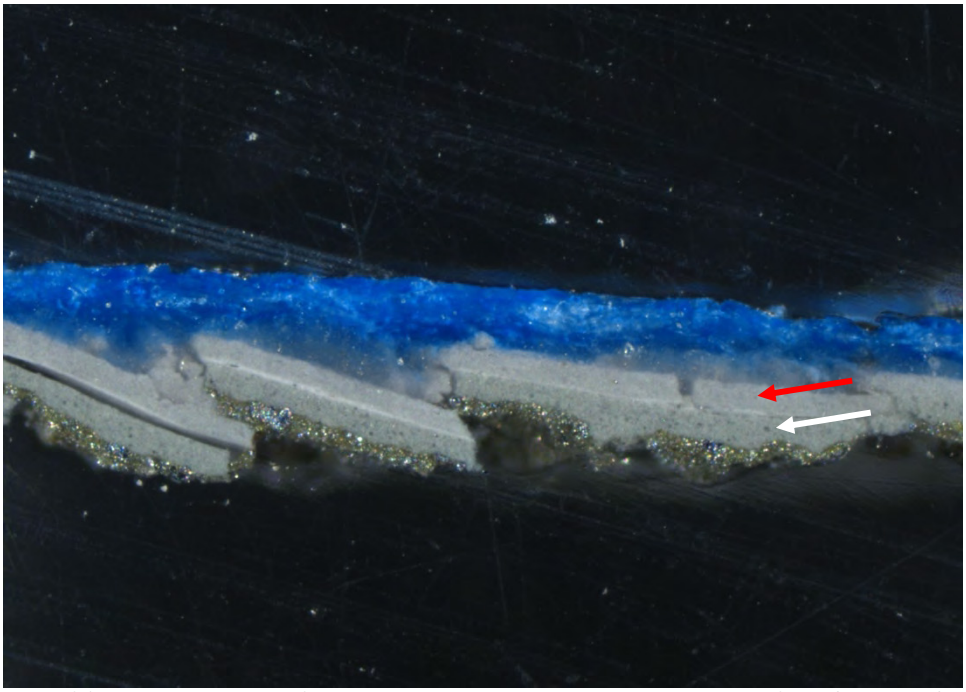


Figure 24. The cross-section of the closure door base shows the color original finish (red arrow) under the 2000s repainting (white arrow) are identical. *D9.31, visible light, 40x magnification, D9.32, visible light, 40x magnification.*

4.3 Delta-09 Launch Facility Interior (Figure 25 - Figure 30)

The Launch Facility consists of two circular subterranean levels surrounding the missile silo at 22 feet and 30 feet below grade. The silo itself extends deeper underground, its base at approximately 82 feet below grade.

The elements analyzed by BCA include the silo wall (D9.1) and missile support structures (D9.3). At Sub Level 1, the elements include: the wall (D9.7); launch tube at 6' above floor level (D9.8) and at 4' (D9.9); metal floor (D9.10); pole (D9.12); ceiling (D9.13). At Sub Level 2, the elements analyzed include: battery frames (D9.14); wall (D9.15); launch tube (D9.16); battery anchors (D9.19); and metal floor (D9.20).

According to NPS, most of the elements have not been repainted since the U.S. Air Force left in the 1990s. This is consistent with the findings from the cross-section analysis and laboratory examination of the samples. The only two elements that have been painted after 2002 are the wall at Sub Level 1 (as documented in PMIS project report) and the wall at Sub Level 2 (as determined by BCA's laboratory analysis).[7] In the 1990s, both walls were likely yellow green.

The original paint scheme in the Launch Facility is not too different from the 1990s scheme. The silo wall has never been repainted; therefore, the current finish is the original. The missile support structures have only been repainted once; their original finish is the same as their current finish in a dark grayish blue. In Sub Level 1, the original finish on the wall and the launch tube were pale green, the floor was in a grayish blue, the metal pole was pale bluish green, and the ceiling in very pale green. The original finish in Sub Level 2 includes deep yellowish green battery frames (darker than its current color) with its anchors in white and the adjacent floor in light vivid yellow green. The wall of Sub Level 2 was pale green, and the entire launch tube was pale bluish green. The floor adjacent to the launch tube may have had a different original paint scheme, but it was too deteriorated to be sampled. Most of the elements were repainted in similar colors throughout the Air Force's operation. A few select elements of interest are discussed in more detail below.

The launch tube on Sub Level 1 currently has two slightly different pale greens. It appears that the lower portion have been repainted more often than the upper portion, which is out of normal reach. This observation was confirmed through sample analysis. The upper portion was painted twice while the lower portion was painted four times. Although the current presentation finish on the upper and lower part appears to be slightly different, they are not distinctive enough to have different color matches. The finish on the upper portion has weathered to a slightly more brownish color and may have lost some of its gloss.

The launch tube on Sub Level 2 was monochromatic during the earliest two paint schemes. The gray color was applied during the third paint scheme in the 1990s and the green color was applied on top of the gray. It is also possible that the entire launch tube was gray for a period of time. The green portion has been repainted four more times, but the gray portion has not been painted again.

[7] Ibid.

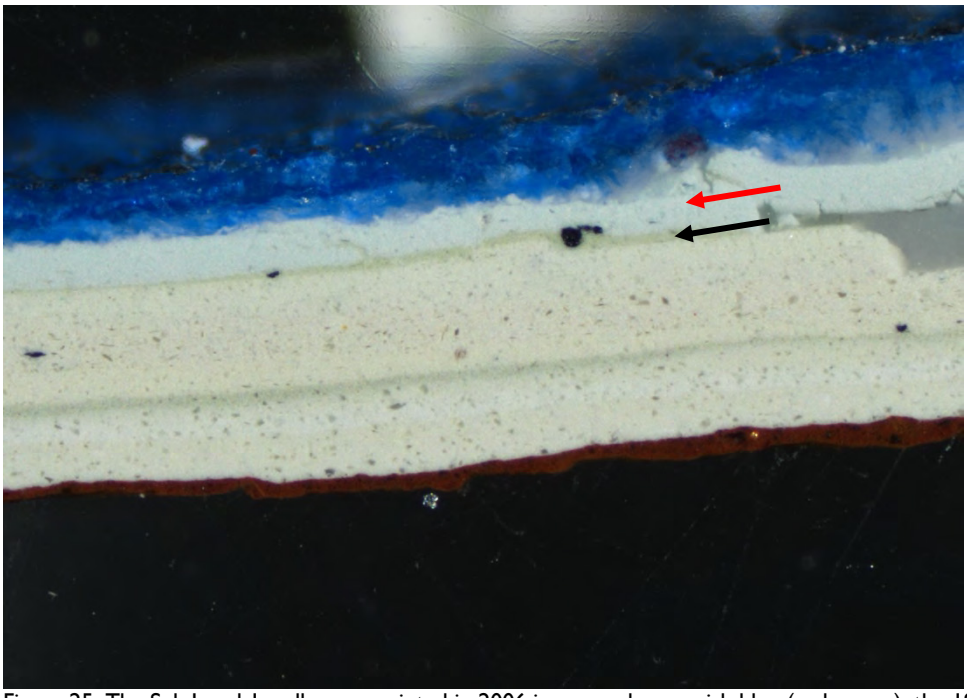


Figure 25. The Sub Level 1 wall was repainted in 2006 in very pale greenish blue (red arrow), the 1990s yellow green finish is just below (black arrow). *D9.7, visible light, 40x magnification.*



Figure 26. The upper portion of the Sub Level 1 launch tube appears slightly different in color from the lower portion. This is likely a result of paint discoloration/deterioration overtime and not because different paint colors were used.

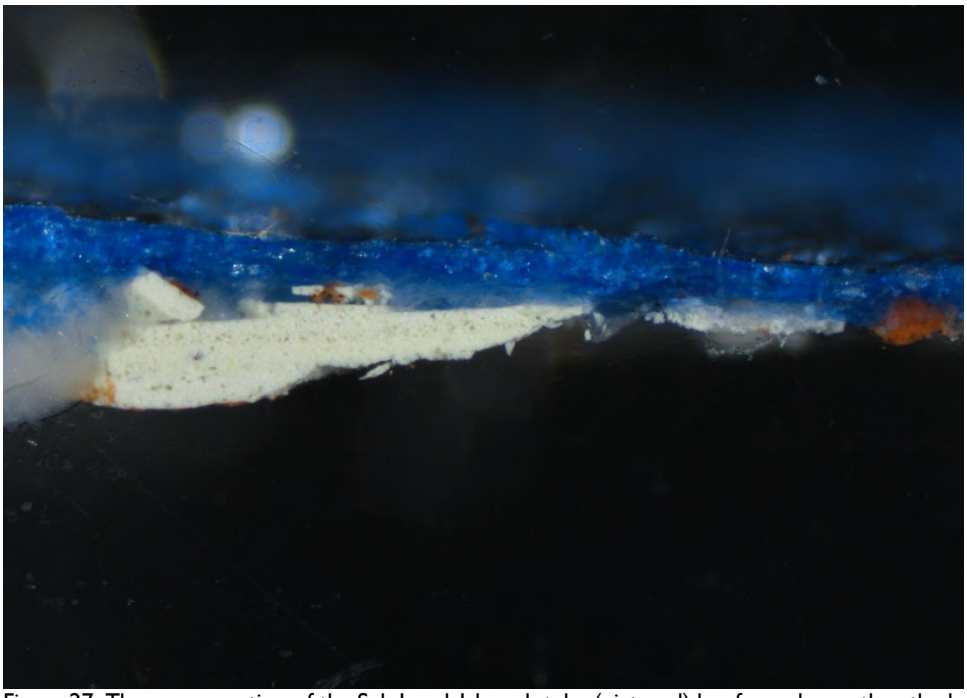


Figure 27. The upper portion of the Sub Level 1 launch tube (pictured) has fewer layers than the lower portion (Figure 28). *D9.8, visible light, 40x magnification.*

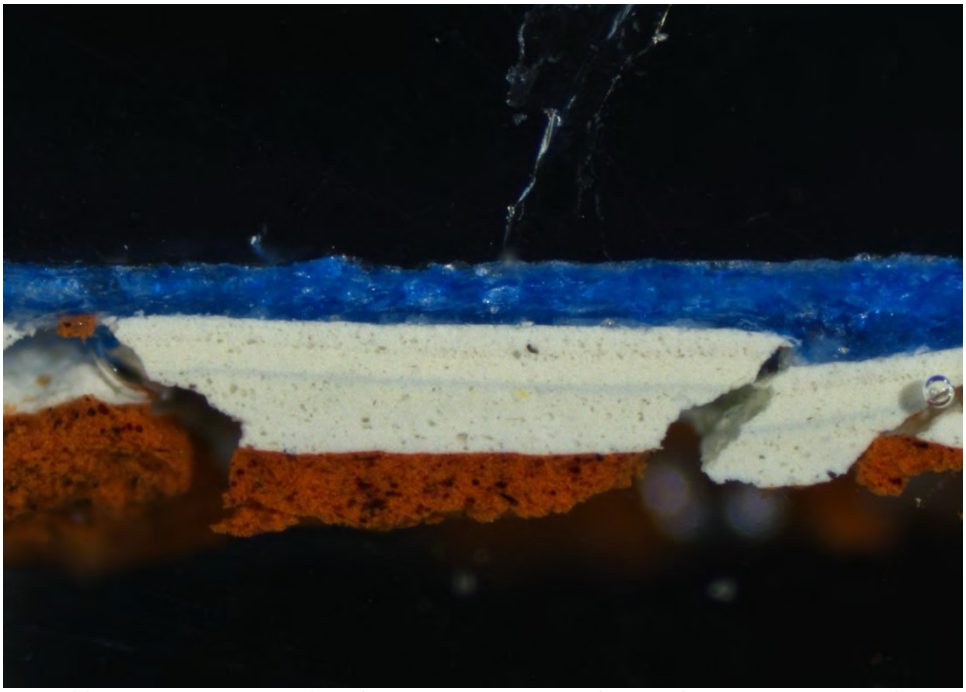


Figure 28. The lower portion of the Sub Level 1 launch tube (pictured) was painted more often than the upper portion (Figure 27). *D9.9, visible light, 40x magnification.*

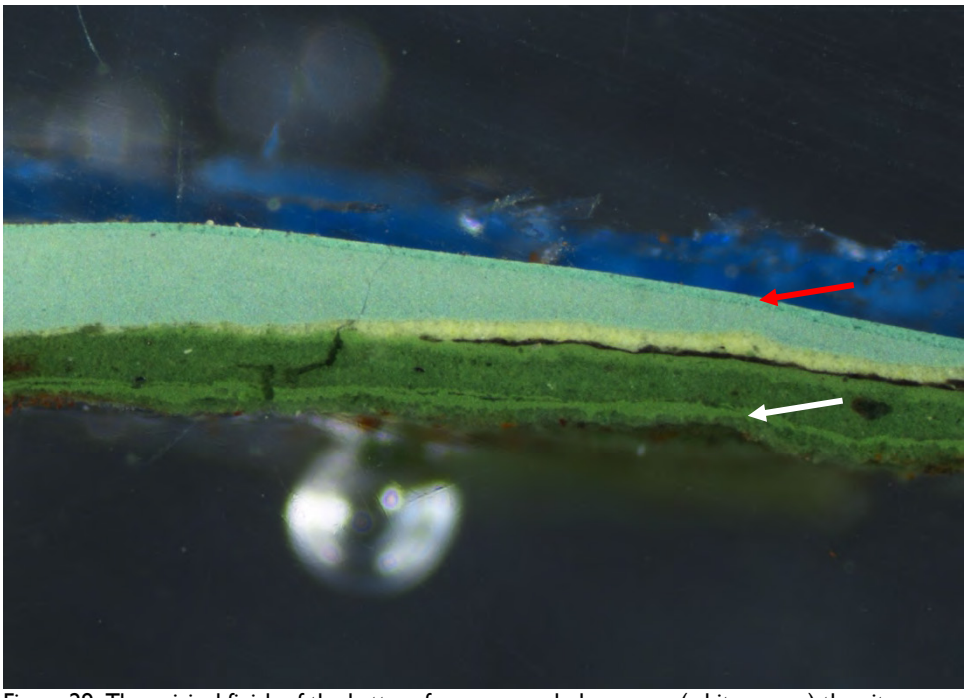


Figure 29. The original finish of the battery frame was a darker green (white arrow) than its present color (red arrow). *D9.14, visible light, 40x magnification.*



Figure 30. The Sub Level 2 launch tube was originally monochromatic. The dual color scheme (gray and pale green) was painted around late 1980s to early 1990s. This sample was removed at the intersection of the gray and pale blue paint. *D9.16, visible light, 40x magnification.*

4.4 Delta-09 Soft Support Building Interior

The Soft Support Building is a small underground room approximately 14 feet by 24 feet. It contains the generator and equipment for Delta-09. BCA analyzed the dual color painted concrete wall (D9.24 lower wall, D9.25 upper wall) and the metal door (D9.26) at this location.

NPS project records indicated that the concrete walls were repainted in 2006 following flood damage.[8] Prior to the current paint scheme, the concrete walls were monochromatic. It was originally pale green then repainted in very light green before they were painted in the current dual-color scheme in 2006. The very light green is likely the 1990s finish. The current light grayish green paint on the door may be the 1990s presentation finish, with the original pale blue finish just below the current layer.

[8] Ibid.

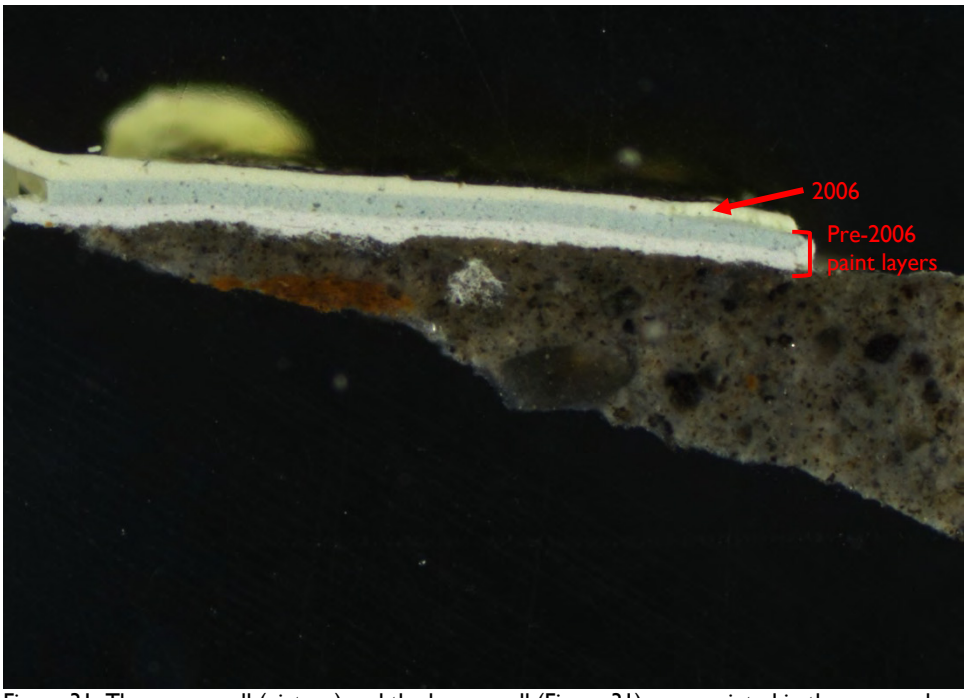


Figure 31. The upper wall (picture) and the lower wall (Figure 31) were painted in the same color until it was repainted in 2006. *D9.25, visible light, 40x magnification.*

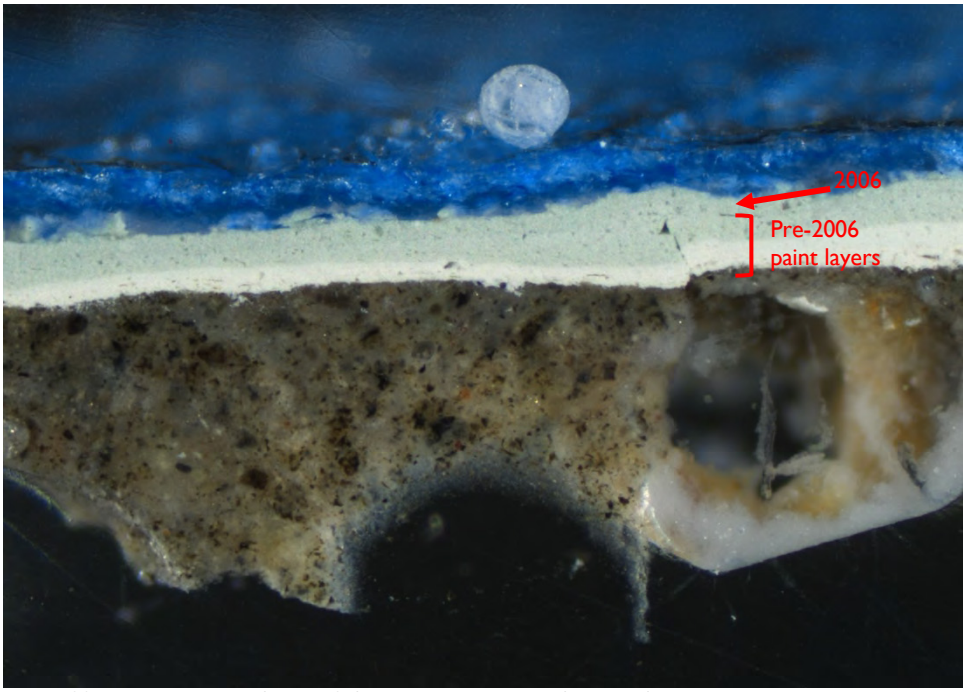


Figure 32. The upper wall (Figure 31) and the lower wall (pictured) were painted in the same color until it was repainted in 2006. *D9.25, visible light, 40x magnification.*

5.0 CONCLUSIONS AND RECOMMENDATIONS

BCA's paint analysis of select elements at Delta-01 and Delta-09 shows that many of the interior features retain their finishes dating to the period of significance in 1990s. While the exterior of Delta-09 has been repainted, the current finishes closely replicate the exterior finishes in the 1990s.

The tables on the following pages include color matches of the finishes identified as the 1990s paint schemes. The tables are organized by the spaces analyzed: Delta-01, Delta-09 Exterior, Delta-09 Launch Facility, and Delta-09 Soft Support Building. The sample number and element where each color was documented is listed in the left column. The color name and color matches to the Munsell and Federal Standard 595C systems are presented in the middle column. A virtual rendition of the Federal Standard color swatch is included in the right column.

Note that some elements include two possible finishes for 1990s, identified as "Potential Color 1" and "Potential Color 2," because BCA was unable to confirm the 1990s finish. If additional repainting project documentation could be found, it could aid in confirming which paint layer most likely dates to the period of significance.

The printed or digital color swatches in the report vary from actual colors. Any attempt to reproduce these pages, including printing from the electronic version of the report, will distort the color of the provided color swatch. Only physical swatches of the stated Federal Standard 595 or Munsell notation should be used for paint replication purposes.

In addition, BCA recommends analyzing the additional 27 paint samples that were removed but not selected for analysis for the current phase of work. This additional analysis would provide a more comprehensive and holistic understanding of the paint schemes at Delta-01 and Delta-09. BCA can retain these samples in the conservation laboratory for future analysis or can return them to NPS for documentation purposes.

5.1 Color Matches

Table 1. Delta-01: Color Matches for 1990s Paint Scheme

Elements	Color Match	FED-STD-595C Swatch
D1.1 Railing	*Finish*: moderate grayish green *Munsell Color Match*: 7.5G 6/2 *FED-STD-595C Match*: 24241	
D1.7 Lower Capsule Wall Potential Color 1	*Finish*: dark bluish gray *Munsell Color Match*: 7.5B 4/2 *FED-STD-595C Match*: 25189	
D1.7 Lower Capsule Wall Potential Color 2	*Finish*: light gray *Munsell Color Match*: 5Y 6/1 *FED-STD-595C Match*: 26357	
D1.8 Upper Capsule Wall	*Finish*: yellowish white *Munsell Color Match*: 5Y 9/1 *FED-STD-595C Match*: 17886	
D1.9 Ramp to Blast Door Potential Color 1	*Finish*: dark gray *Munsell Color Match*: 5B 5/2 *FED-STD-595C Match*: 26118	
D1.9 Ramp to Blast Door Potential Color 2	*Finish*: bluish yellowish gray *Munsell Color Match*: 7.5B 5/2 *FED-STD-595C Match*: 35189	

D1.10 Concrete floor	Potentially unpainted	
D1.14 Base Structure Lower Wall	*Finish*: light blue *Munsell Color Match*: 10B 5/8 *FED-STD-595C Match*: 35250	
D1.15 Base Structure Upper Wall	*Finish*: white *Munsell Color Match*: 10Y 9/1 *FED-STD-595C Match*: 17886	
D1.17 Door Frame	*Finish*: yellowish white *Munsell Color Match*: 5Y 9/1 *FED-STD-595C Match*: 17886	
D1.23 Control Panel	*Finish*: grayish greenish white *Munsell Color Match*: 5GY 9/1 *FED-STD-595C Match*: 17875	
D1.27 Acoustical Enclosure Wall	*Finish*: yellowish white *Munsell Color Match*: 5Y 9/1 *FED-STD-595C Match*: 17886	
D1.28 Acoustical Enclosure Ceiling	*Finish*: yellowish white *Munsell Color Match*: 5Y 9/1 *FED-STD-595C Match*: 17886	

Table 2. Delta-09 Exterior: Color Matches for 1990s Paint Scheme

Elements	Color Match	FED-STD-595C Swatch
D9.21 Viewing Enclosure Bolt	*Finish*: yellowish gray *Munsell Color Match*: N6.25 *FED-STD-595C Match*: 26373	
D9.22 Access Hatch Interior	*Finish*: pale bluish green *Munsell Color Match*: 2.5BG 7/2 *FED-STD-595C Match*: 24410	
D9.23 Cap to Hatch Controls	*Finish*: dark grayish blue *Munsell Color Match*: 10B 2/4 *FED-STD-595C Match*: 25045	
D9.28 Soft Support Building Roof Plate	*Finish*: pale grayish green *Munsell Color Match*: 10G 7/1 *FED-STD-595C Match*: 26480	
D9.31 Closure Door Wall	*Finish*: medium gray *Munsell Color Match*: N5.5 *FED-STD-595C Match*: 26290	
D9.32 Closure Door Base	*Finish*: medium gray *Munsell Color Match*: N5.5 *FED-STD-595C Match*: 26290	

D9.33 Closure Door Track	*Finish*: moderate reddish orange *Munsell Color Match*: 7.5R 5/8 *FED-STD-595C Match*: 31400 *Note: there is no exact FED-STD-595C color match to this paint layer, the provided is the closest match.*	
D9.35 Antenna Base	*Finish*: medium bluish gray *Munsell Color Match*: 5B 7/1 *FED-STD-595C Match*: 26373	

Table 3. Delta-09 Launch Facility: Color Matches for 1990s Paint Scheme

Elements	Color Match	FED-STD-595C Swatch
D9.1 Silo Wall (White)	*Finish*: bright white *Munsell Color Match*: N9.5 *FED-STD-595C Match*: 27885	
D9.1 Silo Wall (Black)	*Finish*: black *Munsell Color Match*: N0.5 *FED-STD-595C Match*: 27041	
D9.3 Missile Support Structure	*Finish*: dark grayish blue *Munsell Color Match*: 10B 2/4 *FED-STD-595C Match*: 25045	
D9.7 Sub Level 1 Wall	*Finish*: moderate yellow green *Munsell Color Match*: between 5GY 7/2 – 7/4 *FED-STD-595C Match*: 14533	
D9.8 Sub Level 1 Launch Tube (6')	*Finish*: pale green *Munsell Color Match*: 7.5GY 9/2 *FED-STD-595C Match*: 24672	
D9.9 Sub Level 1 Launch Tube (4')	*Finish*: pale green *Munsell Color Match*: 7.5GY 9/2 *FED-STD-595C Match*: 24672	

D9.10 Sub Level 1 Floor	*Finish*: dark blue gray *Munsell Color Match*: 5B 4/1 *FED-STD-595C Match*: 26152	
D9.12 Sub Level 1 Pole	*Finish*: moderate yellow green *Munsell Color Match*: between 5GY 7/2 – 7/4 *FED-STD-595C Match*: 14533	
D9.13 Sub Level 1 Ceiling	*Finish*: very pale yellow green *Munsell Color Match*: 10Y 9/2 *FED-STD-595C Match*: 24554	
D9.14 Sub Level 2 Battery Frame	*Finish*: moderate yellowish green *Munsell Color Match*: between 7.5G 5/6 – 6/6 *FED-STD-595C Match*: 14260	
D9.15 Sub Level 2 Wall	*Finish*: moderate yellow green *Munsell Color Match*: between 5GY 7/2 – 7/4 *FED-STD-595C Match*: 14533	
D9.16 Sub Level 2 Launch Tube (Gray)	*Finish*: bluish gray *Munsell Color Match*: 2.5PB 5/2 *FED-STD-595C Match*: 26173	

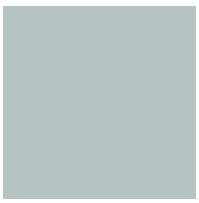
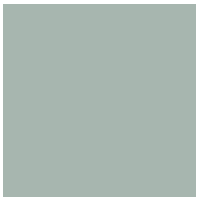
D9.16 Sub Level 2 Launch Tube (Light Green)	*Finish*: very light bluish green *Munsell Color Match*: 7.5G 7/2 *FED-STD-595C Match*: 34410	
D9.19 Sub Level 2 Battery Anchor	*Finish*: light greenish bluish gray *Munsell Color Match*: 10BG 7/2 *FED-STD-595C Match*: 25530	
D9.20 Sub Level 2 Floor	*Finish*: light greenish bluish gray *Munsell Color Match*: 10BG 7/2 *FED-STD-595C Match*: 25530	

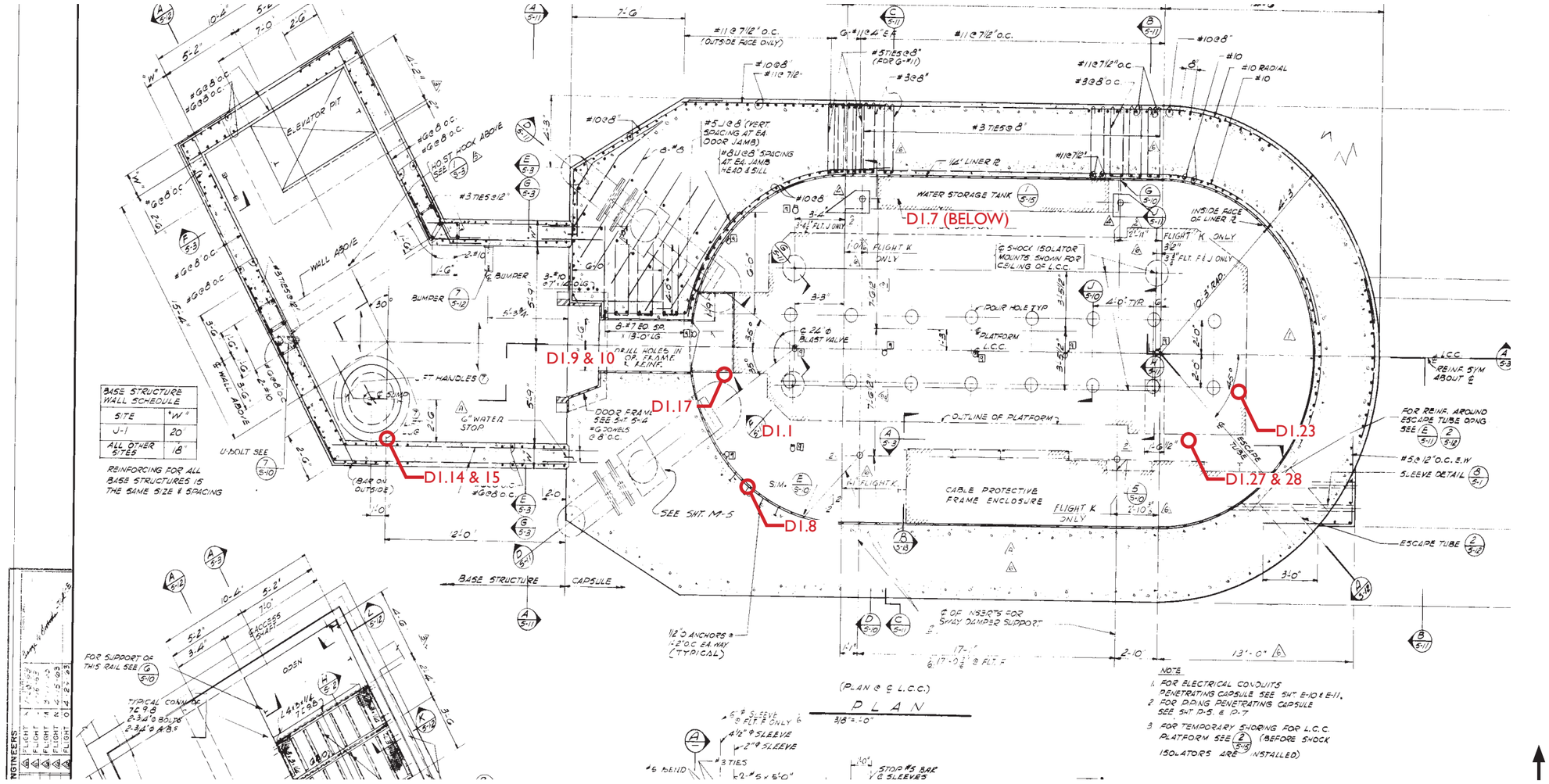
Table 4. Delta-09 Soft Support Building Interior: Color Matches for 1990s Paint Scheme

Elements	Color Match	FED-STD-595C Swatch
D9.24 Lower Wall	*Finish*: very light green *Munsell Color Match*: 5G 7/2 *FED-STD-595C Match*: 26480	
D9.25 Upper Wall	*Finish*: very light green *Munsell Color Match*: 5G 7/2 *FED-STD-595C Match*: 26480	
D9.26 Door	*Finish*: light grayish green *Munsell Color Match*: 10GY 7/1 *FED-STD-595C Match*: 36480	

Appendix A
Sample Location Key

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key

Samples Collected by Building Conservation Associates, Inc. in April, 2024



DELTA-01 PLAN

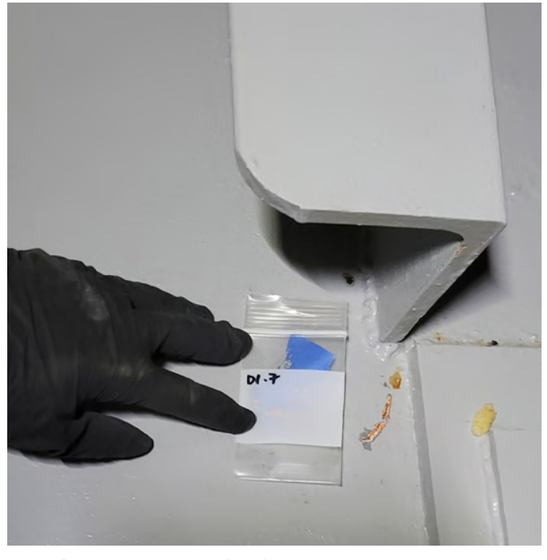
Key

D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key
Samples Collected by Building Conservation Associates, Inc. in April, 2024



D1.1 Railing



D1.7 Capsule lower wall (gray)



D1.8 Capsule upper wall (white)


D1.9 Ramp to blast door


D1.10 Concrete floor



D1.14 Base structure lower wall (blue)



D1.15 Base structure upper wall (white)



D1.17 Capsule door frame

DELTA-01 SAMPLE LOCATION IMAGES

Key

D1.##	**Delta-01 Finishes Sample Number**
D9.##	**Delta-09 Finishes Sample Number**

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key

Samples Collected by Building Conservation Associates, Inc. in April, 2024



D1.23 Control panel



D1.27 Capsule interior wall



D1.28 Capsule interior ceiling

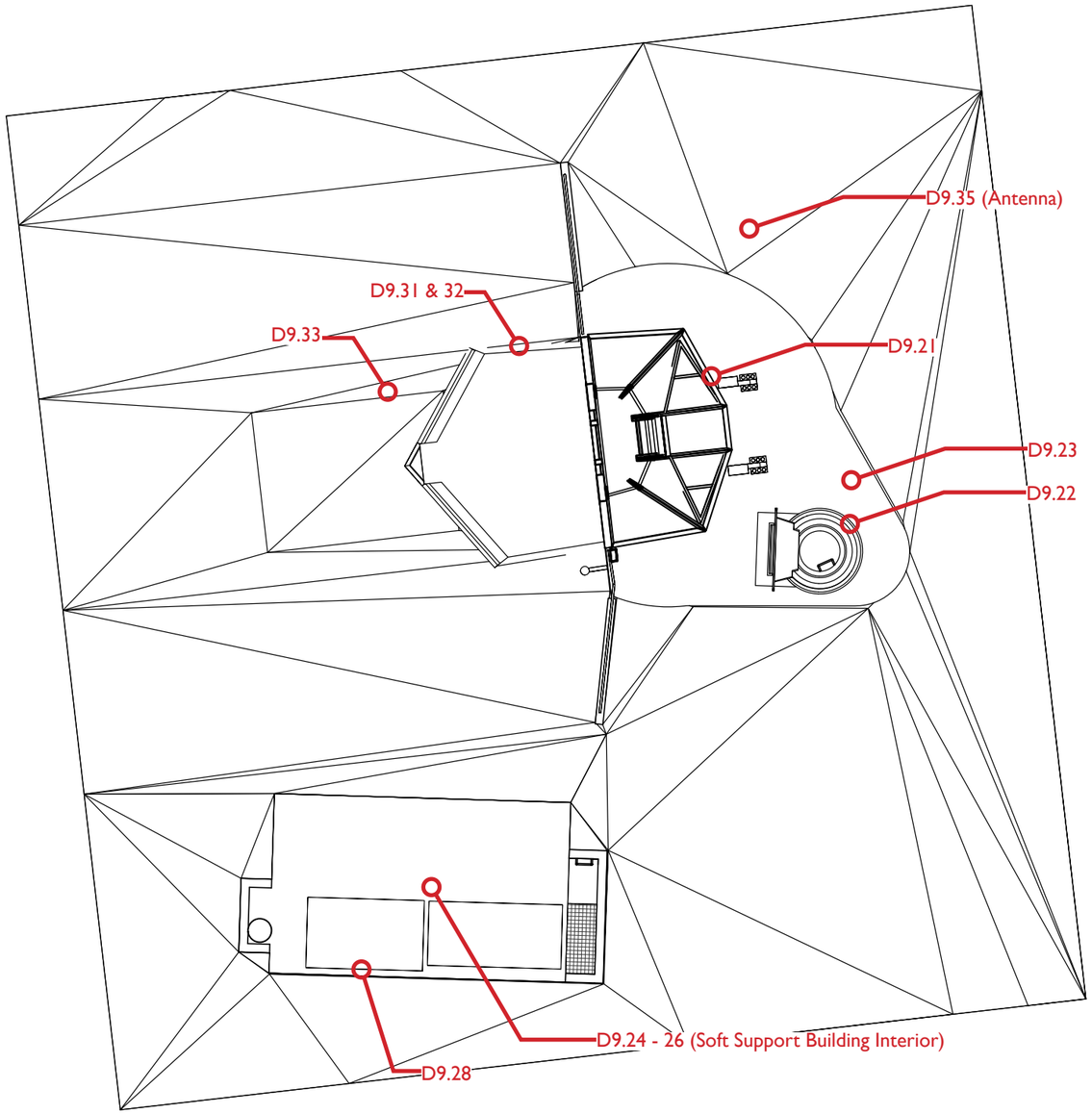
DELTA-01 SAMPLE LOCATION IMAGES

Key

D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key

Samples Collected by Building Conservation Associates, Inc. in April, 2024



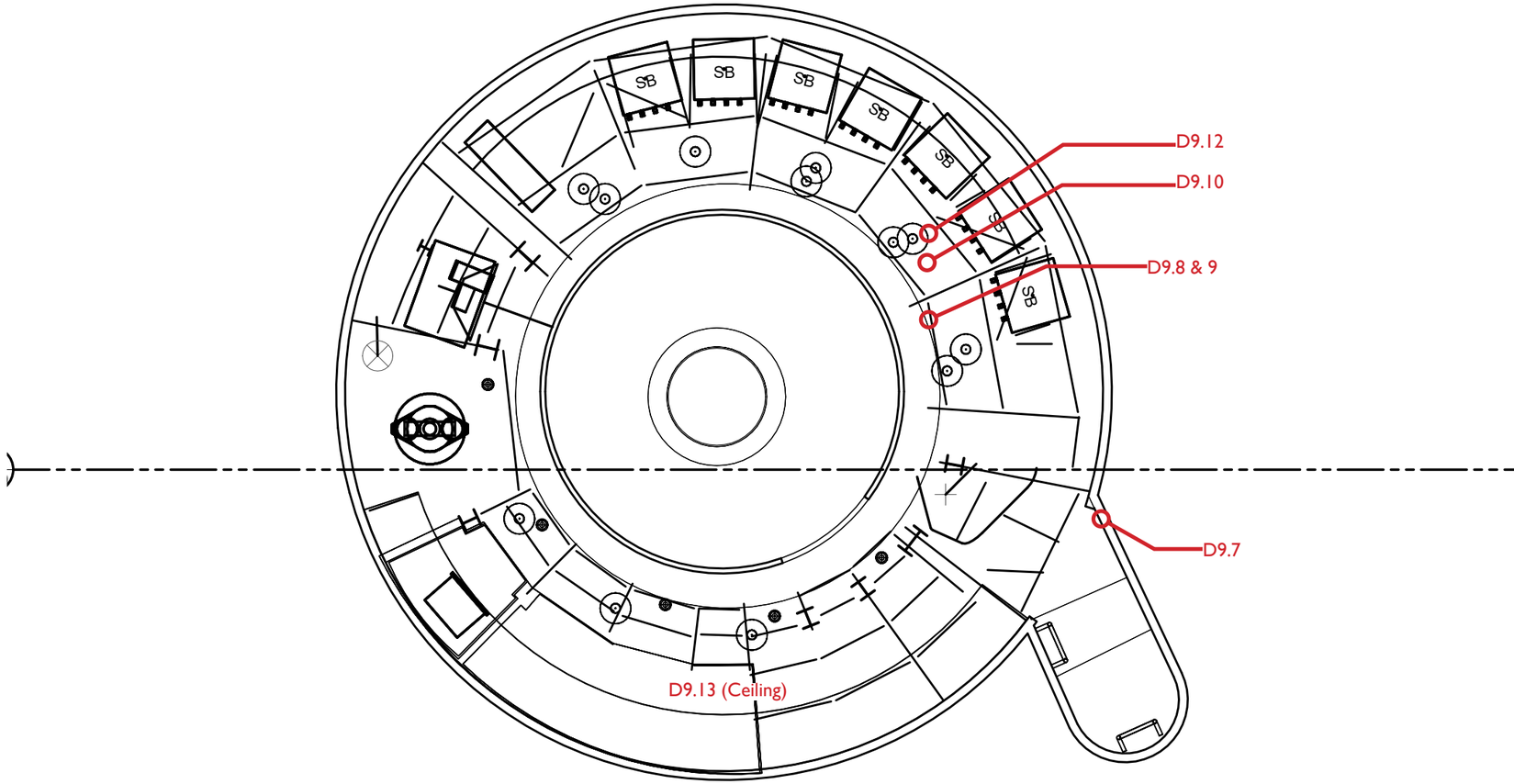
N →

DELTA-09 TOPO GRADE (SEVEN GENERATIONS A + E)

Key	
D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key

Samples Collected by Building Conservation Associates, Inc. in April, 2024



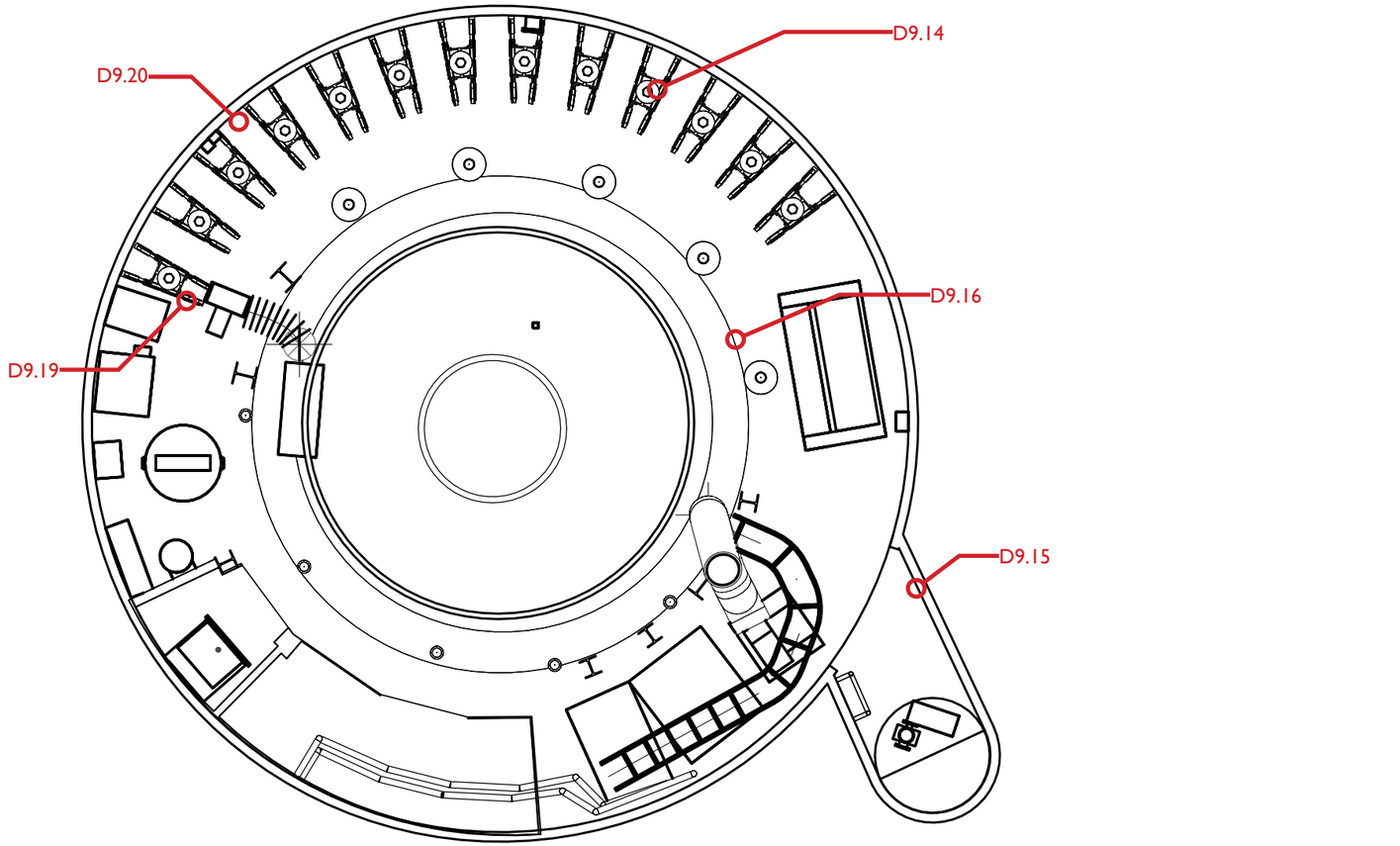
DELTA-09 SUB LEVEL 1 PLAN (SEVEN GENERATIONS A + E)

Key

D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key

Samples Collected by Building Conservation Associates, Inc. in April, 2024

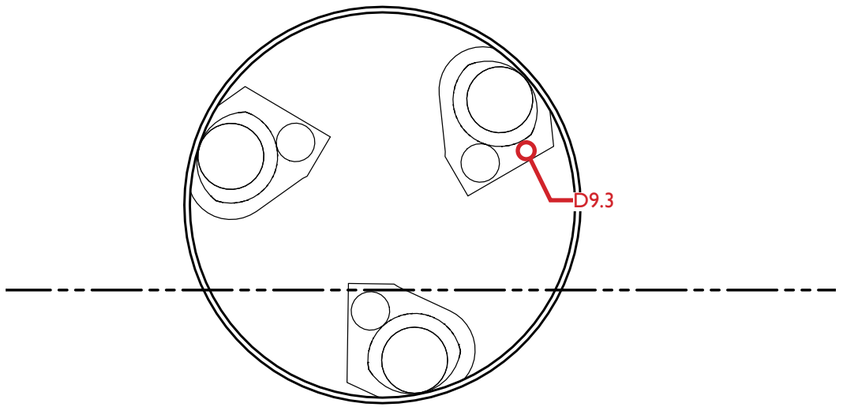


DELTA-09 SUB LEVEL 2 PLAN (SEVEN GENERATIONS A + E)

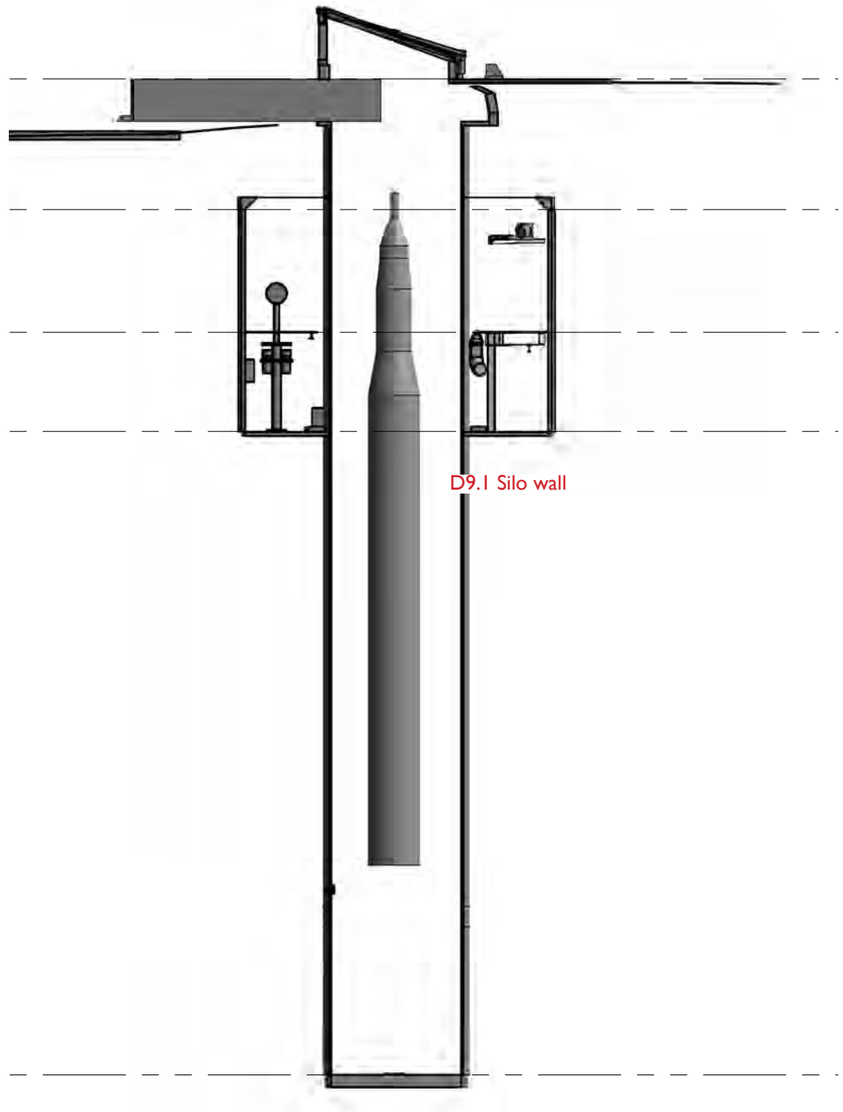
Key	
D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key

Samples Collected by Building Conservation Associates, Inc. in April, 2024



DELTA-09 SUB LEVEL 3 PLAN (SEVEN GENERATIONS A + E)



DELTA-09 SILO SECTION (SEVEN GENERATIONS A + E)

Key

D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key
Samples Collected by Building Conservation Associates, Inc. in April, 2024



D9.1 Silo wall



D9.3 Missile support structure



D9.7 Sub Level 1 wall (light blue/green)



D9.8 Sub Level 1 launch tube (approx. 6')


D9.9 Sub Level 1 launch tube (approx. 4')


D9.10 Sub Level 1 floor


D9.12 Sub Level 1 pole


D9.13 Sub Level 1 ceiling

DELTA-09 SAMPLE LOCATION IMAGES

Key

D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

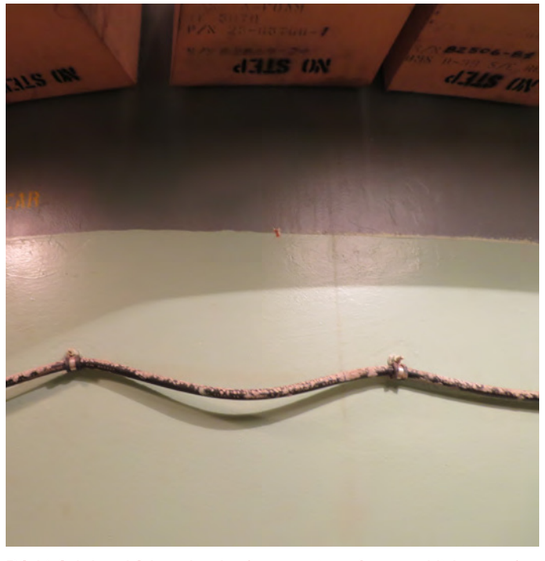
Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key
Samples Collected by Building Conservation Associates, Inc. in April, 2024



D9.14 Sub Level 2 battery frame



D9.15 Sub Level 2 wall (light green)



D9.16 Sub Level 2 launch tube (intersection of gray and light green)



D9.19 Sub Level 2 battery anchor



D9.20 Sub Level 2 floor



D9.21 Exterior viewing enclosure bolt



D9.22 Hatch interior



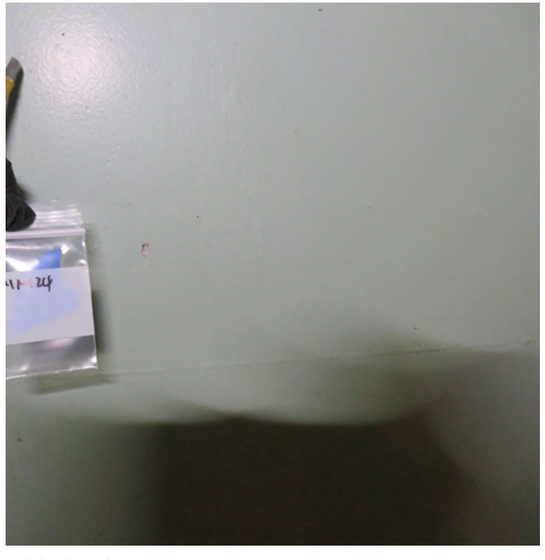
D9.23 Cap

DELTA-09 SAMPLE LOCATION IMAGES

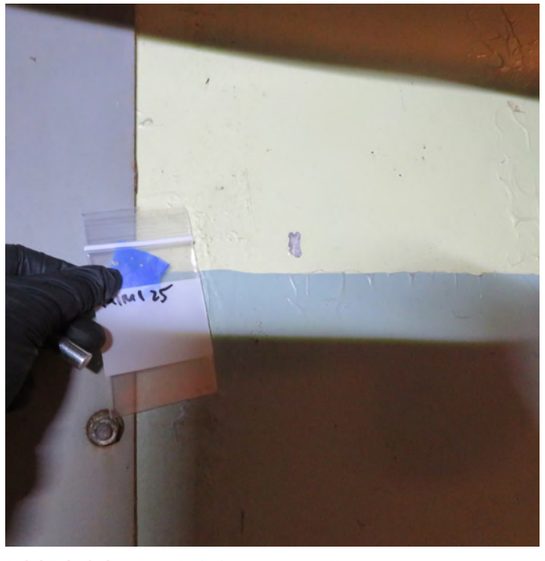
Key

D1.##	Delta-01 Finishes Sample Number
D9.##	Delta-09 Finishes Sample Number

Minuteman Missile National Historic Site - Delta-01 and Delta-09 Paint Analysis: Sample Location Key
Samples Collected by Building Conservation Associates, Inc. in April, 2024



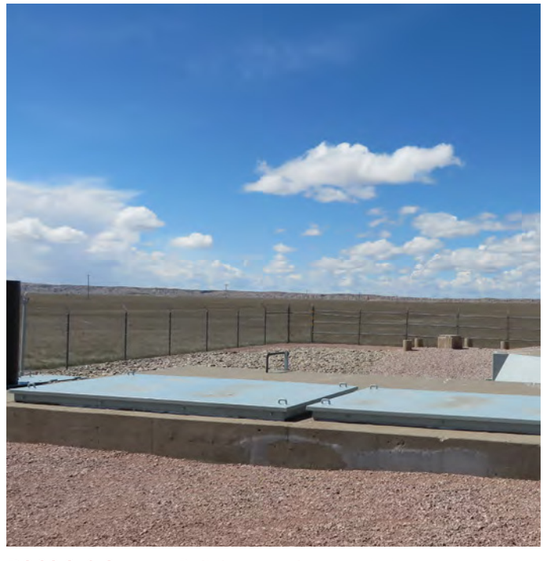
D9.24 Soft Support Building lower wall



D9.25 Soft Support Building upper wall



D9.26 Soft Support Building door



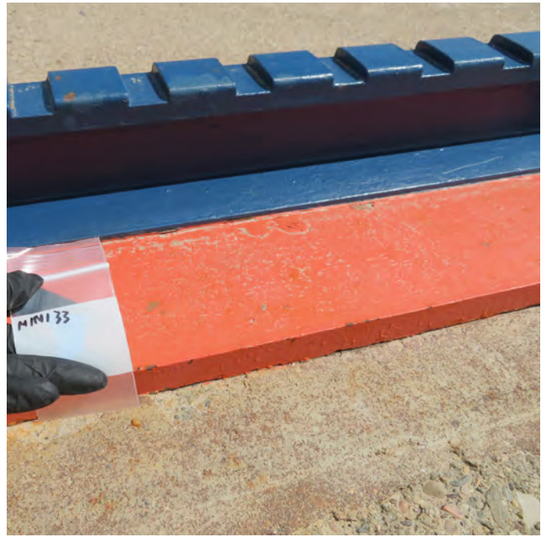
D9.28 Soft Support Building exterior metal plate



D9.31 Closure door wall



D9.32 Closure door base



D9.33 Closure door track (orange)



D9.35 Ultra high frequency antenna base

DELTA-09 SAMPLE LOCATION IMAGES

Key

D1.##	**Delta-01 Finishes Sample Number**
D9.##	**Delta-09 Finishes Sample Number**

Appendix B
Sample Stratigraphy Sheets

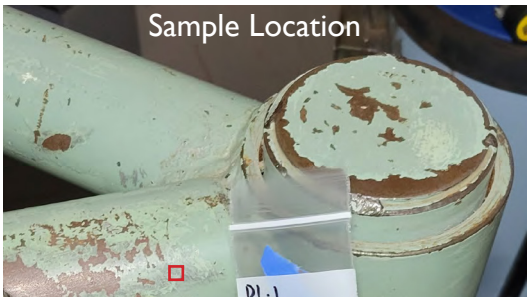
Minuteman Missile National Historic Site

Delta-01 and Delta-09 Paint Analysis

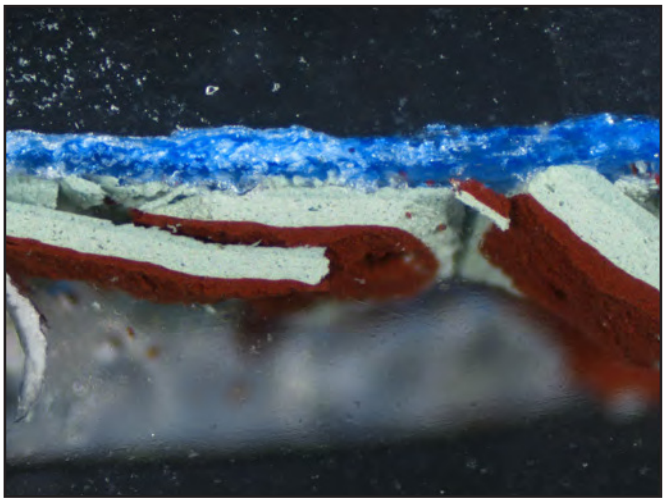
SAMPLE STRATIGRAPHY SHEETS

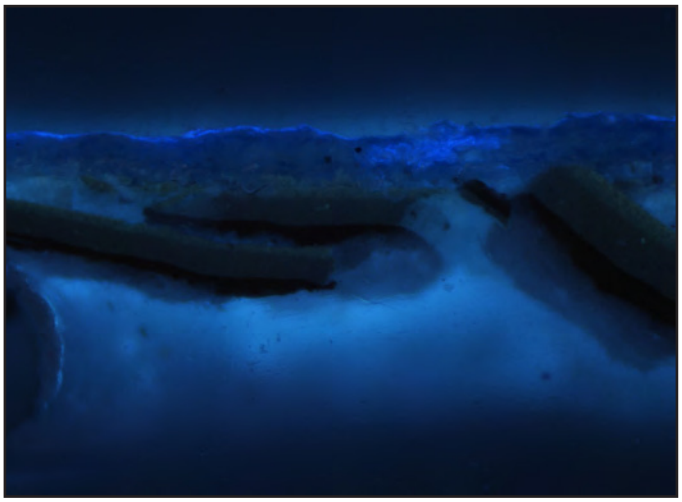


BUILDING NAME: MIMI NHS Delta-01 and Delta-09	
CONSTRUCTION DATE: 1961 - 1962	
TOTAL NUMBER OF SAMPLES: 35	
SUBSTRATE TYPE: Metal, Concrete	
DATE SAMPLED: April 2024	**DATE ANALYZED:** April - June 2024
SAMPLED BY: M. Luo-Hita	**ANALYZED BY:** M. Luo-Hita, D. Krotzer
MICROSCOPE: Nikon Eclipse E200 compound fluorescence microscope	**CAMERA:** Nikon DS-F*i*3
DESCRIPTION: Exterior and interior paint samples removed from Delta-01 and Delta-09.	



SAMPLE #: D1.1	**ROOM:** Delta-01
DESCRIPTION: Railing	





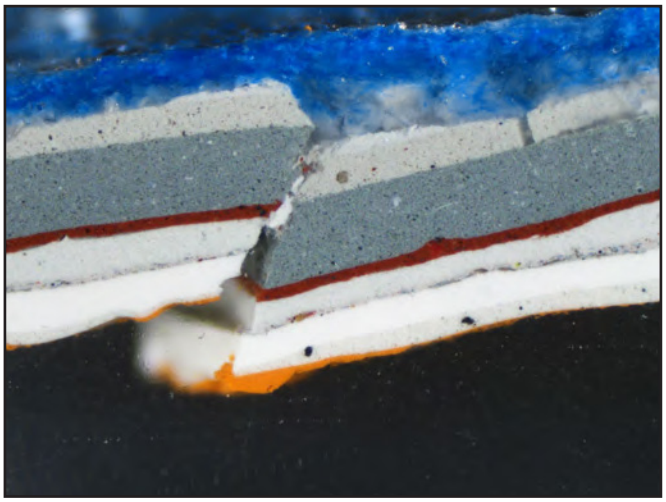
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark reddish brown	N/A		Primer
2	**moderate grayish green**	7.5G 6/2	24241	Original
3	**moderate grayish green**	7.5G 6/2	24241	1990s presentation finish

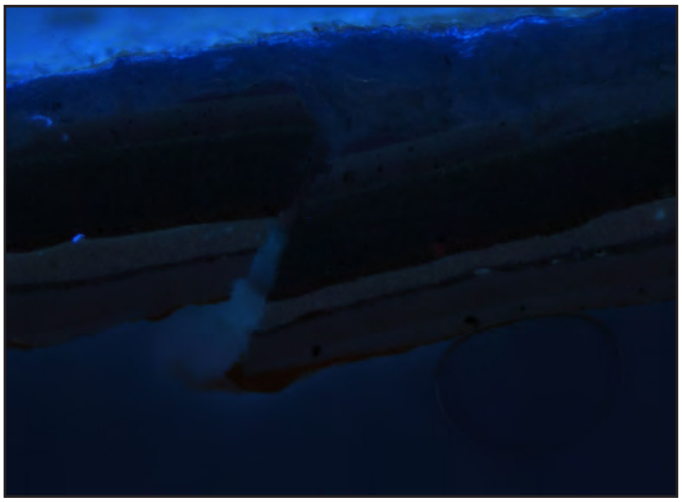
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



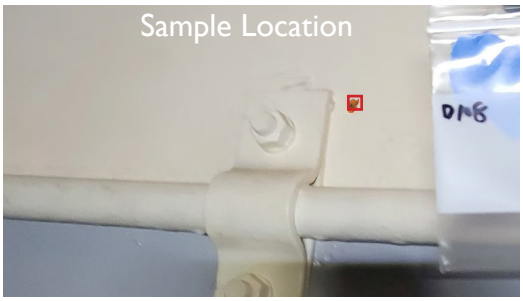
SAMPLE #: D1.7	**ROOM:** Delta-01
DESCRIPTION: Lower capsule wall	



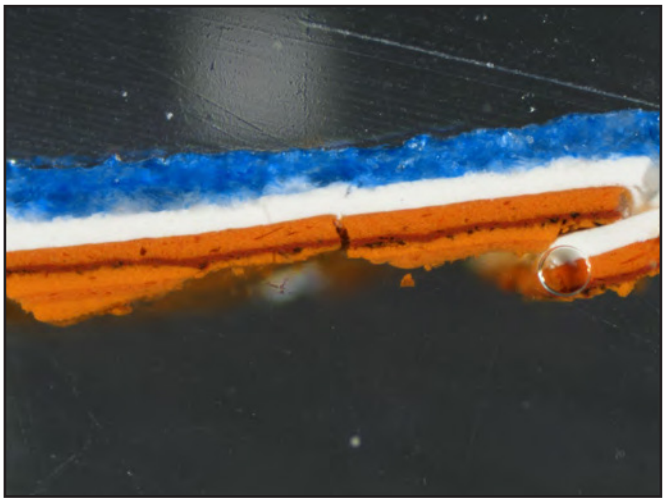


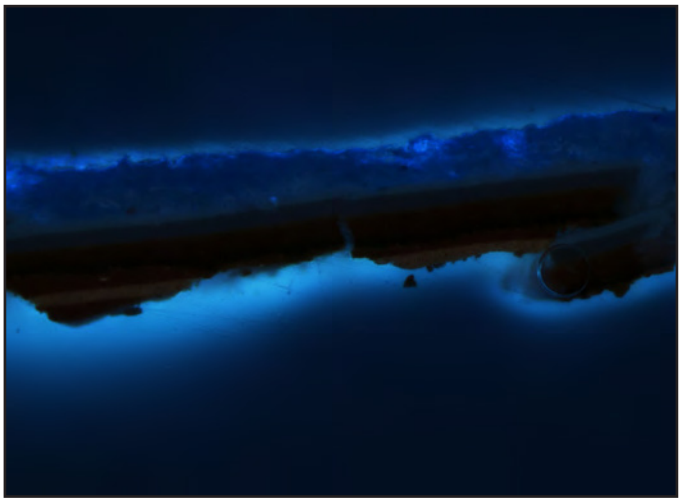
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	bright orange			Primer
2	grayish white			Primer/preparatory layer
3	white			Primer/preparatory layer?
4	**silver**			Original finish
5	dark brownish red			Primer
6	**dark bluish gray**	7.5B 4/2	25189	Potential 1990s presentation finish
7	**light gray**	5Y 6/1	26357	Potential 1990s presentation finish
8	**light bluish gray**			2012 repainting?

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D1.8	**ROOM:** Delta-01
DESCRIPTION: Upper capsule wall	

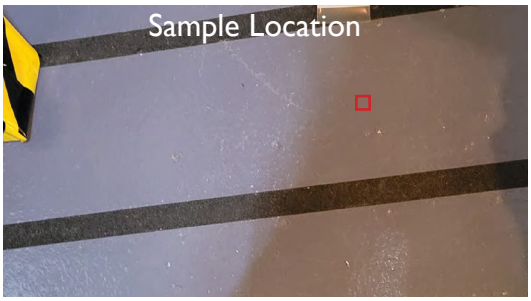




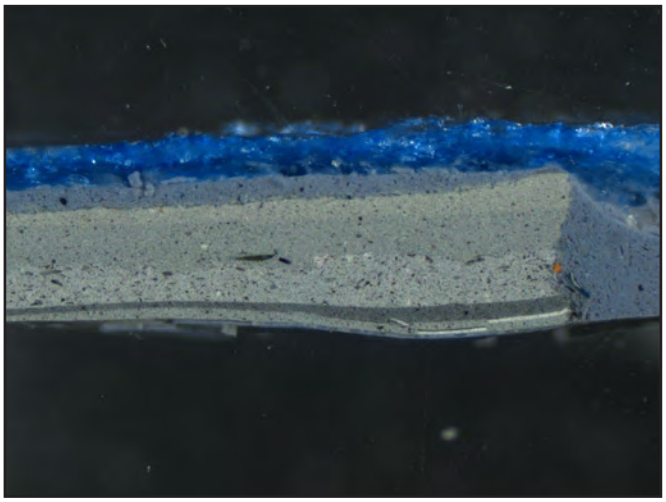
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	bright orange			
2	bright orange			
3	bright orange			
4	dark brownish red			
5	**white**	5Y 9/1	17886	Original

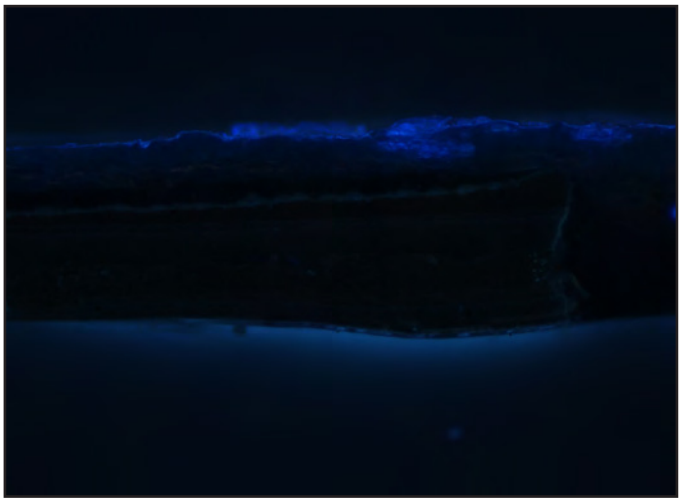
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



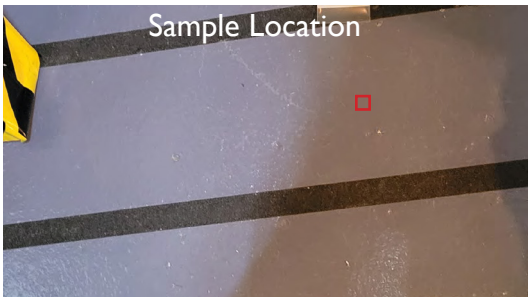
SAMPLE #: D1.9	**ROOM:** Delta-01
DESCRIPTION: Ramp to blast door (left side of sample)	



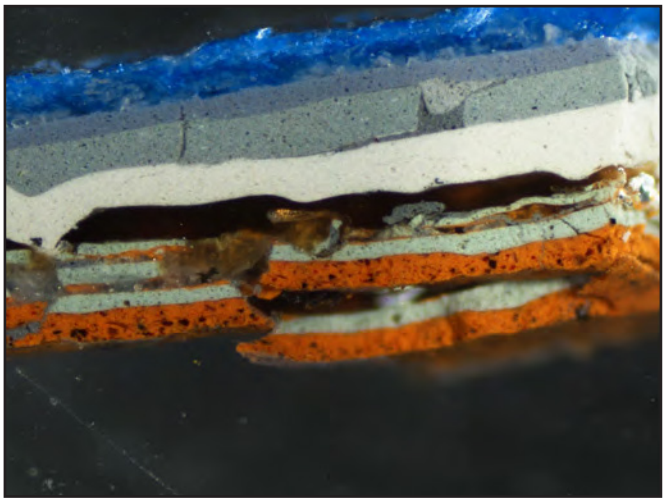


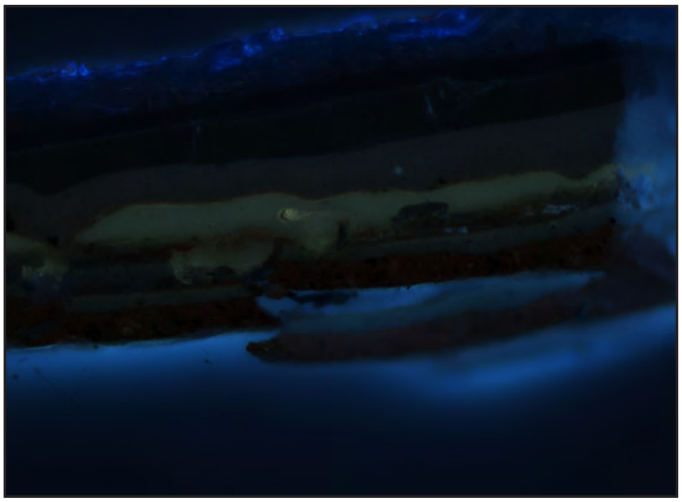
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
				See next page for earliest layers
4	grayish white			
5	**dark gray**	5B 5/2	26118	Potential 1990s presentation finish
6	gray			
7	**bluish yellowish gray**	7.5B 5/2	35189	Potential 1990s presentation finish
8	bluish gray			Primer or patch
9	yellowish gray			Primer or patch
10	**dark yellowish gray**	N 3.75	26152	Pre-2012
11	**dark bluish gray**		35164	2013?

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D1.9	**ROOM:** Delta-01
DESCRIPTION: Ramp to blast door (right side of sample)	

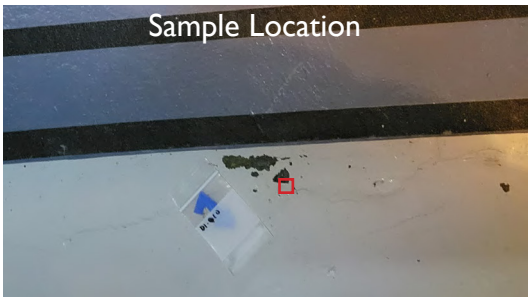




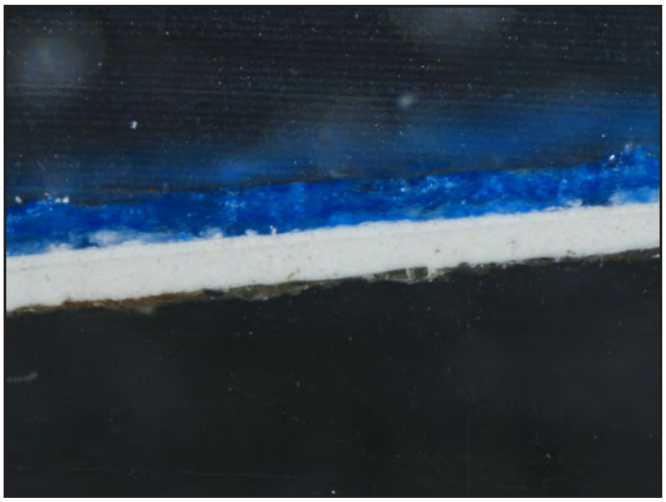
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate				
1	dark orangish red			
2	moderate grayish green			
3	**translucent yellowish brown**			
4	grayish white			
5	**dark gray**	5B 5/2	26118	Potential 1990s presentation finish
6	gray			
7	**bluish yellowish gray**	7.5B 5/2	35189	Not captured in this cross-section, see previous page.
8	bluish gray			primer or patch
9	yellowish gray			primer or patch
10	**dark yellowish gray**	N 3.75	26152	Pre-2012
11	**dark bluish gray**		35164	2013?

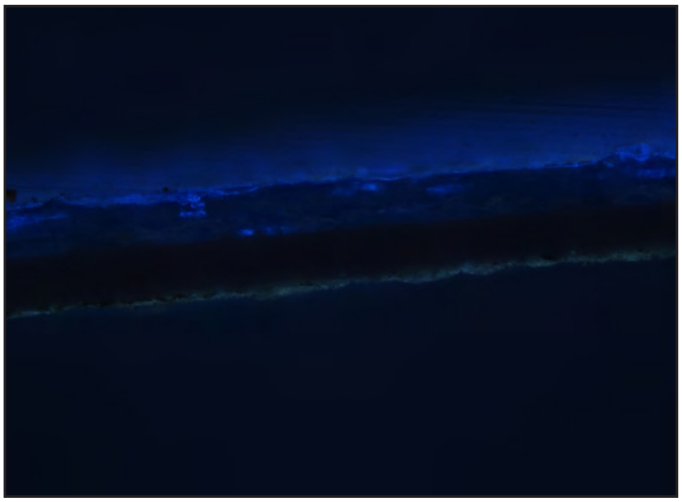
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



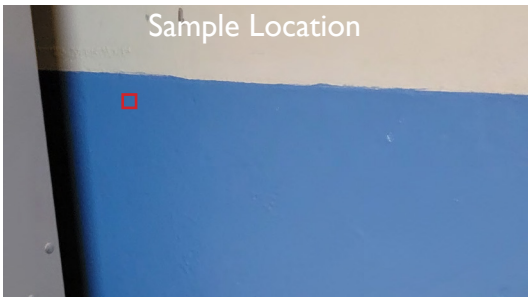
SAMPLE #: D1.10	**ROOM:** Delta-01
DESCRIPTION: Concrete floor	



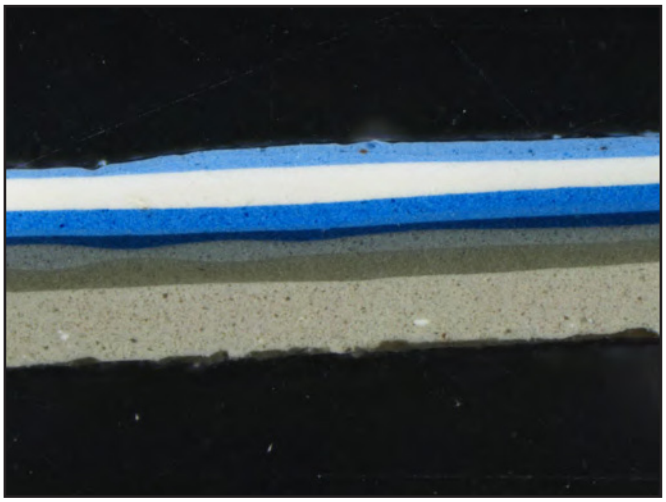


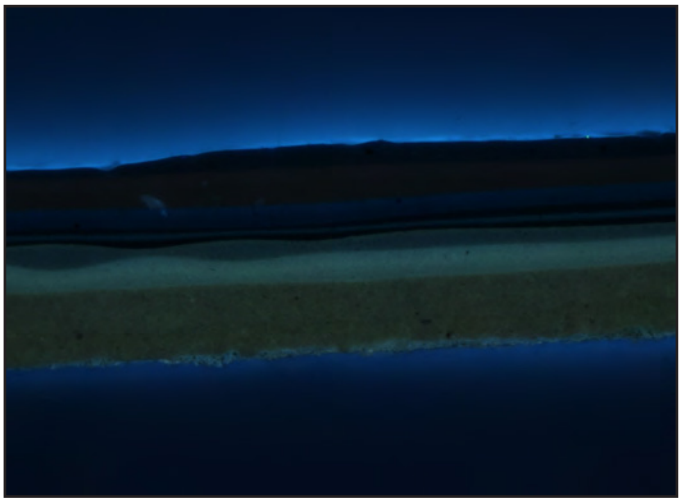
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Concrete			
1	Transparent			Sealer or primer
2	grayish white			2012 primer?
3	**grayish white**	N7.75	16515	2012

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D1.14	**ROOM:** Delta-01
DESCRIPTION: Lower wall in base structure	





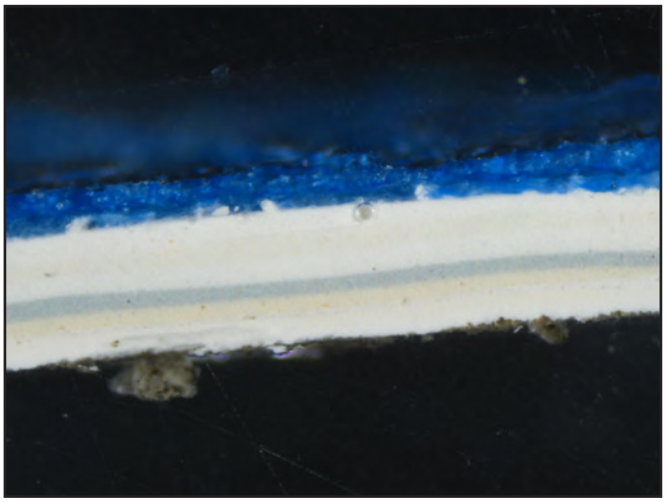
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Concrete			
1	transparent			Coating/sealant
2	**yellowish gray**			Original
3	**moderate greenish gray**			
4	**moderate bluish gray**			
5	**deep blue**			
6	**vivid blue**			C.1982
7	white			
8	**light blue**	10B 5/8	35250	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D1.15	**ROOM:** Delta-01
DESCRIPTION: Upper wall in base structure	



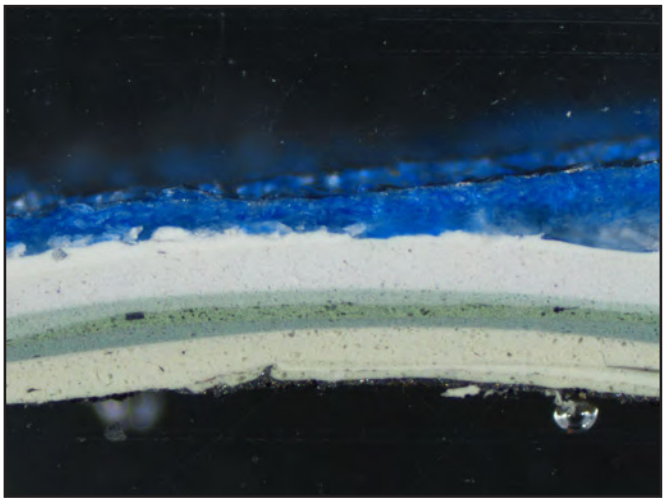


LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Concrete			
1	transparent			Coating/sealant
2	**pale yellow**			Original
3	**light blue**			
4	white			
5	**yellowish white**			C.1982
6	**white**	10Y 9/1	17886	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D1.17	**ROOM:** Delta-01
DESCRIPTION: Door frame	





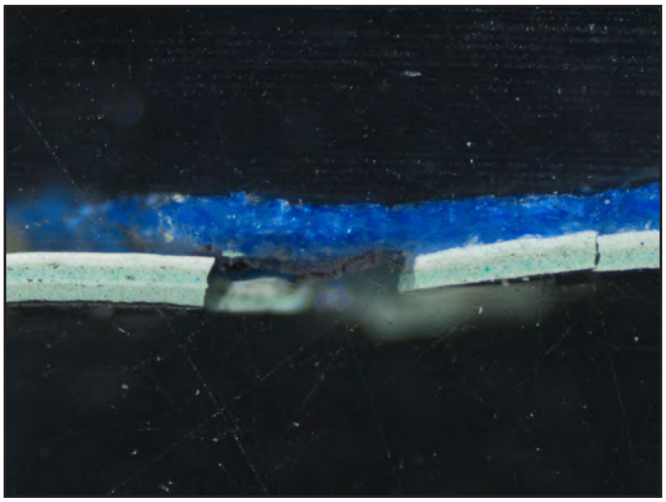
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	**pale green**			Original
2	pale green			
3	**moderate grayish blue**			
4	**moderate yellow green**			
5	**very pale blue**			
6	grayish white			
7	**yellowish white**	5Y 9/1	17886	1990s presentation finish

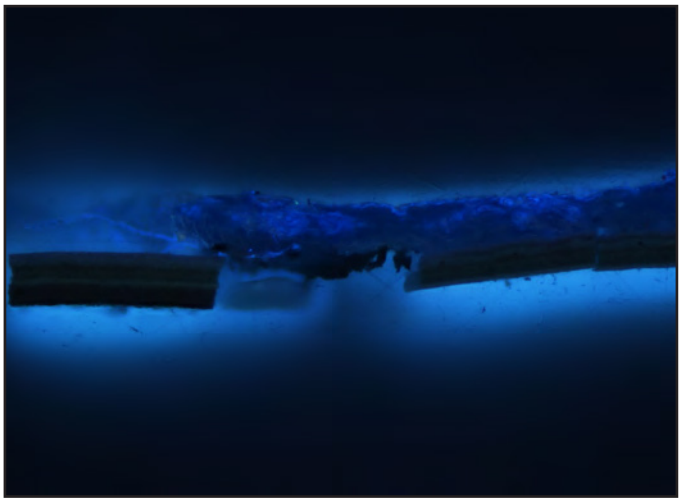
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



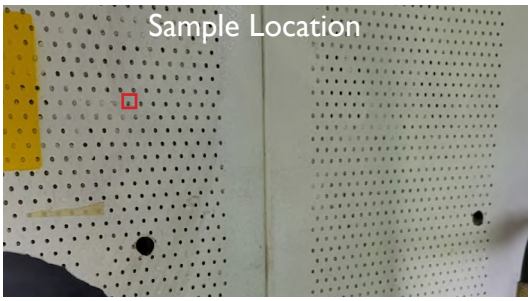
SAMPLE #: D1.23	**ROOM:** Delta-01
DESCRIPTION: Control panel	



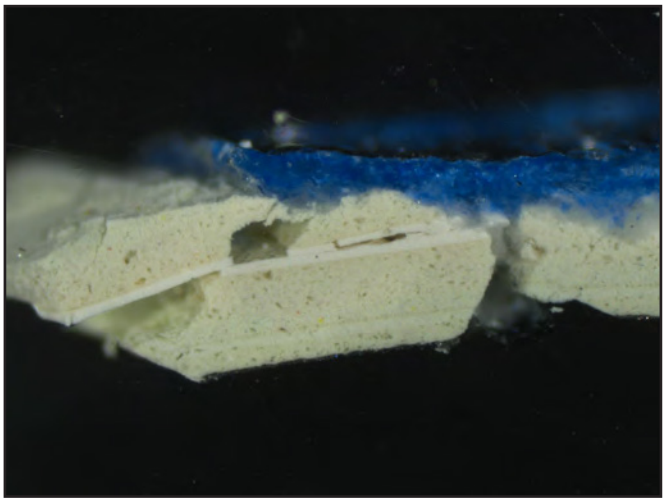


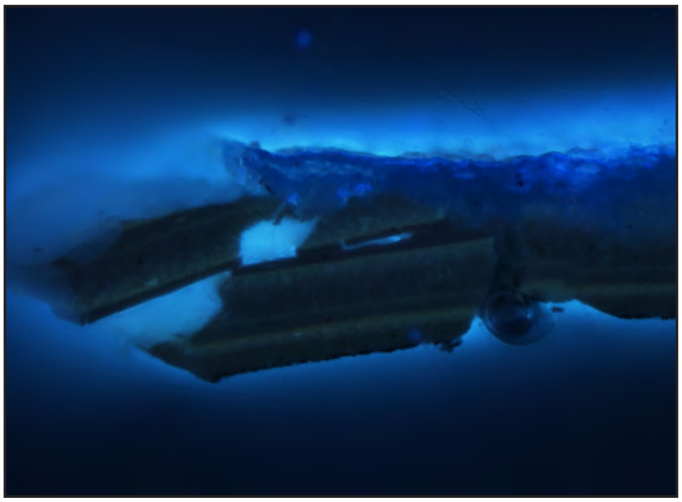
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	medium gray			Primer?
2	**pale green**			Original
3	white			
4	light blueish green			
5	grayish white			
6	**grayish greenish white**	5GY 9/1	17875	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D1.27	**ROOM:** Delta-01
DESCRIPTION: Acoustical enclosure wall	





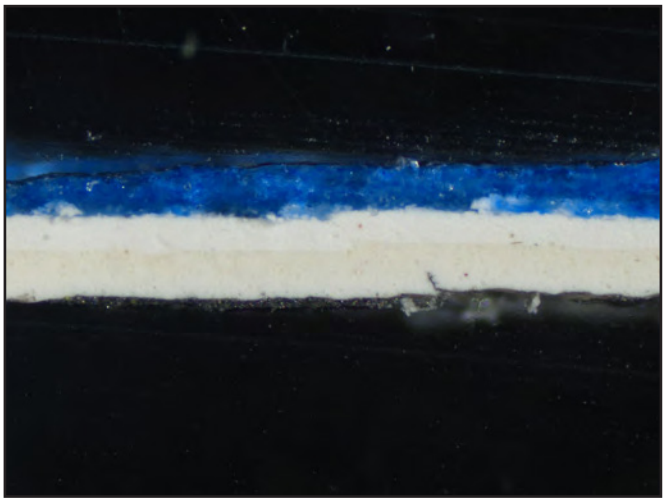
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	pale green			
2	**pale green**			Original
3	pale green			
4	pale green			
5	**yellowish white**	5Y 9/1	17886	1990s presentation finish

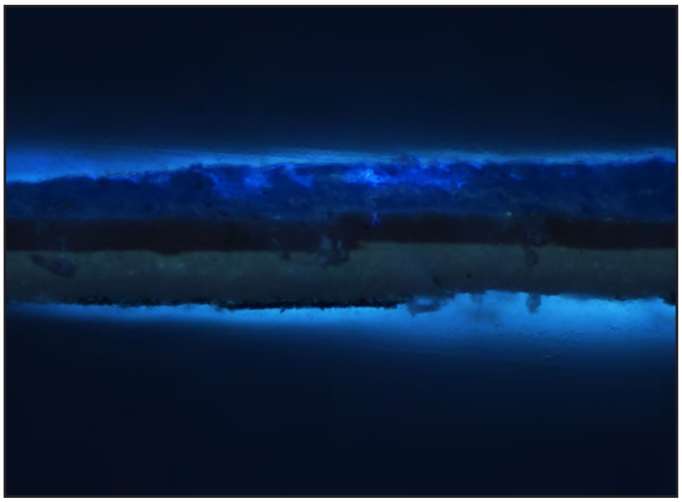
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D1.28	**ROOM:** Delta-01
DESCRIPTION: Acoustical enclosure ceiling	



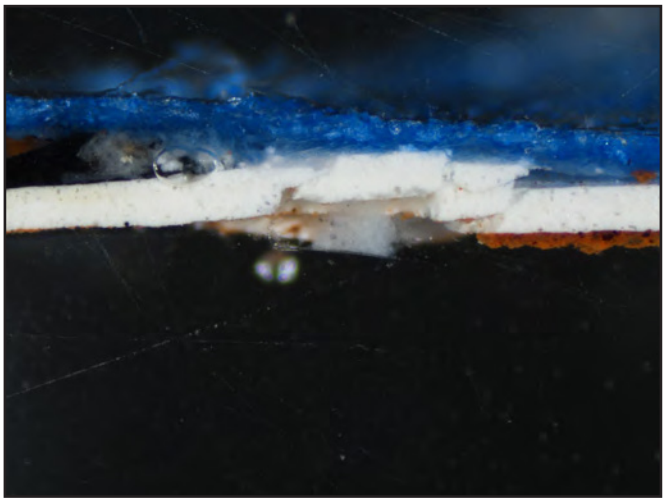


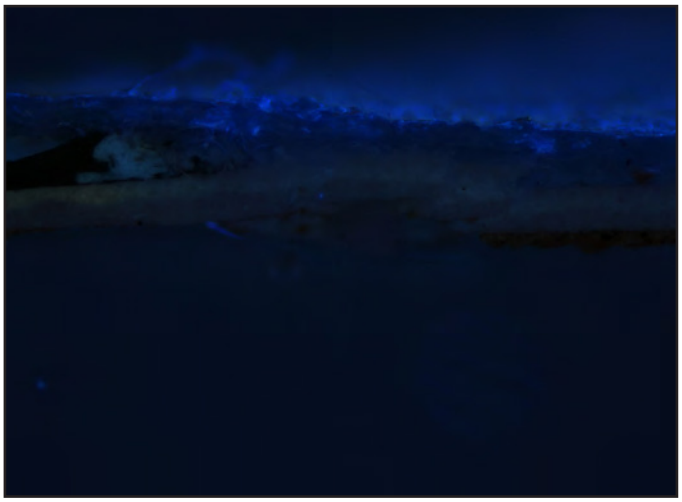
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	yellowish white			
2	**yellowish white**			Original
3	**yellowish white**	5Y 9/1	17886	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.1	**ROOM:** Delta-09
DESCRIPTION: Silo wall	





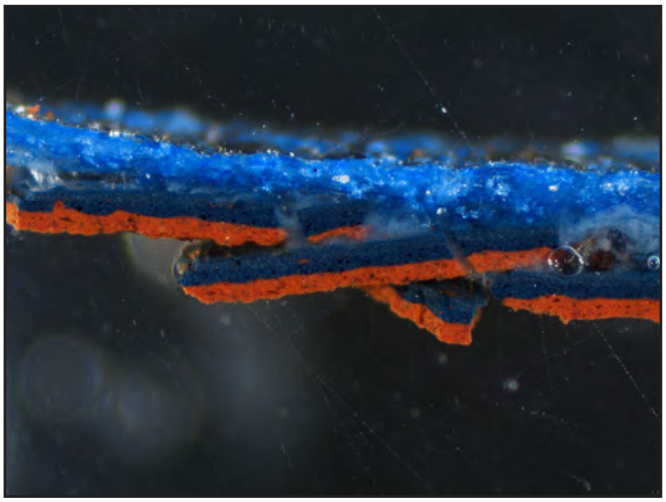
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark orangish red			Primer
2	**bright white**	N9.5	27885	Original white presentation finish
3	**black**	N0.5	27041	Original black presentation finish

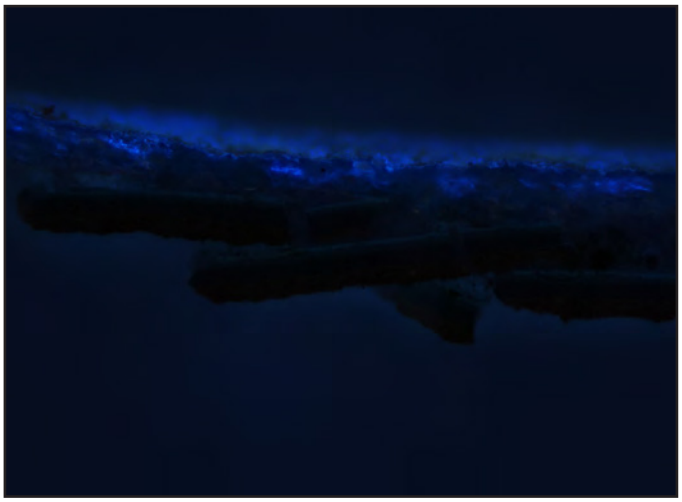
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.3	**ROOM:** Delta-09
DESCRIPTION: Missile support structure	



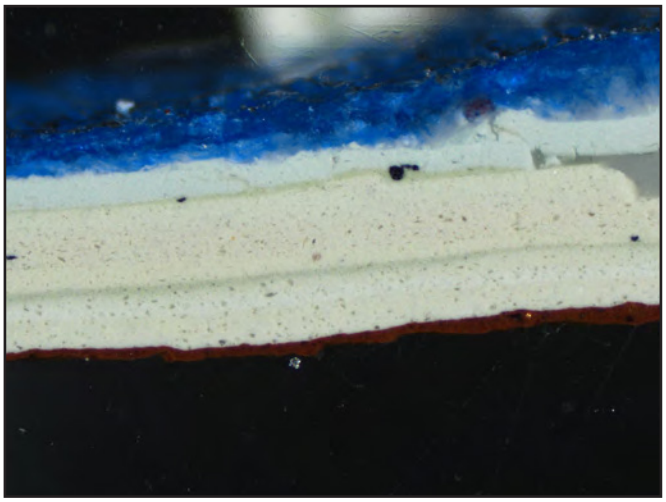


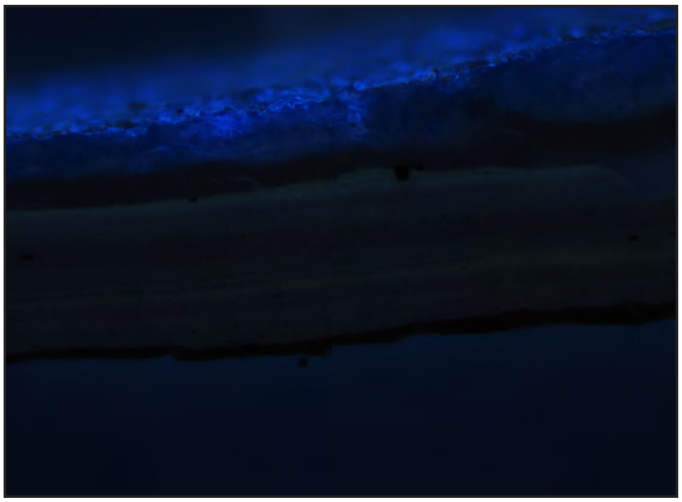
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark orangish red			Primer
2	**dark grayish blue**			Original
3	**dark grayish blue**	10B 2/4	25045	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.7	**ROOM:** Delta-09
DESCRIPTION: Sub Level 1 wall	

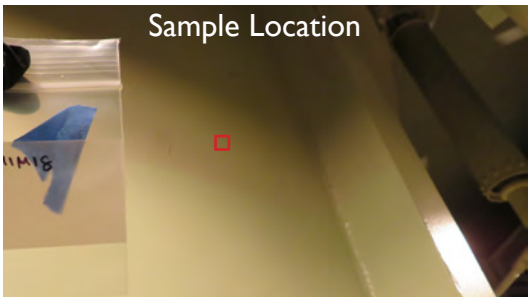




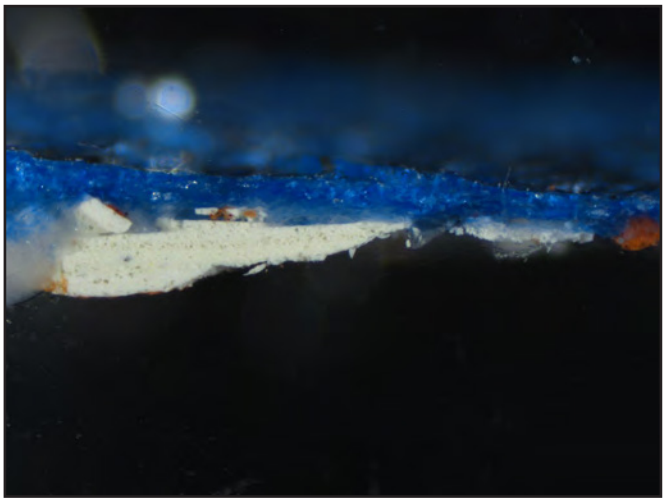
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark yellowish brown			
2	pale green			Original
3	very pale green			
4	**pale green**			
5	light bluish green			
6	pale green			
7	**moderate yellow green**	5GY 7/2 - 7/4	14533	1990s presentation finish
8	**very pale greenish blue**			2006

// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.8	**ROOM:** Delta-09
DESCRIPTION: Sub Level 1 launch tube at 6’	



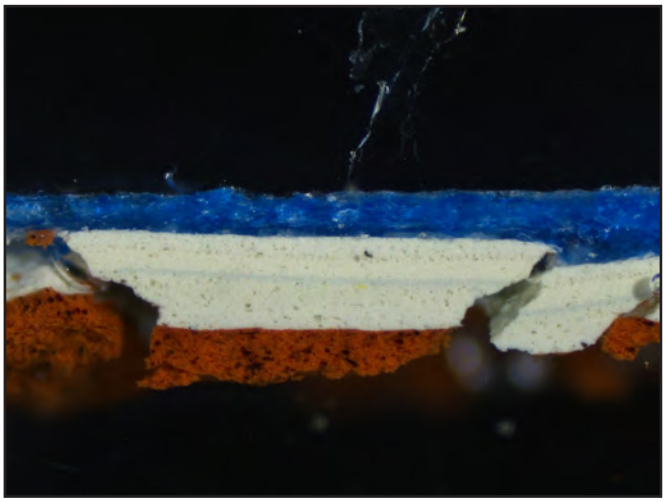


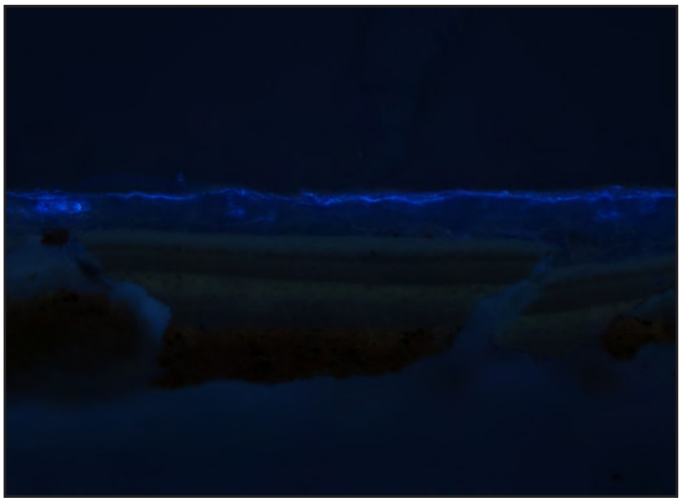
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark orangish red			
2	**pale green**			
3	**pale green**	7.5GY 9/2	24672	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.9	**ROOM:** Delta-09
DESCRIPTION: Sub Level 1 launch tube	

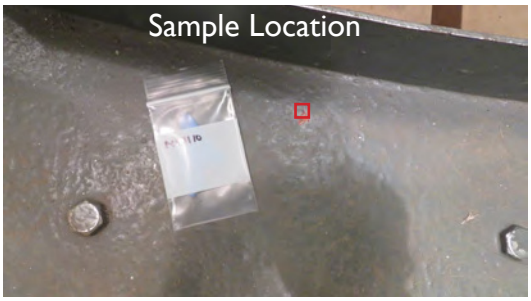




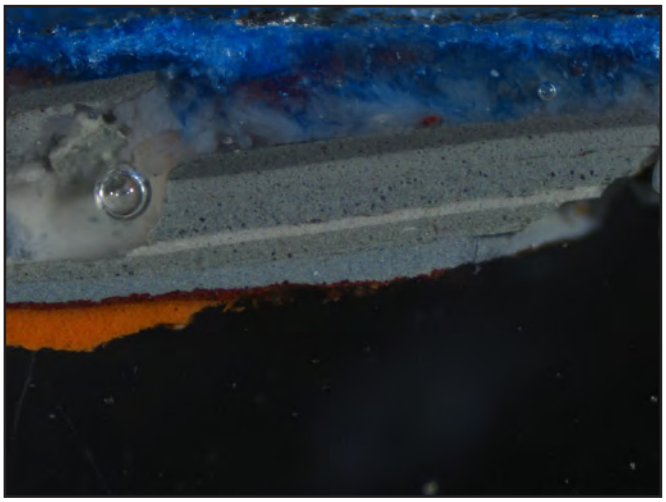
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark yellowish brown			
2	**pale green**			
3	pale green			
4	**light bluish green**			
5	**pale green**			
6	**pale green (current)**	7.5GY 9/2	24672	1990s presentation finish

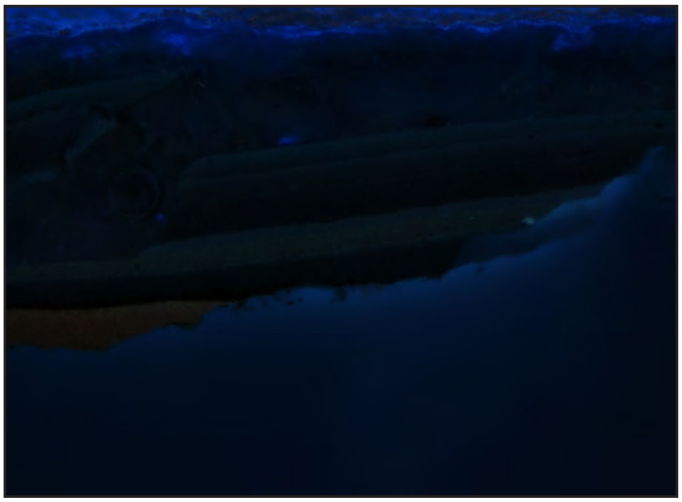
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.10	**ROOM:** Delta-09
DESCRIPTION: Sub Level 1 floor	



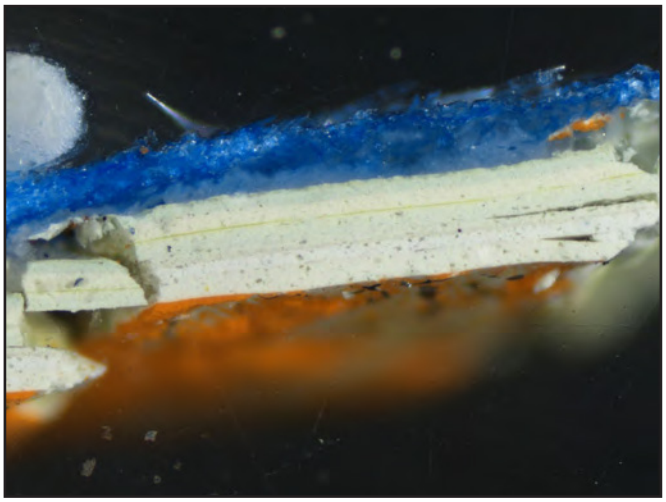


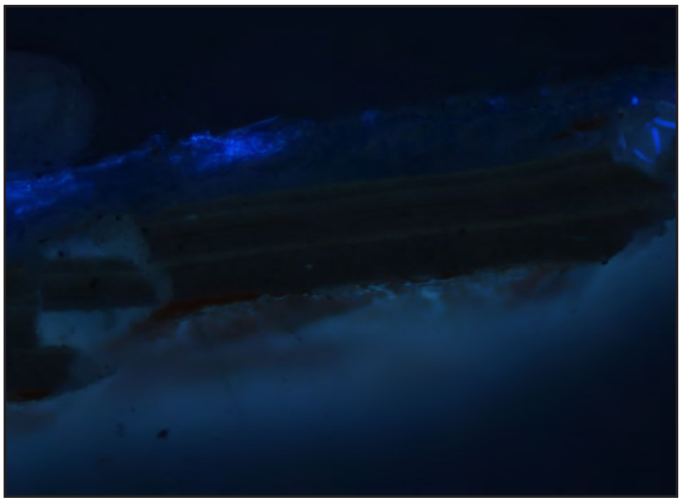
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	vivid orange			Primer
2	dark grayish reddish brown			Primer
3	**grayish blue**			Original
4	grayish green			
5	light bluish gray			
6	**grayish blue**			
7	grayish blue			
8	**dark blue gray**	5B 4/1	26152	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.12	**ROOM:** Delta-09
DESCRIPTION: Sub Level 1 Pole	





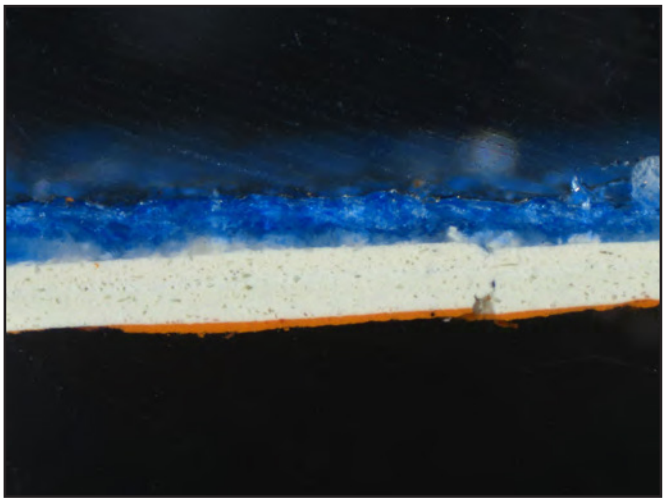
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	vivid orange			Primer
2	**pale bluish green**			Original
3	pale bluish green			
4	pale green			
5	pale green			
6	**brillant yellow green**			
7	pale green			
8	**very light bluish green**			
9	**moderate yellow green**	5GY 7/2 - 7/4	14533	1990s presentation finish

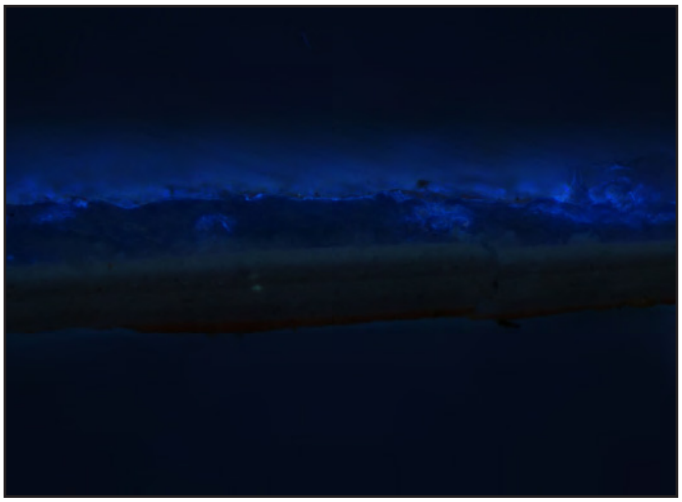
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.13	**ROOM:** Delta-09
DESCRIPTION: Sub Level 1 ceiling	



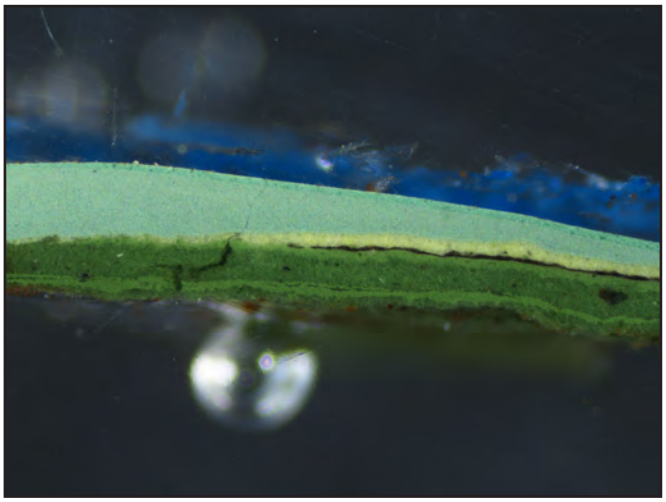


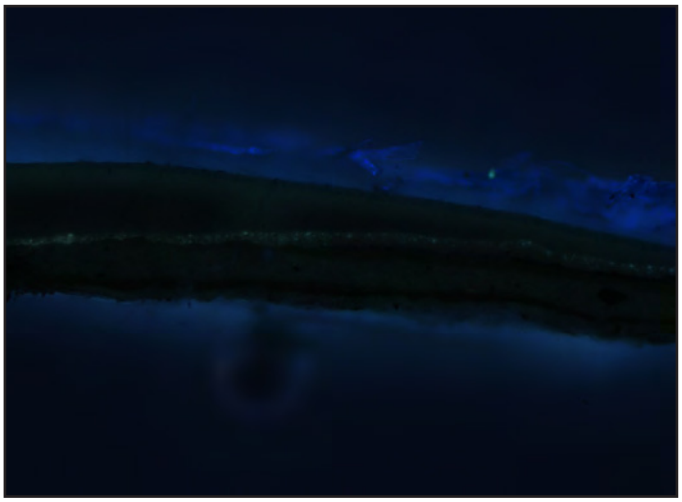
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	vivid orange			Primer
2	**very pale green**			Original
3	very pale green			
4	**very pale yellow green**	10Y 9/2	24554	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.14	**ROOM:** Delta-09
DESCRIPTION: Sub Level 2 battery frame	

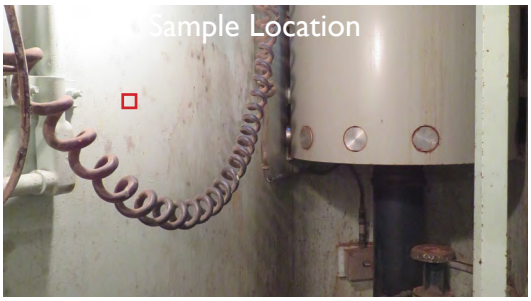




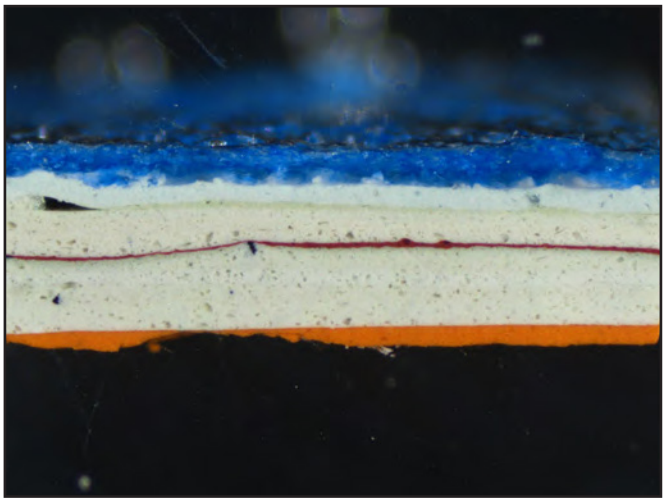
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark reddish brown			Primer
2	deep yellowish green			
3	**deep yellowish green**			Original
4	deep yellowish green			
5	deep yellowish green			
6	dark grayish green			
7	vivid yellow green			
8	very light bluish green			
9	**moderate yellowish green**	7.5G 5/6 - 6/6	14260	1990s presentation finish

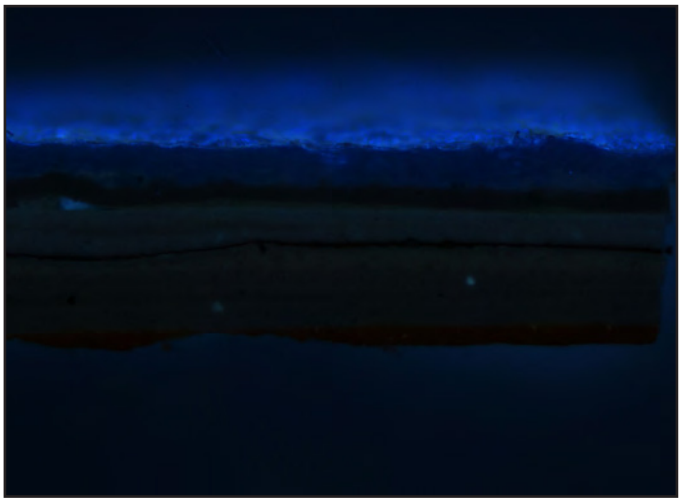
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



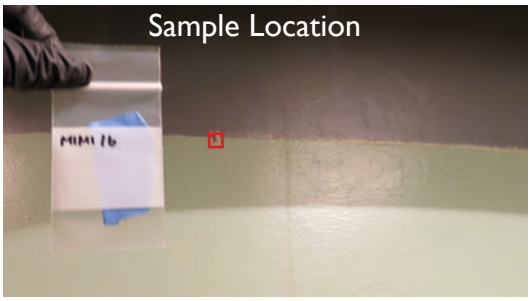
SAMPLE #: D9.15	**ROOM:** Delta-09
DESCRIPTION: Sub Level 2 wall	



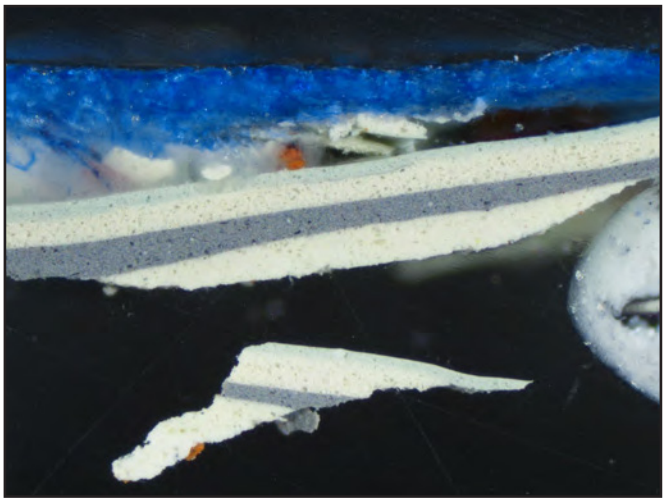


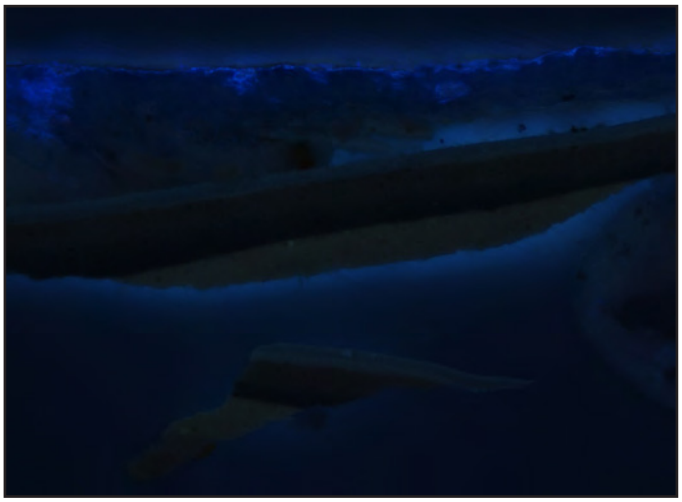
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	vivid orange			
2	**pale green**			
3	pale green			
4	deep reddish brown			
5	pale green			
6	pale green			
7	**moderate yellow green**	5GY 7/2 - 7/4	14533	1990s presentation finish
8	**very pale greenish blue**			

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.16	**ROOM:** Delta-09
DESCRIPTION: Sub Level 2 launch tube	





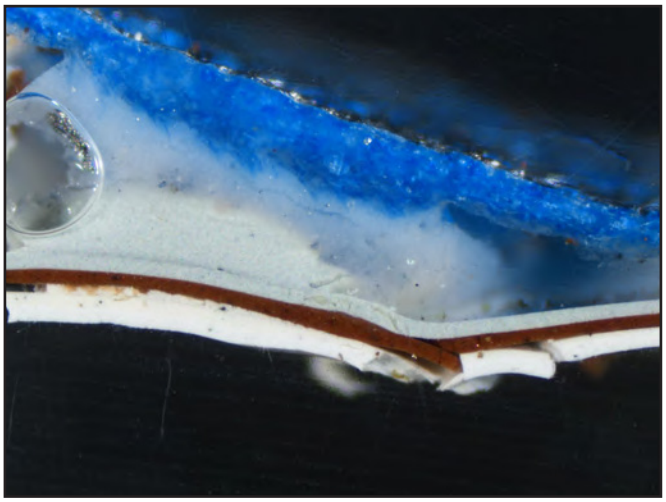
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark reddish brown			Primer
2	**pale bluish green**			Original
3	pale green			
4	**bluish gray**	2.5PB 5/2	26173	1990s gray presentation finish
5	pale yellowish green			
6	pale bluish green			
7	pale green			
8	**very light bluish green**	7.5G 7/2	34410	1990s green presentation finish

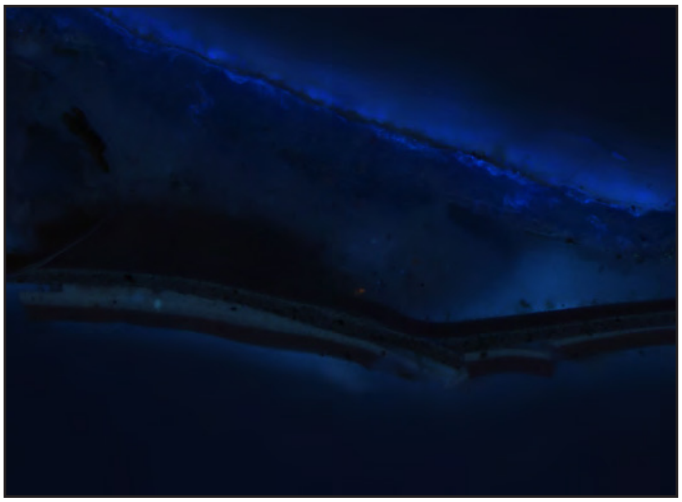
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.19	**ROOM:** Delta-09
DESCRIPTION: Sub Level 2 battery anchor	



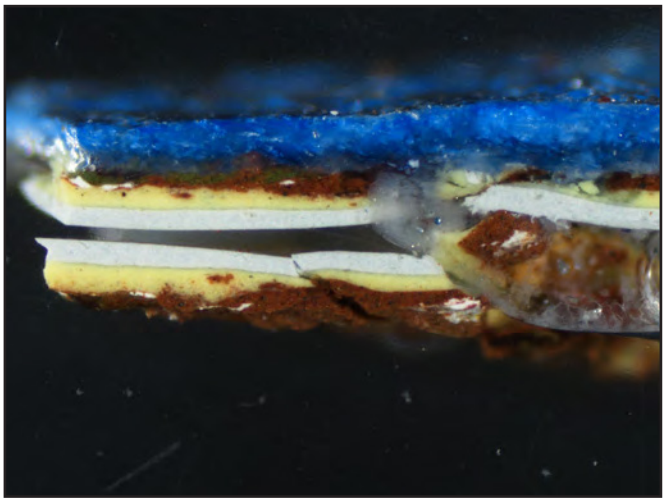


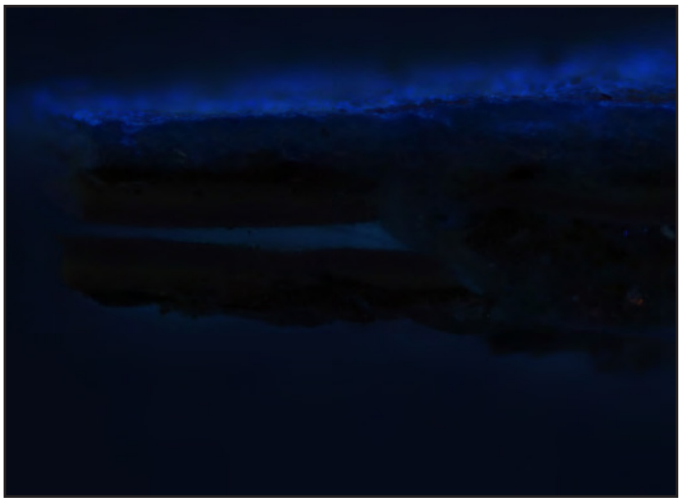
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	bright white			
2	**bright white**			Original
3	strong brown			Primer?
4	**light greenish bluish gray**	10BG 7/2	25530	1990s presentation finish

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.20	**ROOM:** Delta-09
DESCRIPTION: Sub Level 2 floor	





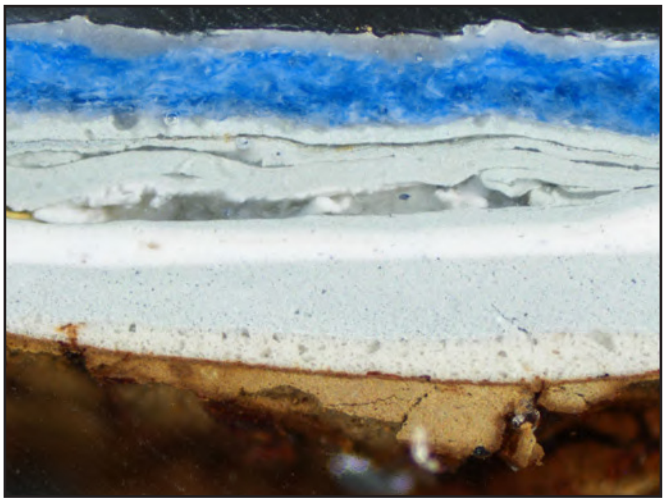
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark reddish brown			Primer
2	**light vivid yellow green**			Original
3	**light greenish bluish gray**	10BG 7/2	25530	1990s presentation finish

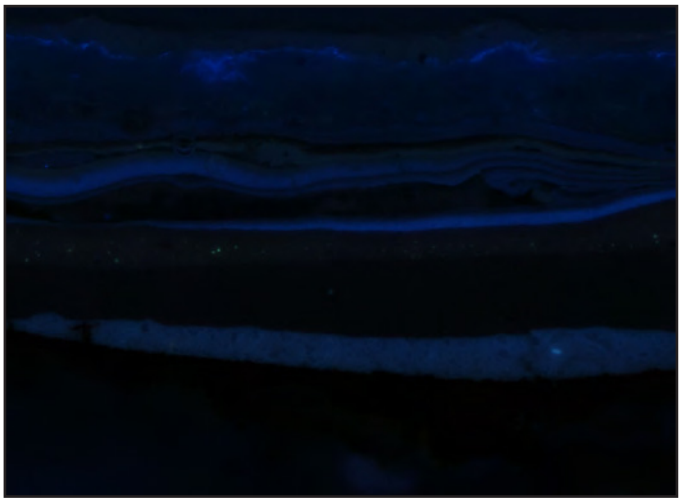
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.21	**ROOM:** Delta-09
DESCRIPTION: Viewing enclosure bolt	



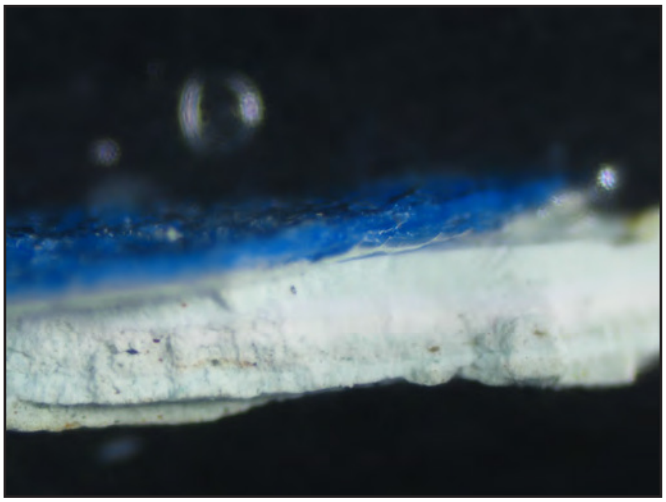


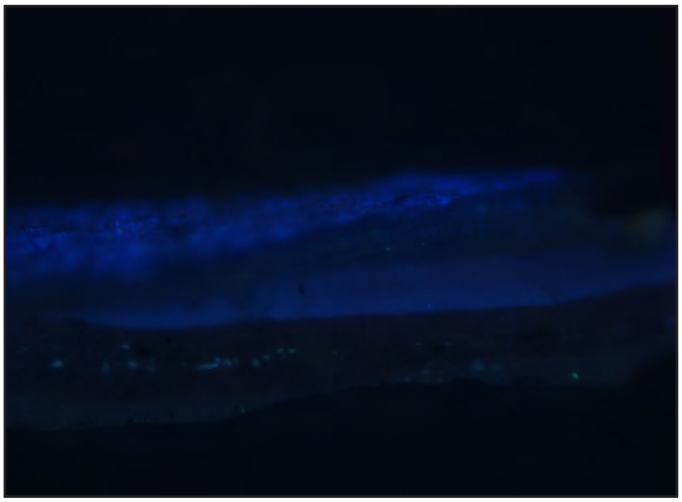
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark brown			
2	light yellow brown			
3	**yellowish gray**	N6.25	26373	2001 original finish
4	pale blue			
5	white			
6	pale blue			
7	**pale blue**			

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.22	**ROOM:** Delta-09
DESCRIPTION: Access hatch interior	





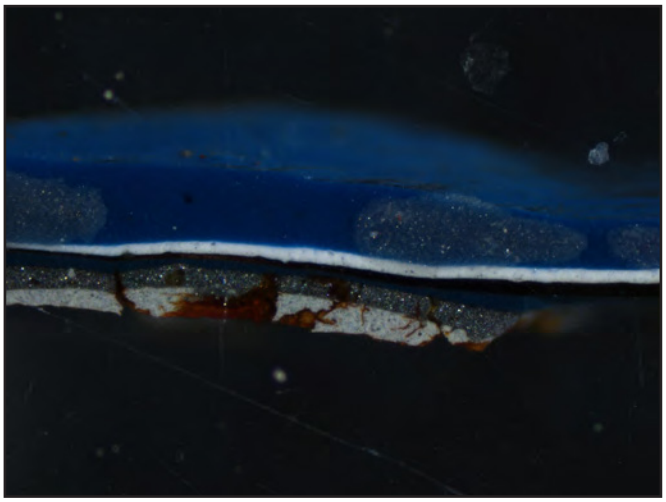
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark reddish brown			Primer
2	**very light bluish green**			Original
3	dark gray			
4	**silver**			Not captured in cross-section
5	dark gray			
6	pale green			
7	**pale bluish green**	2.5BG 7/2	24410	1990s presentation finish
8	white			
9	**pale greenish blue**			

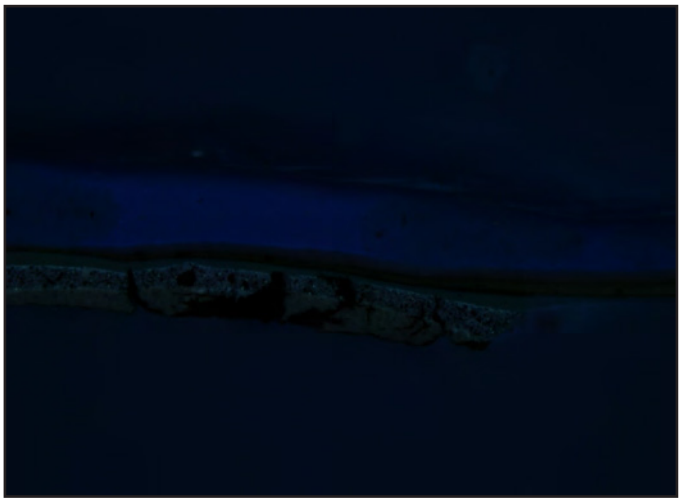
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.23	**ROOM:** Delta-09
DESCRIPTION: Cap to Access Hatch Controls	



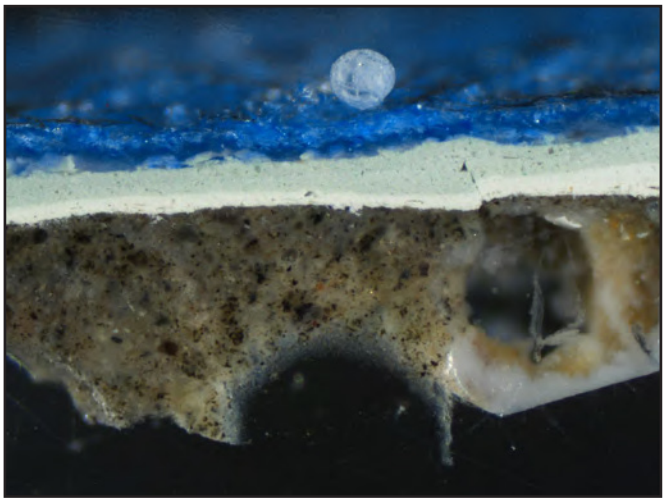


LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark brown			Primer
2	light yellow brown			Primer
3	**grayish blue**			Original
4	**silver**			
5	**dark grayish blue**	10B 2/4	25045	1990s presentation finish
6	**black**			Transparent coating
7	white			
8	**dark blue**			

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.24	**ROOM:** Delta-09
DESCRIPTION: Soft Support Building lower wall	





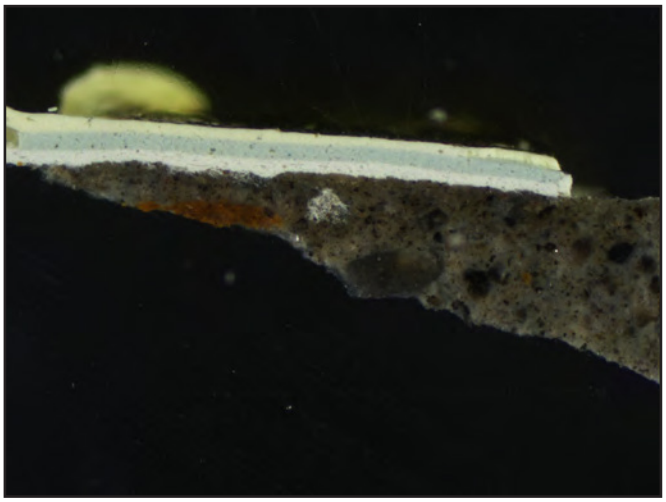
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Concrete			
1	**pale green**			Original
2	**very light green**	5G 7/2	26480	1990s presentation finish
3	**very light green**			2006

// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.25	**ROOM:** Delta-09
DESCRIPTION: Soft Support Building upper wall	





LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Concrete			
1	**pale green**			Original
2	**very light green**	5G 7/2	26480	1990s presentation finish
3	**pale yellow green**			2006

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.26	**ROOM:** Delta-09
DESCRIPTION: Soft Support Building door	

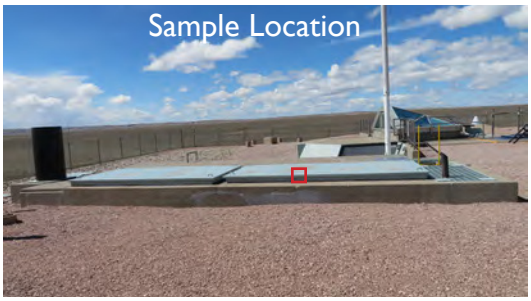




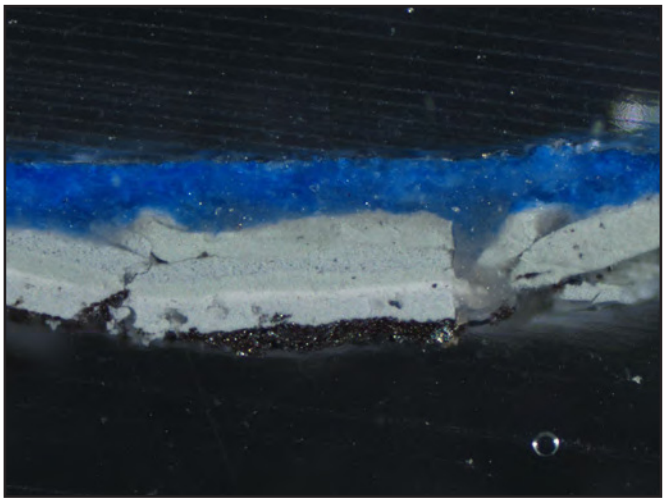
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	**pale blue**			
2	**light grayish green**	10GY 7/1	36480	1990s presentation finish

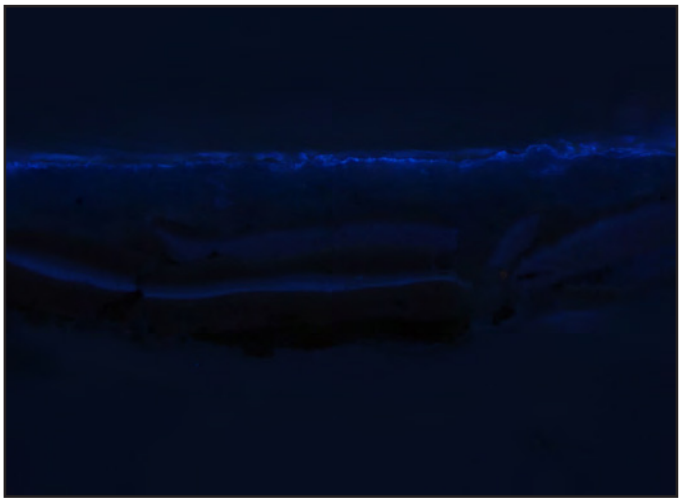
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.28	**ROOM:** Delta-09
DESCRIPTION: Soft Support Building roof plate	



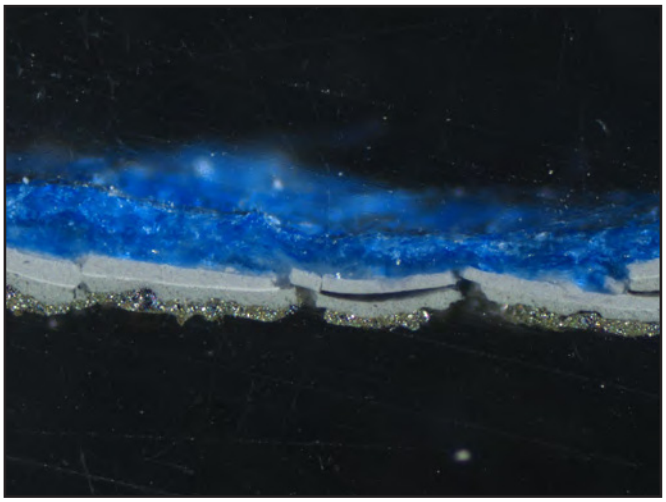


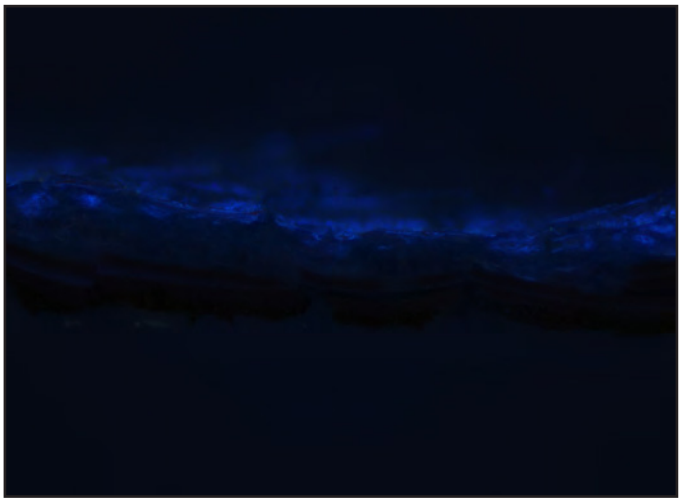
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	**pale grayish green**			Original
2	white			Primer
3	**pale grayish green**			
4	**pale grayish green**	10G 7/1	26480	1990s presentation finish
5	**pale grayish green**			Recent repainting

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.31	**ROOM:** Delta-09
DESCRIPTION: Closure door wall	





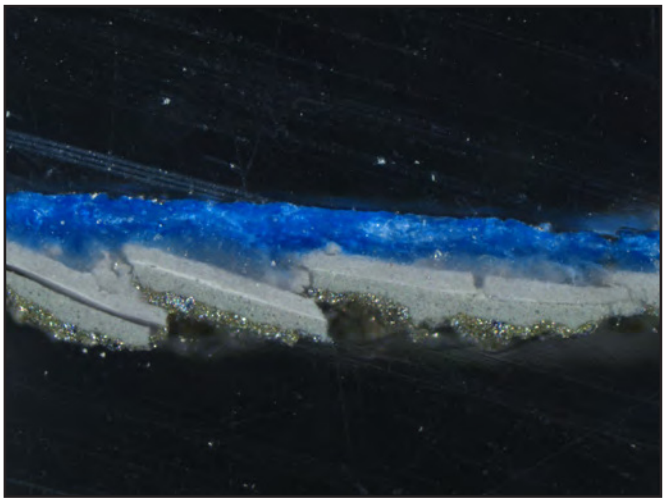
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	medium gray			
2	**medium gray**	N 5.5	26290	1990s presentation finish
3	**medium gray**			

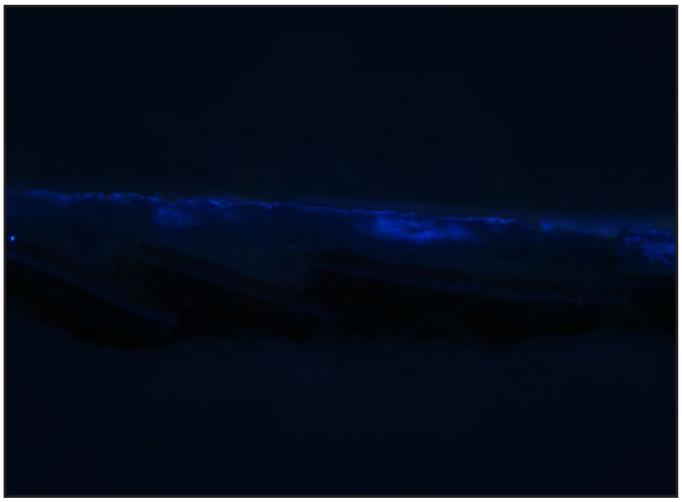
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.32	**ROOM:** Delta-09
DESCRIPTION: Closure door base	



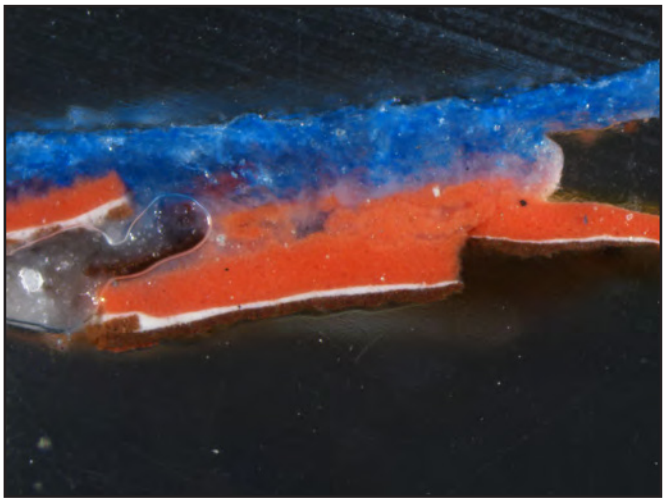


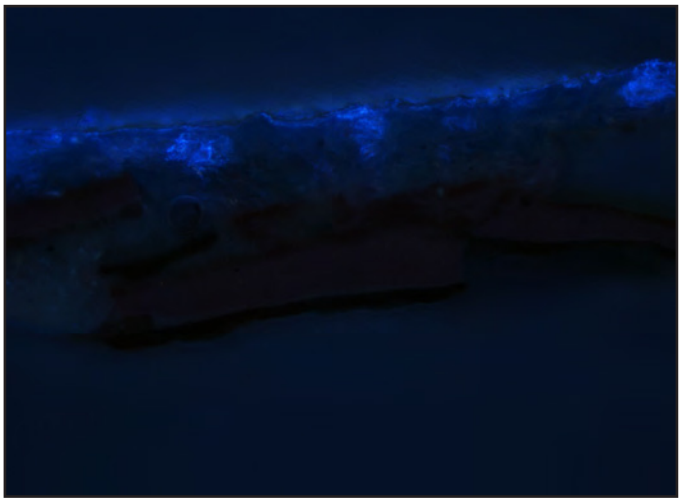
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate				
1	medium gray			
2	**medium gray**	N 5.5	26290	1990s presentation finish
3	**medium gray**			Recent repainting

// denotes a break in the sample.
Bold denotes known presentation layer.



SAMPLE #: D9.33	**ROOM:** Delta-09
DESCRIPTION: Closure door track	





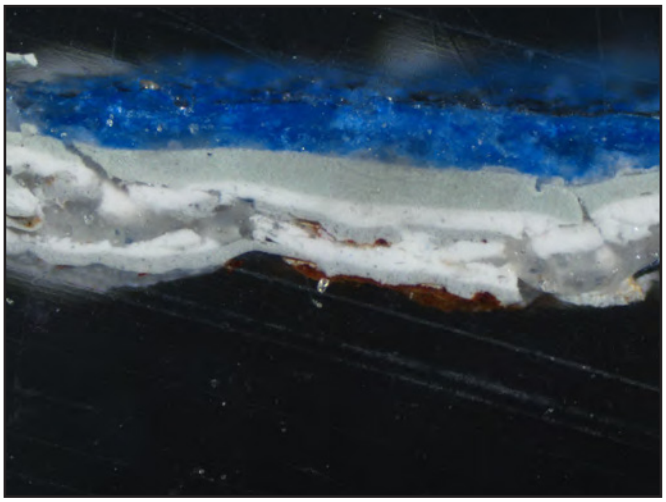
LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate				
1	dark brownish red			Primer
2	dark orangish brown			Primer
3	white			Primer
4	**moderate reddish orange**	7.5R 5/8	31400	1990s presentation finish
5	**strong reddish orange**	7.5R 5/10	31400	Recent repainting but is a different paint type from the elastic paint

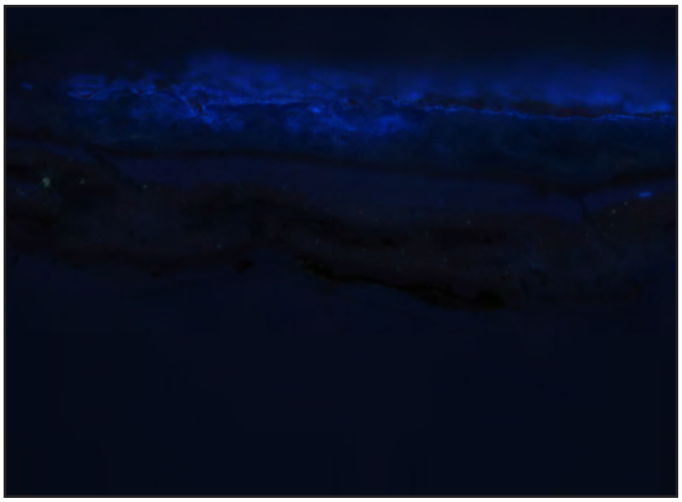
// denotes a break in the sample.
Bold denotes known presentation layer.

Minuteman Missile National Historic Site
Delta-01 and Delta-09 Paint Analysis



SAMPLE #: D9.35	**ROOM:** Delta-09
DESCRIPTION: Ultra high frequency antenna base	





LAYER	REFLECTED LIGHT COLOR	MUNSELL	FEDERAL STANDARD COLOR	NOTES
Substrate	Metal			
1	dark orangish brown			
2	**medium bluish gray**	5B 7/1	26373	1990s presentation finish
3	white			
4	**light greenish gray**			Recent repainting

// denotes a break in the sample.
Bold denotes known presentation layer.

Page intentionally left blank

Appendix C. Structural Inspection Reports

Page intentionally left blank

National Parks Service - Delta-09 Minuteman Missile Silo

Delta-09 Missile Silo



Missile Silo PRELIMINARY INSPECTION REPORT

Tuesday, October 26, 2021

Gecko Job Number: 2021-02524

Name	Certification	Date of Inspection	Signature
Kyler Chrestay	Supervisor ASNT LVL II UT Inspector	Tuesday, October 26, 2021	
Anson Reppermund	Data Analyst ASNT LVL II UT Inspector	Monday, November 1, 2021	
Roberto Mendoza	PAUT Technician ASNT LVL II UT Inspector	Tuesday, November 9, 2021	
Jose Aparicio	NDT Technology Manager ASNT LVL III		

PRELIMINARY REPORT - Gecko Job Number: 2021-02524

To access your entire inspection log on to the Gecko Portal ™ at portal.geckorobotics.com with your username and password. If you do not have a username/password or you are having issues with the Portal please email us at sales@geckorobotics.com.

Table of Contents:

1 Abstract **3**
Introduction 3
Mission Readiness 4
Efficient Maintenance 4

RUG Test Method and Procedure **5**
Rapid Ultrasonic Gridding (RUG) 5
Techniques and Methodology 5
Limitations of the Inspection 5
Data Validation 7
Recommendations and Monitoring 8

Summary **9**
Asset Description: 9
Inspection Findings: 10
Useful Life Estimation: 11
Point of Comparison: Previously Scanned Silo Liner Plates from 91st Missile Wing 11

Safety Information **13**

Inspection Notes **14**
Scope of Work: 15
PAUT Inspection Results: 15
Gecko Robotics Inspection: 15

Inspection Photographs **16**

RUG Inspection Deliverable **21**
Gecko Inspection Map 21
Gecko C-scan: 22
Indication Definition: **25**

PAUT Inspection Deliverables **38**
Gecko Inspection Map: 38
Gecko C-scan: 39
Personal Access System - B-scan Data 42

Equipment Information **44**

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

1 Abstract

1.1. Introduction

The Delta-09 inspection was a demonstration of capability to the United States Air Force to support the Minuteman III and GBSD programs as part of SBIR Phase II contract FA86492099078. A USAF launch facility was not available within the program's schedule. As an alternative, permission was received by the National Park Service to complete the demonstration at the Delta-09 Launch Facility near Wall, South Dakota. The inspection accomplished two goals; 1) it demonstrated the Gecko Robotics technology for corrosion inspection of silo structures in a relevant environment and 2) it provided the National Park Service with an assessment of the condition of the Delta-09 Launch Facility to inform future restoration programs. Like the Delta-09 Launch Facility, the age of each Minuteman III Launch Facility (LF) puts the facilities steel interior structure at risk of corrosion due to water infiltration through the exterior concrete structure.Over time, the reinforced concrete has cracked and separated, allowing water ingress. The current inspection techniques in the 8 year Programmed Depot Maintenance (PDM) maintenance cycle are largely manual and do not provide a clear picture of corrosion issues in the Launch Equipment Room (LER), Personal Access System (PAS), and Launch Tube (LT). Corrosion problems left unattended allow water ingress into operational LFs which can damage critical electronic components or cause the missile to become inoperable due to excessive water entry. Both issues not only cause extremely expensive repairs, but limit the operational capabilities of each missile wing. The manual inspection techniques, inability to identify corrosion behind the steel liner butting up to the concrete, and standardized (not LF specific) inspection intervals pose a significant risk to LF operational readiness.

Transitioning to a robotic inspection approach coupled with digital data analysis tools will eliminate the operational risk of water entry into the LFs and save the USAF millions of dollars aggregated over the 450 operational LFs by providing a more complete assessment of LF condition, reduce the maintenance cost to complete inspection and enable targeted repairs based on reliable damage state information. Gecko Robotics inspections can be incorporated into every 8 year PDM cycle and help determine optimal maintenance intervals based on the inspection findings. The Gecko Robotics inspection approach can provide semi-automated, large area scanning to complete the mapping of the LF corrosion condition within three, 8-hour shifts and provide the 309 MXW, Minuteman III System Program Office and the operational missile wings with actionable information to execute targeted, efficient repairs and save valuable time for maintainers to perform higher value tasks.

The Gecko Robotics inspection approach will also provide the USAF with the data to enable critical decision making regarding USAF-wide LF readiness, maintenance planning and

information to support risk assessments for the upcoming Ground Based Strategic Deterrent (GBSD) program.

1.2. Mission Readiness

A Gecko Robotics inspection brings to light previously unknown, but potentially critical problems such as corrosion damage before it can become a through-wall leak in the LF which introduces water into the environment and can compromise the structural integrity of the asset. Defects like these can directly endanger the missile or electronic launch components.

The inspection of the Delta-09 silo identified indications of localized corrosion damage that was previously unknown. This information will enable the NPS maintenance team to implement repair and mitigation actions before the damage becomes more severe and more expensive to repair.

Due to the limited number and size of damage indications present, Gecko Robotics identified Condition Monitoring Locations (CMLs) that are recommended to be tracked to inform a more accurate lifetime estimate with respect to localized indications. CML monitoring represents a significantly lower operational cost and effort.

By leveraging knowledge collected as a part of a Gecko Robotics inspection, the NPS and Air Force may achieve significant cost savings through a “smart” Risk Based Inspection (RBI) program.

1.3. Efficient Maintenance

Effective scheduling of maintenance is critical to reducing cost and preserving the on-alert status of a Missile Wing’s fleet. The Ultrasonic Thickness inspection by Gecko Robotics was executed within three 8-hour shifts. Including approximately 4 hours of the last shift which were devoted to the cleaning of the historic Delta 09 Launch Facility.

With respect to data, an auto-validated deliverable is available to the customer within hours of completion of the inspection and the manually validated deliverable captured by the TOKA robotic system is available to the customer within 72 hours of completion of the inspection. The Gecko Robotics inspection and delivery of results fits well within a typical PDM timeline for a single site, allowing maintenance teams to take immediate action and increase the confidence in the long-term performance of an LF.

2. RUG Test Method and Procedure

2.1. Rapid Ultrasonic Gridding (RUG)

RUG is a nondestructive examination (NDE) method of performing ultrasonic thickness gauging in which multiple ultrasonic thickness probes are utilized, simultaneously, to rapidly gather thickness measurements. Like other ultrasonic testing (UT) methods, RUG captures raw A-Scan data, which can be presented in B-Scan or C-Scan modes — or used to create visual representation as 3-D models. However, RUG is capable of capturing multiple A-Scan data points at a much faster rate than traditional thickness measuring techniques for post-inspection data validation.

2.2. Techniques and Methodology

RUG tools utilize multiple thickness probes, anywhere from 4 up to approximately 100 probes at a time collecting thickness measurements at a density of up to 0.050" along the direction of travel. As such, the speed of coverage is greatly increased over methods utilizing a single thickness probe. The spacing of the probes and the frequency of recording varies depending on the amount of thickness data needed.

RUG can be performed using manual scanners or robotic crawlers. Using robotics and up to 100 thickness probes at a time spaced from a range of ¼” to 3” apart, millions of data points with A-scans can be gathered in a matter of hours.

RUG does not rely on manual grid marking for determining the location of the thickness data. The use of encoders allows tracking of measurement data location and verification of RUG findings.

Instrumentation calibration and asset inspection is conducted using current inspection procedure GR.110 – Rev. 3, available upon request.

2.3. Limitations of the Inspection

Using robotic solutions, Gecko Robotics is able to access areas of industrial assets remotely without the need for access via scaffolding or manlifts. However, due to the physical limitations of the robotic platform, some obstacles may limit access.

The robotic inspection systems are limited to inspection of ferrous surfaces. The robotic crawlers cannot traverse over obstacles greater than 0.375 inch in height from the inspection surface and nonferrous coatings cannot be greater than 0.1 inch thick.

Figure 01 - Major Obstacles

Launch Tube	LER/PAS
Air Ducting	Autocollimator Bench
Piping	Ballistic Gas Generator
Electrical Conduit	Electronics Rack
Missile Support Structure	Storage Batteries
Sensor Junction Box	B-Plug
	Personnel Access Ladder

In order to conduct a completely comprehensive inspection either robotically or manually, the obstacles listed above would need to be removed to afford direct access to inaccessible liner sections. The C-scans below of the Launch Tube with the Obstacle Annotations toggled on and off, show the coverage missed due to obstacles. The total liner area inspected via the TOKA robotic system represents 62.8% of the total surface area of the Launch Tube.

Note: Blank areas at an elevation greater than 52.2 feet above the bottom of the launch tube were skipped at the request of the NPS due to the robotic crawler tracking rust colored debris across the asset. The duct obstacle in the LT is not expected to be present in an active LT.

Figure 02 - 2D Heatmap of Launch Tube

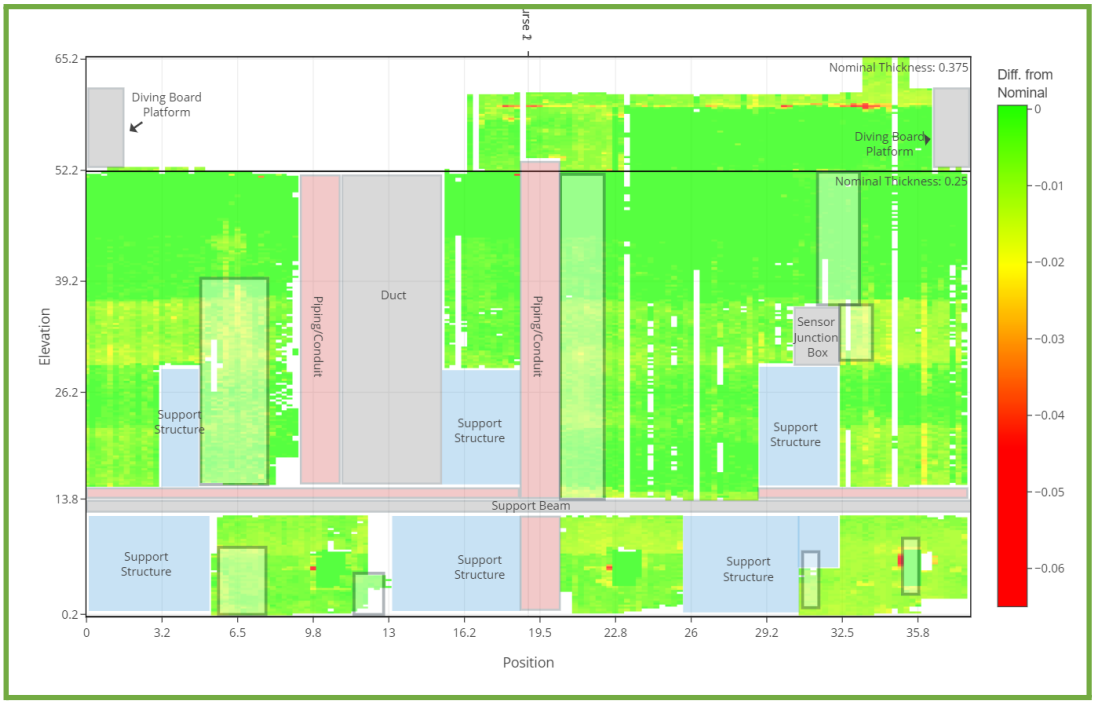
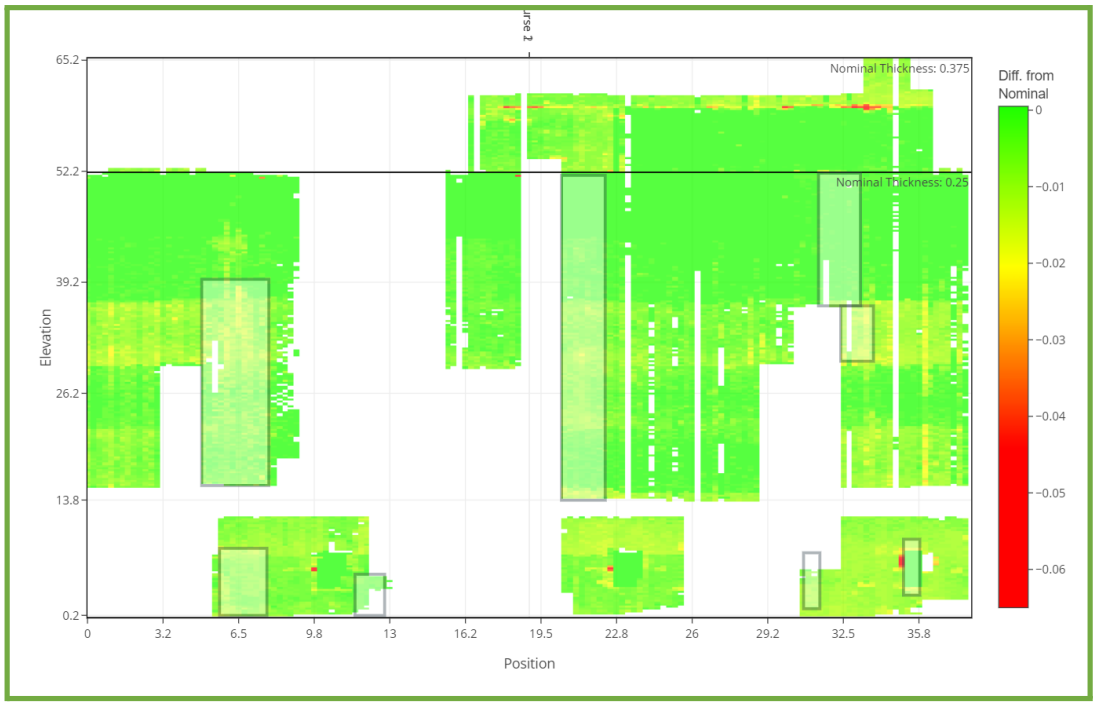


Figure 03 - 2D Heatmap of Launch Tube excluding obstacles



2.4. Data Validation

Data Validation is conducted using Gecko Robotics proprietary tools including various algorithms using machine learning and a review of processed data by qualified personnel.

The data processing algorithms used in Gecko Robotics' analysis of the LT use methods that we call Mode 2 and Mode 3. These names refer to which ultrasonic reflections are used to calculate the effective wall thickness. Mode 2 uses the interface reflection and the 1st backwall echo whereas Mode 3 uses the 1st and 2nd backwall echoes, or in other words the second and third peaks. The algorithms favor Mode 3 when multiple echoes are present in A-scan, which allows for more robust references in the A-scan to give a higher confidence or quality of reading.

Due to the signal scattering characteristics of corrosion, when signs of corrosion are detected, multiple backwall echos may not exist, and the data processing algorithms may be switched to Mode 2.

2.5. Recommendations and Monitoring

While Gecko Robotics found several localized areas of corrosion, all represent mild corrosion and do not threaten the 50% minimum effective thickness threshold that could indicate a compromise in structural integrity. Since no prior detailed inspection data was available, Gecko is unable to estimate the rate of corrosion progression, Gecko is unable to estimate how quickly the corrosion is affecting this asset. Gecko Robotics recommends tracking the thickness of the identified CMLs to inform a more accurate lifetime estimate with respect to localized indications.

Failing coatings and rough inspection surfaces can interfere with UT data collection. To gain more insight in these areas, Gecko Robotics recommends abrading areas of Coating Failure, Disbonding of Coating, and Inspection Surface Side Corrosion to expose the bare metal surface of the liner prior to inspection.

By exposing the bare metal surface, we enable our Ultrasonic Thickness transducers to maintain coupling with the inspection surface and therefore are able to increase the fidelity of the robotic inspection. This preparation also enables the value of our visual inspection by exposing defects to the TOKA robotic system.

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

3. Summary

3.1. Asset Description:

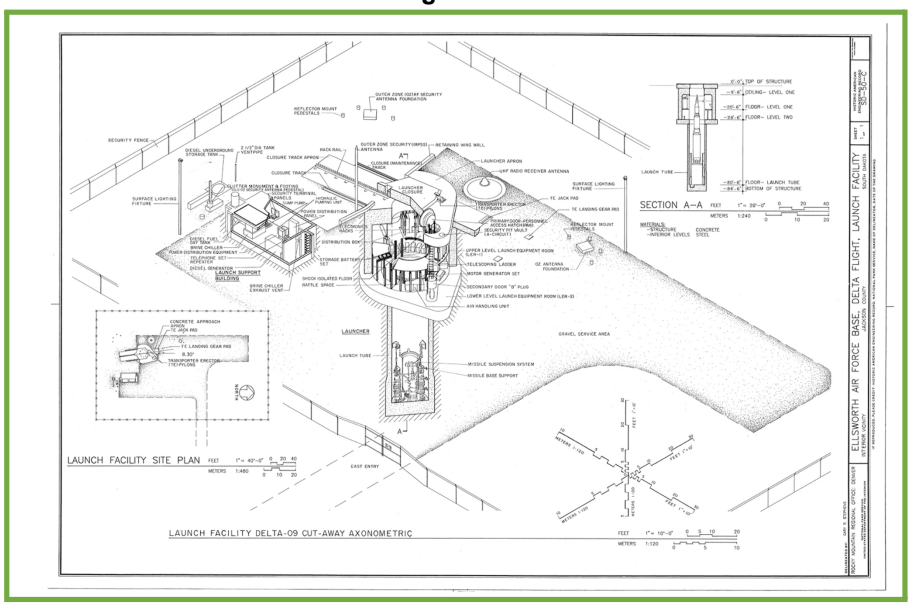
In accordance with the SBIR Phase contract FA86492099078, Gecko Robotics demonstrated the capability of a robotic Ultrasonic Thickness inspection and report of the condition of the Delta-09 Missile Silo Launch Facility. Active Launch Facilities similar to Delta 09, house the Minuteman III Intercontinental Ballistic Missile, designed to be launched within minutes of confirmation of launch, and carry it's nuclear ordinance over 6000 miles within 30 minutes to its intended target.

The Delta-09 Launch Facility consists of a Personal Access System (PAS), Launch Equipment Rooms (LER), and Launch Tube (LT). Accessed through the PAS via a telescoping ladder which descends into the LERs.

The LER consists of two separate levels, the LER 1 and LER 2. Each has a diameter of 25ft and are concentric to the upper section of the Launch Tube (LT) at depths of 20ft and 28ft below the surface of the launcher respectively. The LER houses all of the essential equipment to maintain and operate the Launch Facility such as the Autocollimator Bench used for the targeting procedure of the early Minuteman Missiles, Ballistic Gas Generator used to open the 110 ton LT blast door, Electronics Rack for guidance and controls, and Storage Batteries as a power redundancy.

The LT is accessible via a retractable 'Diving Board' on LER 1 and consists of a concrete reinforced liner with a 12ft inner diameter and reaches a total depth of 80ft.

Figure 04



3.2. Inspection Findings:

The Ultrasonic Thickness inspection and report of the condition of the Delta-09 Missile Silo Launch Facility included: Launch Tube, Launch Equipment Room - 1, Launch Equipment Room - 2, and the Personal Access System. Gecko was able to perform an inspection to map out all accessible areas of the Missile Silo within the scope by gathering 8,884,447 readings. This was accomplished by taking at least 36 readings per sensor per foot of the Missile Silo. The following summarizes the three locations exhibiting the most significant indications of wall loss due to corrosion:

Figure 05
Launch Tube

Measured Thickness	Nominal Thickness	Location
0.186 in	0.250”	Position 9.8 ft, Elevation 5.8 ft
0.188 in	0.250”	Position 22.5 ft, Elevation 5.8 ft
0.198 in	0.250”	Position 35.0 ft, Elevation 6.8 ft

Figure 06
Launch Equipment Room - 1

Measured Thickness	Nominal Thickness	Location
0.227 in	0.250”	Position 14.0 ft, Elevation 6.9 ft
0.238 in	0.250”	Position 13.4 ft, Elevation 5.6 ft
0.245 in	0.250”	Position 13.4 ft, Elevation 5.6 ft

Figure 07
Launch Equipment Room - 2

Measured Thickness	Nominal Thickness	Location
0.218 in	0.250”	Position 0.7 ft, Elevation 0.1 ft
0.230 in	0.250”	Position 0.2 ft, Elevation 1.4 ft
0.233 in	0.250”	Position 8.7 ft, Elevation 1.4 ft

Figure 08
Personal Access System

Measured Thickness	Nominal Thickness	Location
0.169 in	0.250”	Position 1.4 ft, Elevation 4.0 ft
0.172 in	0.250”	Position 0.6 ft, Elevation 20.2 ft
0.179 in	0.250”	Position 0.5 ft, Elevation 16.4 ft

Final readings were compiled using Gecko Robotics' proprietary software program designed for industrial inspections. These results are available on the Gecko Portal to anyone given permission by the National Parks Service staff or SBIR team, with a secure username and password. The inspection results were finalized on Monday, November 08, 2021 and the National Parks Service was given access to all inspection results.

By utilizing this report, the customer acknowledges responsibility for and agrees that the accuracy and interpretation of inspection data within the portal and the accuracy and interpretation of the several outputs of the portal, will be dependent on the accuracy and use of Customer-controlled data variables, logic rules, system functions, and its own independent analysis.

3.3. Useful Life Estimation:

Utilizing the most critical indications in the Launch Tube, Gecko Robotics can estimate an asset Long Term Corrosion Rate of 0.0011 inches per year, which defines the Remaining Life estimation at 55.38 years. Gecko Robotics assumes a minimum effective thickness of 50% wall loss. Long Term corrosion rate is calculated based on a construction date of 1961. With only one inspection interval available, Short Term Corrosion Rate is unable to be estimated.

As seen through the estimation above, assuming that the asset is run under the same conditions, Gecko Robotics suggests that the remaining life with regards to asset integrity of the Delta 09 Launch Facility is not a concerning factor for the NPS. The data collected should be considered baseline readings. Further inspection will help define more accurate corrosion rates and remaining life.

As stated under “Recommendations and Monitoring”:

> *Gecko Robotics found several localized areas of corrosion, but all represent mild corrosion and do not threaten the 50% minimum effective thickness threshold that could indicate a compromise in structural integrity. Since there is no historical reference of the status of the LF liner, Gecko is unable to estimate how quickly the corrosion is affecting this asset. Gecko Robotics recommends tracking the thickness of the identified CMLs to inform a more accurate lifetime estimate with respect to localized indications.*

3.4. Point of Comparison: Previously Scanned Silo Liner Plates from 91st Missile Wing

As a comparison point to the sound condition of the Delta-09 Launch Facility, a previous assessment has been performed on steel liner plates from operational launch facilities under the 91st Missile Wing at Minot AFB. The inspection results represent the potential damage that can result from backside corrosion left unmitigated. Two steel launch facility liner plates were inspected with the Toka 4 UT inspection robot and as a result Gecko Robotics identified several areas with over 50% wall loss undetectable on the front side by the human eye. Figures A and B below depict the front side, backside, and results of the UT inspection data.

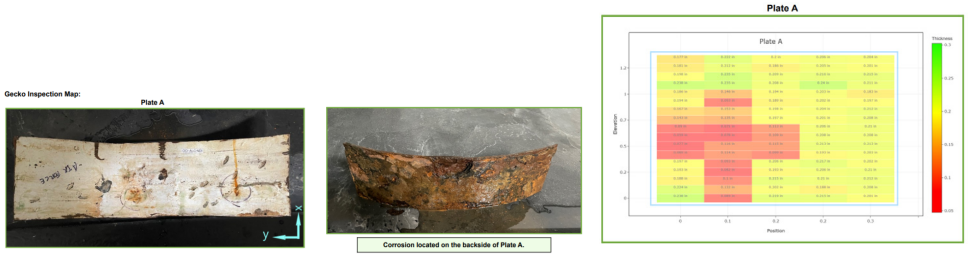


Figure 9: Plate A Frontside (5" - ⅜" x 18" - ¼"), Backside, and UT heatmap depicting areas with over 50% corrosion in red



Figure 10: Plate B (3" - ¾" x 7" - ⅝") Frontside, Backside, and UT heatmap depicting areas with over 50% corrosion in red

The amount of corrosion on the two plates revealed areas that are determined to be below the effective level of thickness and would be in need of repair. This damage would not be able to be identified using current Technical Order inspection requirements. Left unmitigated, this could potentially lead to water ingress into the Launch Facility, jeopardizing mission readiness.

FIGURE 11: GENERAL INFORMATION

Plant:	Operating Company:
Delta-09 Minuteman Missile Silo	National Parks Service
Address:	**Date:**
I-90 Exit 116, Wall, SD 57790	Tuesday, October 26, 2021
Unit ID:	**Contact Name:**
Delta-09 Missile Silo	NPS
Plant Contact Phone:	**Reporting Inspector:**
NPS	Kyler Chrestay

FIGURE 12: ASSET INFORMATION

Year Built:	Manufacturer:
See Engineering Drawing	See Engineering Drawing
Asset Contents:	**Asset Dimensions:**

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

Missile	12" OD
Original Wall Thickness:	**Material Alloy:**
Varied	Carbon Steel
Coating Thickness:	**Coating Type:**
See Engineering Drawing	See Engineering Drawing

FIGURE 13: JOB SPECIFIC INFORMATION

Walls Accessed By:	**Hole Watch Provided:**
Ground / Suspended Basket	Yes
Safety Harnesses Needed:	**Adequate Access to Inspection Target:**
Yes	Yes
Air Monitor Needed:	**Respirator Required:**
Yes	No
Exclusive Access:	**Lighting Adequate:**
Yes	Yes
Number of Inspectors:	**Number of Robots:**
2	1
Safety Certifications Needed:	**Permits Required:**
General Work	No

4. Safety Information

This project was executed in accordance with the Gecko Robotics Safety Program. Safety is always the top priority on our projects. All persons on the crew are trained in accordance with our safety and health program.

The following were completed to prevent accidents and unsafe conditions:

- Gecko daily JSA and work area walkthrough before and after every shift

Safety is always the top priority on any project. As with all projects, Gecko welcomes any safety suggestions to help keep its employees safe and healthy.

5. Inspection Notes

A more specific summary of the major findings throughout the ultrasonic inspection of the LT can be found in Section 3.2. Figure 5 specifies the three locations exhibiting the most significant indications of wall loss due to corrosion in the LT, LER-1, LER-2, and PAS.

Figure 14
RUG Inspection

Inspection Type:	Cleanliness:
Ultrasound Thickness	Fair
Coating on Asset:	**Most Prevalent Issues:**
See Engineering Drawing	Disbonded coating and coating failure
Data Deliverable Resolution:	**Sensor Spacing:**
3" x 3"	1”
Transducer Frequency:	**Transducer Description:**
10 MHz	0.125” Element / 0.65” Spherical Focus

Figure 15
PAUT Inspection

Client: National Park Services
Job #: 2021-02524
PO/WO #: N/A
Location: Wall,SD
Procedure: ☒ Manual AUT ☐ PAUT-Piping ☐ TOFD ☒ PAUT-Vessel
Unit #: Delta-09 Minuteman Missile Silo
Item Inspected: Launch Equipment 1&2, PAS system.
Code: Corrosion Mapping as Per Client
Material: CS **Thickness**: Estimated 0.250
Surface condition: ☐ Buffed ☐ Machined ☐ Sand blasted ☐ Ground ☒ Painted ☐ Other
Heat Treatment: N/A
Surface temp.: ☐ < 40°F ☒ 40°F - 140°F ☐ >140°F
Scanning surface: ☐ O.D. ☒ I.D
Technique: ☒ Manual UT ☒ PAUT ☐ TOFD **Type**: ☐ P/E ☐ Pitch-Catch ☒ PA **Method**: ☒ Contact ☐ Other

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

5.1. Scope of Work:

Perform Automated and Semi Automated RAUT on accessible areas of Launch Equipment Room 1&2 and Personal Access System.

Note: Full coverage could not be accomplished where there were obstructions and/or poor surface conditions.

5.2. PAUT Inspection Results:

Corrosion was detected in two areas (see PAUT Inspection Deliverables below for further details)

5.3. Gecko Robotics Inspection:

During the Ultrasonic Thickness inspection performed on Delta-09 Missile Silo the supervising Robot specialist / UT technician visually identified items of concern. The data identified or not identified by the technician should be verified by the designated authorized visual inspector associated with your facility. The items of concern are as follows:

- Coating Failure
- Disbonding of Coating
- Inspection Surface Side Corrosion
- Wall loss on Personal Access System

As a general rule, each of the NDE methods will have practical limits with respect to accuracy. Areas of disbonded coating and coating failures can contribute to poor data quality. Visual inspection is performed as a substitute for UT.

Consider removing the coating where disbondment is suspected to perform additional NDE.

Please see Figures 16-22 and the Gecko Portal which detail the locations and significance of the items of concern listed above.

6. Inspection Photographs

Personal Access System
Figure 16



Figure 17



Note: Figures 16 and 17 are overlapping images, with the right-most indication in Figure 16 being the same as the left-most indication in Figure 17.

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

Figure 18



Note: As confirmed by our PAUT Technician, ASNT LVL II UT Inspector, the indications identified in Figures 16 and 17 were located directly above F1MW-S1 as shown in Figure 42 and below the B-plug stop ring. This correlates to the common features seen in Figure 18. These indications were not captured via PAUT due to access limitations, specifically clearance between PAS liner and the ladder as well as surface conditions contributing to probe liftoff.

Launch Tube

Figure 19:
Inspection surface side corrosion, Coating failure



GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

Figure 20:
Coating failure and disbonding





Figure 21:
Coating disbonding



Figure 22:
Inspection surface side corrosion, Coating failure

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

7. RUG Inspection Deliverable

7.1. Gecko Inspection Map

The drawing, 3D rendering, and 2D C-scan shown below detail the quantitative UT scan conducted on the LT. Localized indications are called out and detailed in figures 28-41.

Figure 23

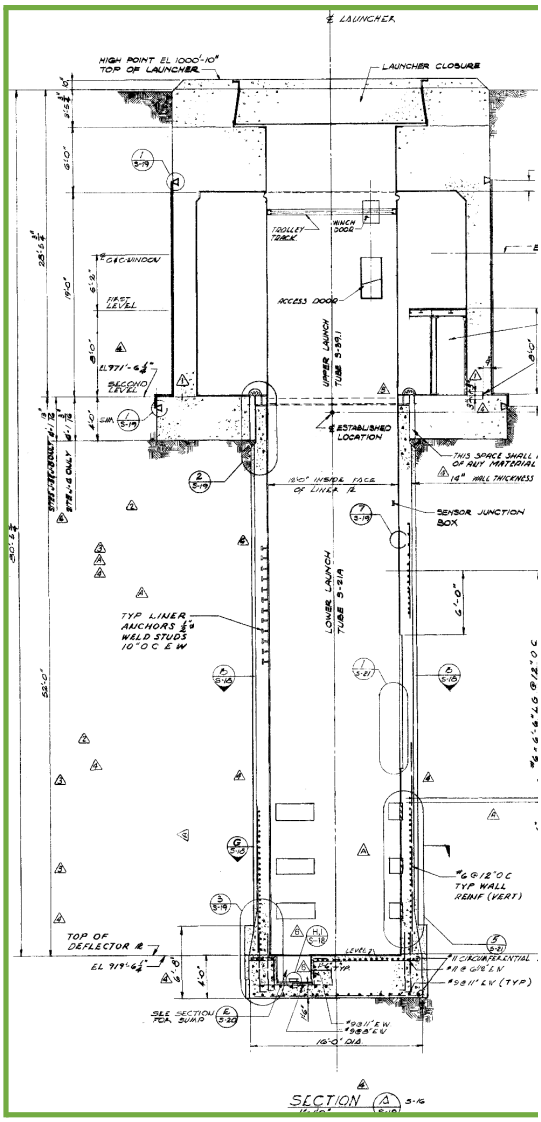


Figure 24

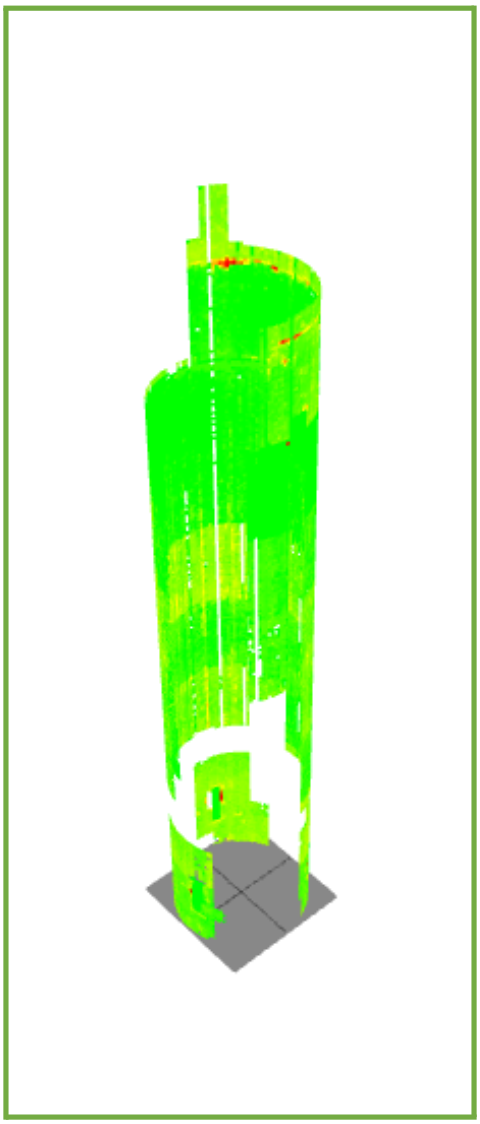
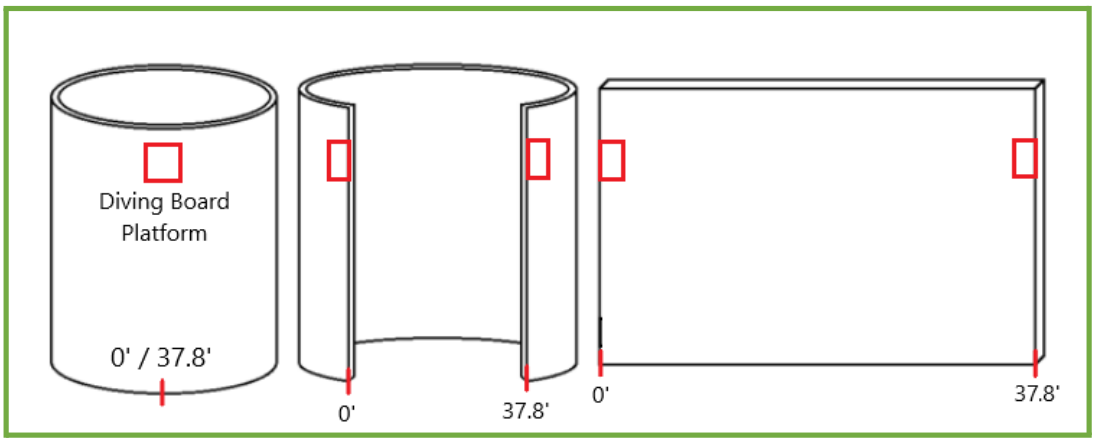
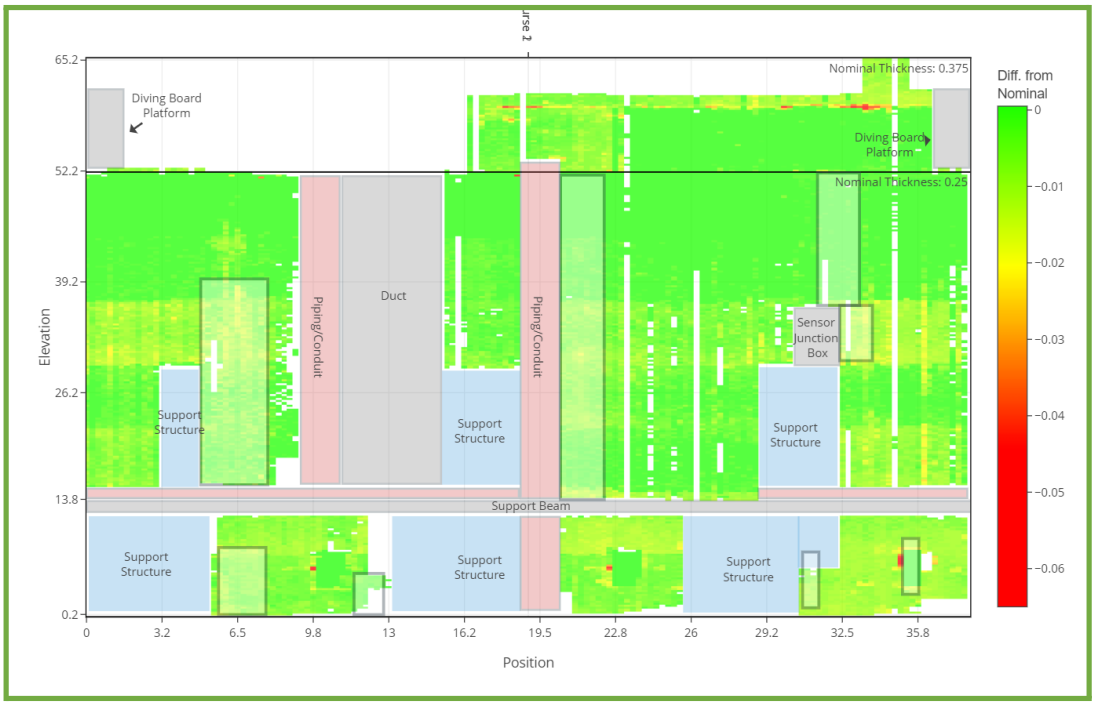


Figure 25



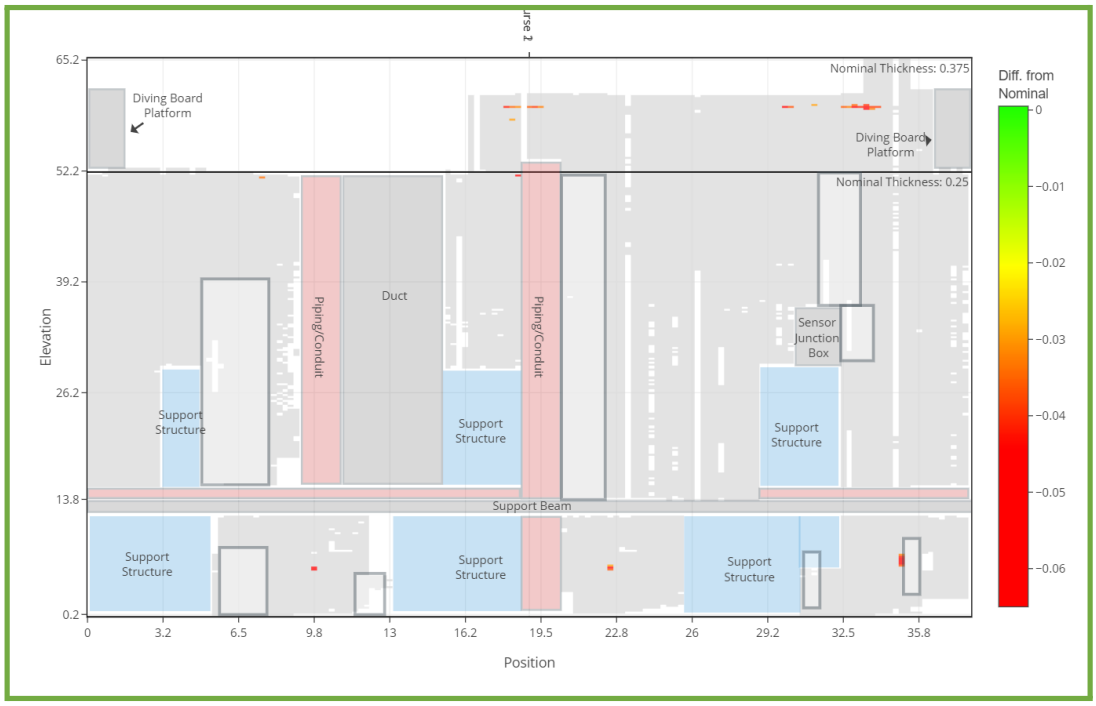
7.2. Gecko C-scan:

Figure 26
Launch Tube



GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

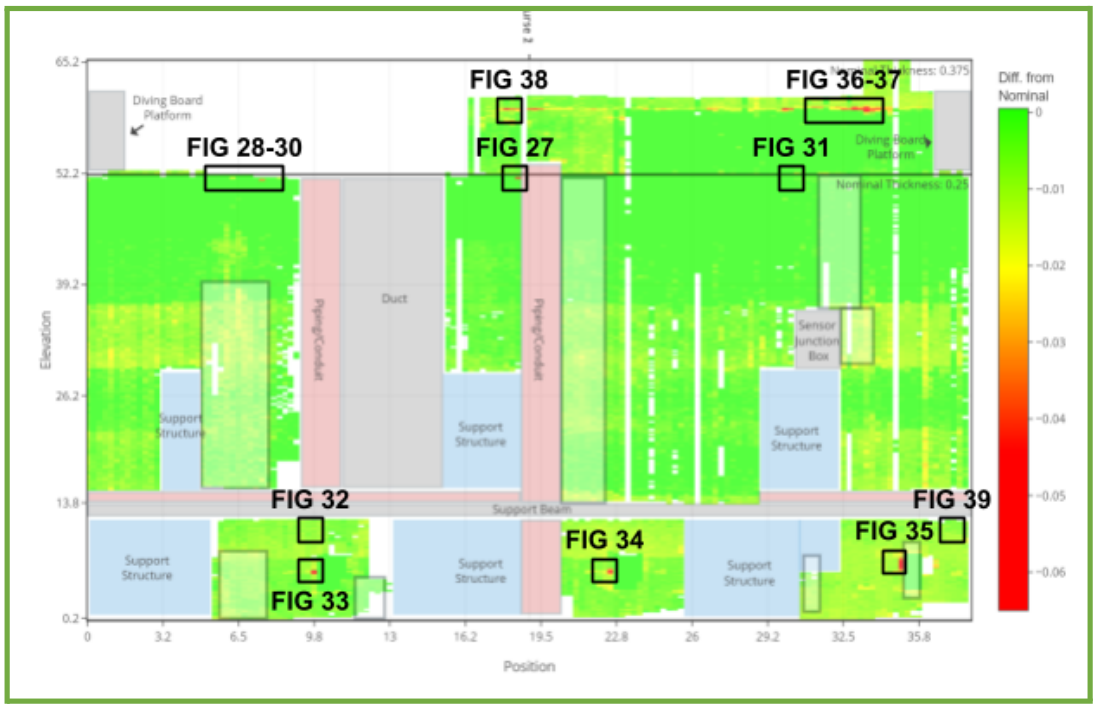
Figure 27
Areas >0.030" from Nominal



PRELIMINARY REPORT - Gecko Job Number: 2021-02524

To access your entire inspection log on to the Gecko Portal ™ at portal.geckorobotics.com with your username and password. If you do not have a username/password or you are having issues with the Portal please email us at sales@geckorobotics.com.

Figure 28
Correlation between localized defects identified in B-scans to C-scan.



Note: Please see Figures 29-31 which detail the indications identified in each of the bounding boxes in Figure 28.

7.3. Indication Definition:

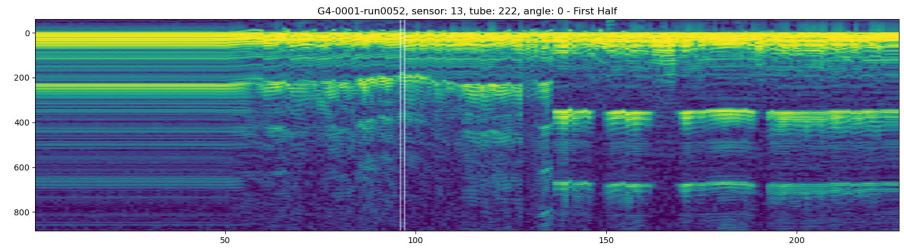
Corrosion	Inclusion
Natural and gradual damage process by exposure of metallic materials with their environment.	Body or particle recognizably distinct from the substance in which it is embedded caused by manufacturing defect.

Although inclusions represent a diminished effective wall thickness and are called out in the B-scans below, they do not commonly represent a concern with respect to the structural integrity of an asset such as the Launch Facility. Most Gecko Robotics' customers only ask for inclusions to be indicated in cases of pressure vessels, or when there are damage mechanisms in close proximity as that can exacerbate mechanical failure and increase the complexity of repair.

For those reasons, all inclusions found in the data analysis process are called out below in this report (Figures 31, 32, 39), but are not represented in the C-scans available in the Portal.

CML 01 - CML 10 are indicated below and can be used to track the identified areas of corrosion.

Figure 29
CML 01

Location	Position 18.5 ft, Elevation 51.75 ft (thickness: 0.196")
Indication	Mild Corrosion
B-scan	

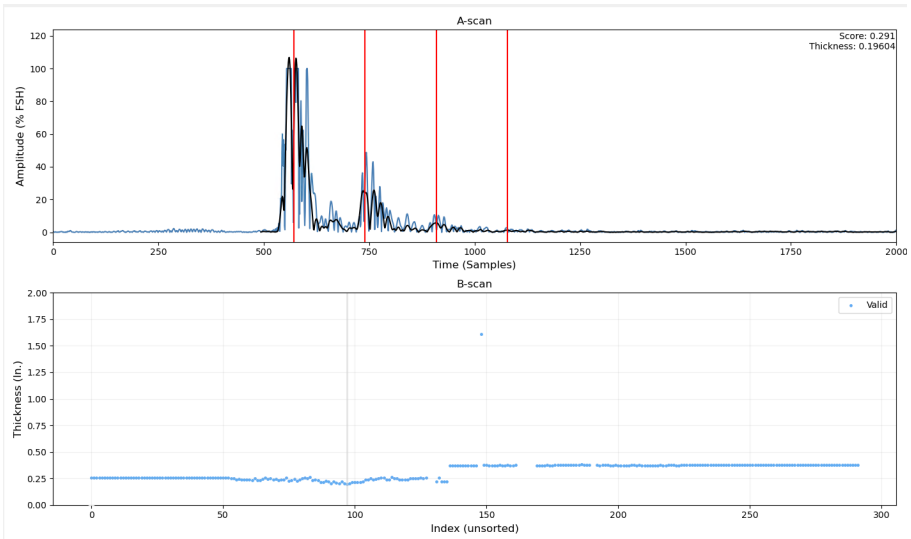
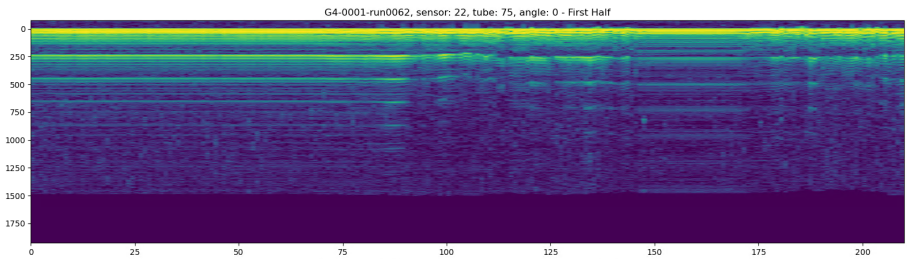
A-scan	
Corrosion Rate (LT)	0.0009 in/yr

Figure 30
CML 02

Location	Position 6.3 ft, Elevation 51.75 ft (thickness: 0.230”)
Indication	Mild Corrosion
B-scan	

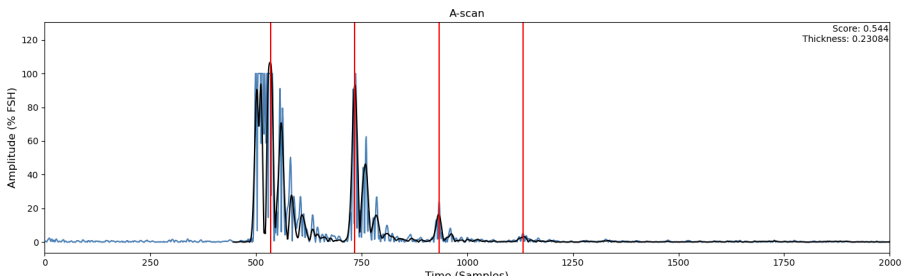
A-scan	
Corrosion Rate (LT)	0.000333 in/yr

Figure 31
CML 03

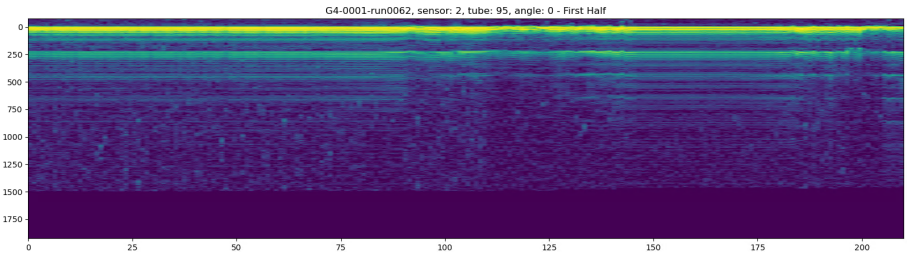
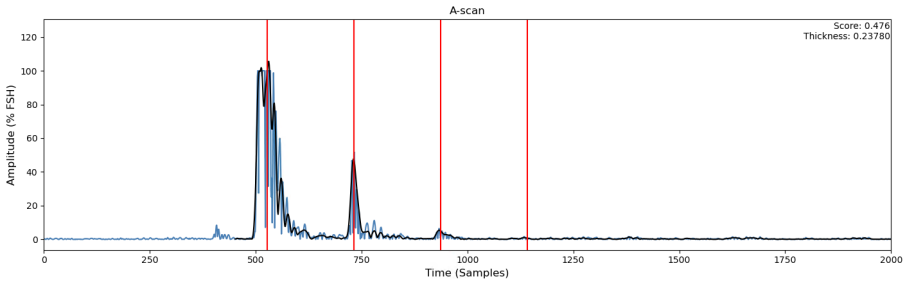
Location	Position 8.25 ft, Elevation 51.75 ft (thickness: 0.237”)
Indication	Mild Corrosion
B-scan	
A-scan	
Corrosion Rate (LT)	0.000217 in/yr

Figure 32
CML 04

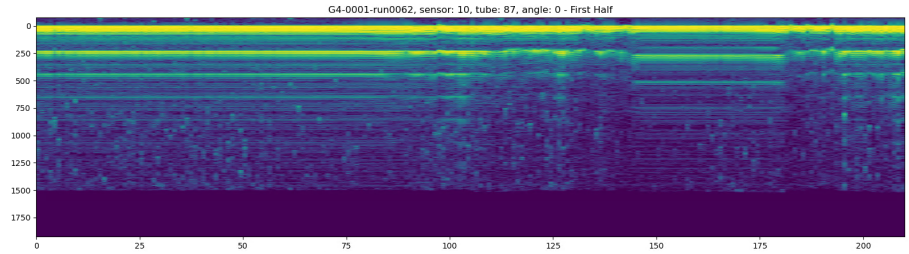
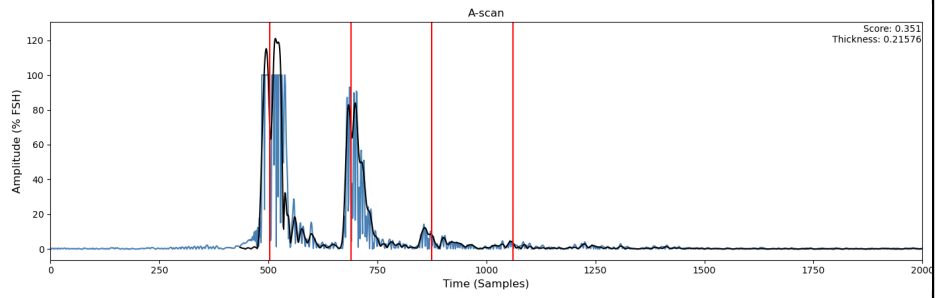
Location	Position 7.5 ft, Elevation 51.1 ft (thickness: 0.215”)
Indication	Mild Corrosion
B-scan	
A-scan	
Corrosion Rate (LT)	0.000583 in/yr

Figure 33

Location	Position 30.75 ft, Elevation 51.75 ft
Indication	Inclusion

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

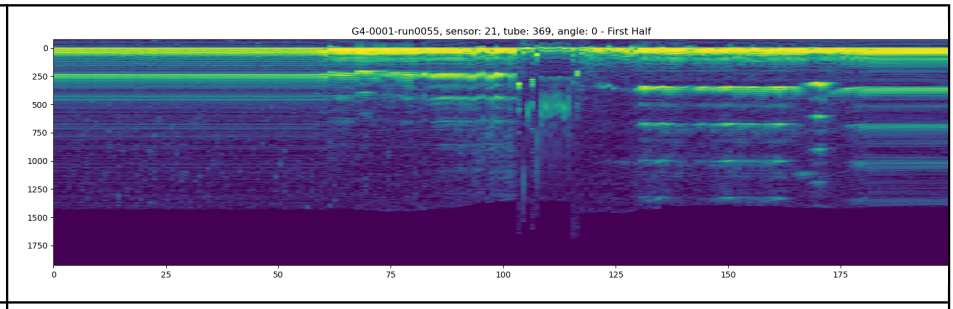
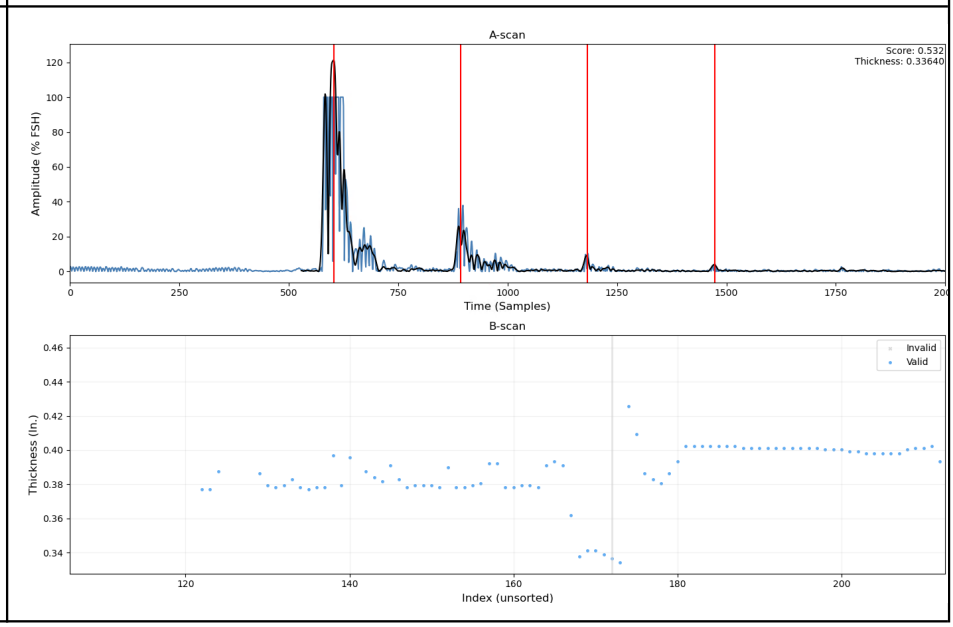
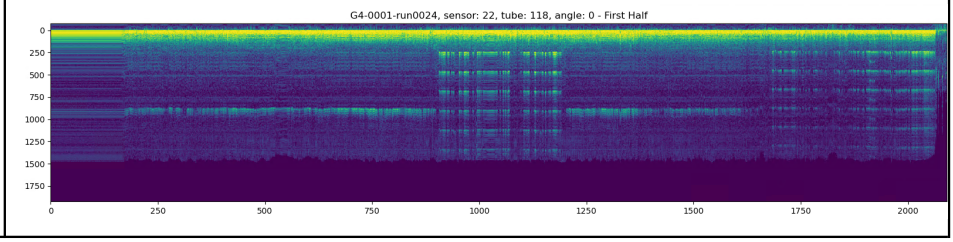
B-scan	
A-scan	

Figure 34

Location	Position 9.8 ft, Elevation 10.5 ft
Indication	Inclusion
B-scan	

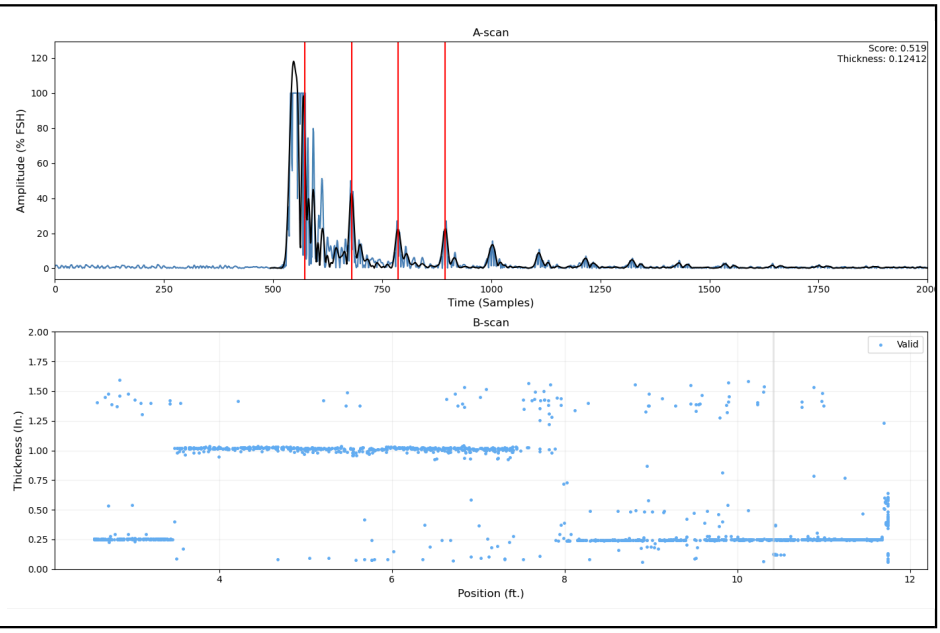
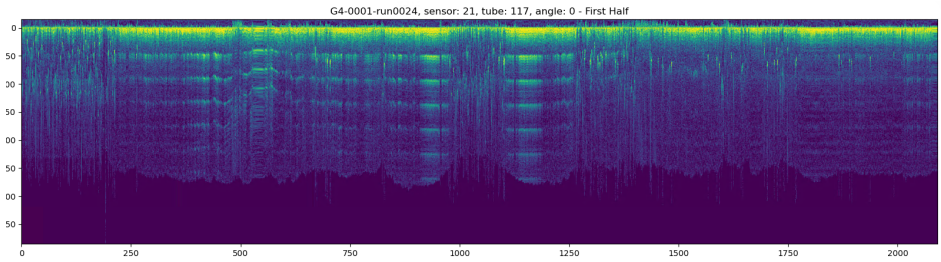
A-scan	

Figure 35
CML 05

Location	Position 9.8 ft, Elevation 5.8 ft (thickness: 0.185”)
Indication	Mild Corrosion
B-scan	

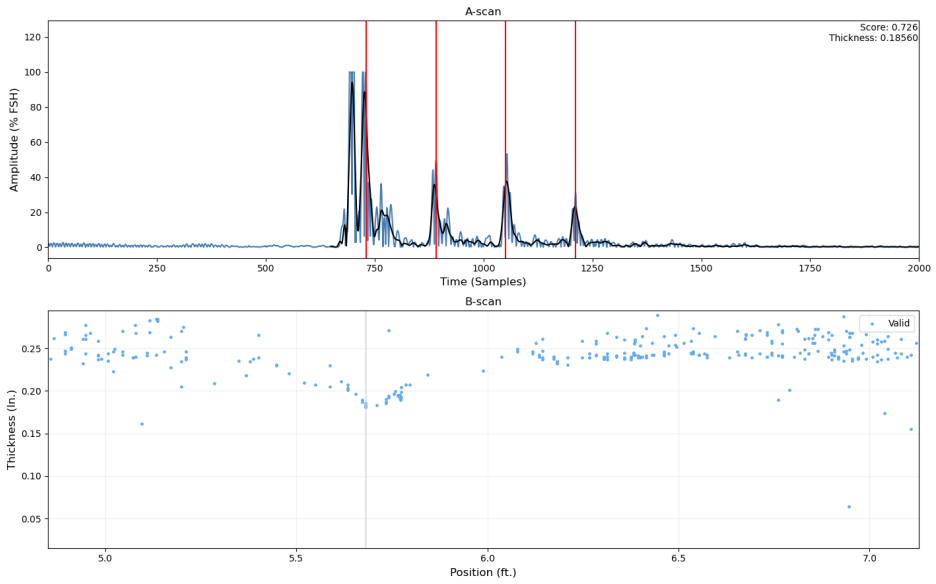
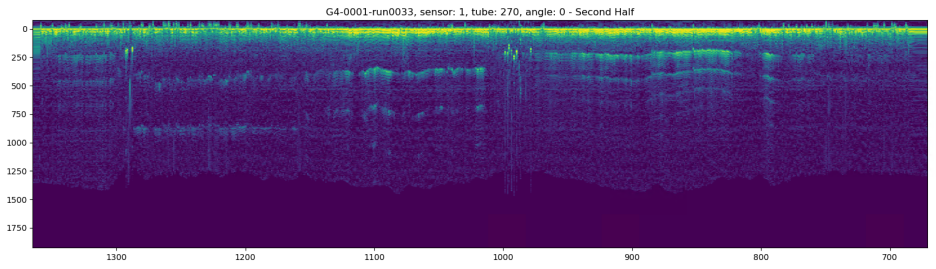
A-scan	
Corrosion Rate (LT)	0.001083 in/yr

Figure 36
CML 06

Location	Position 22.5 ft, Elevation 5.8 ft (thickness: 0.188”)
Indication	Mild Corrosion
B-scan	

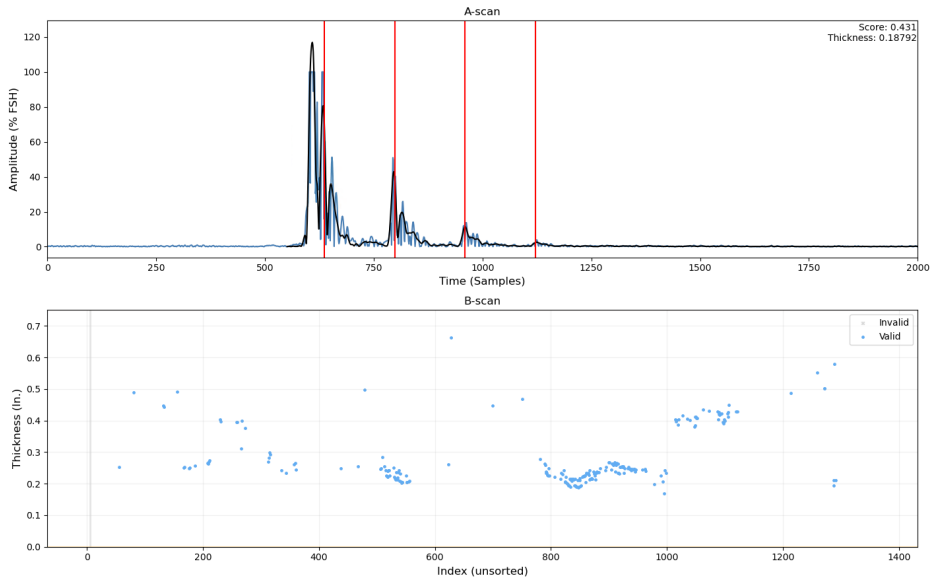
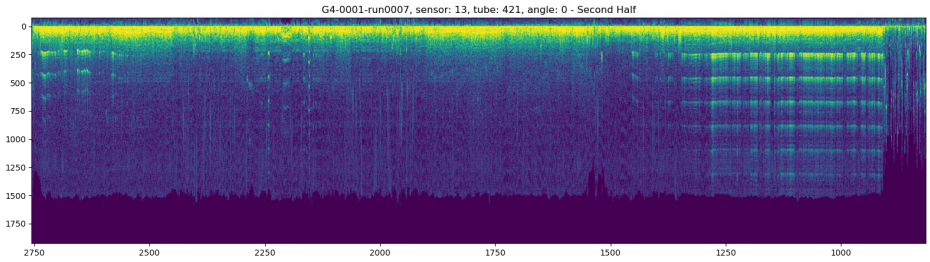
A-scan	
Corrosion Rate (LT)	0.001033 in/yr

Figure 37
CML 07

Location	Position 35.0 ft, Elevation 6.8 ft (thickness: 0.198”)
Indication	Mild Corrosion
B-scan	

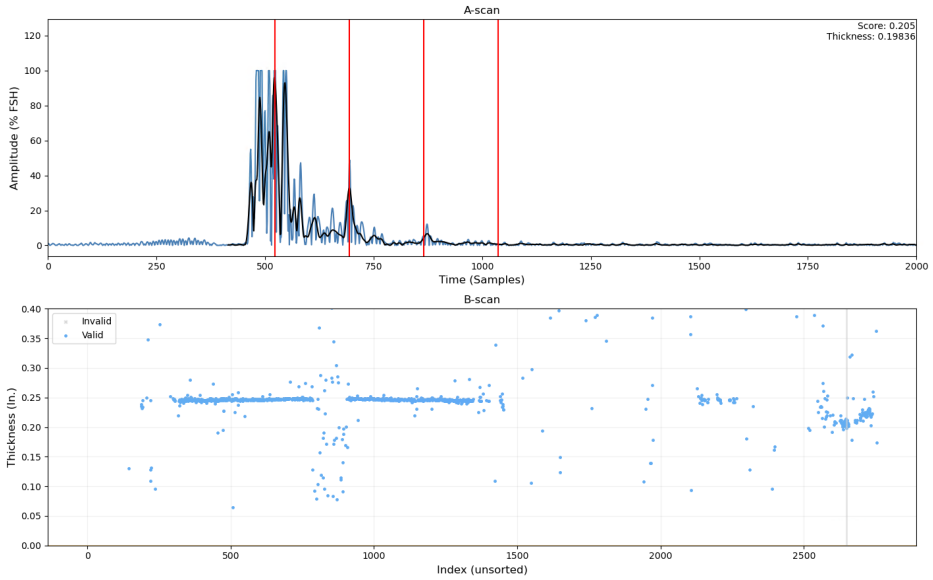
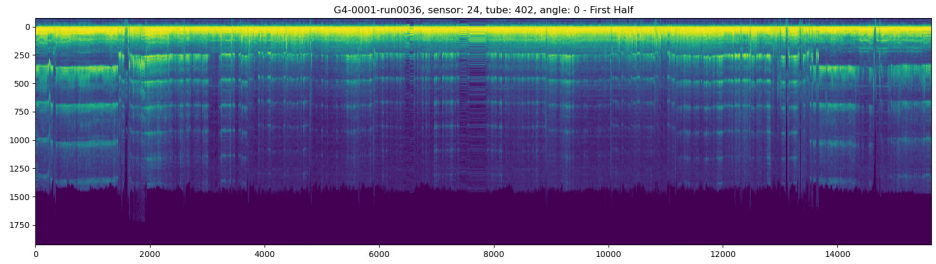
A-scan	
Corrosion Rate (LT)	0.000867 in/yr

Figure 38
CML 08

Location	Position 33.5 ft, Elevation 59.8 ft (thickness: 0.310”)
Indication	Mild Corrosion
B-scan	

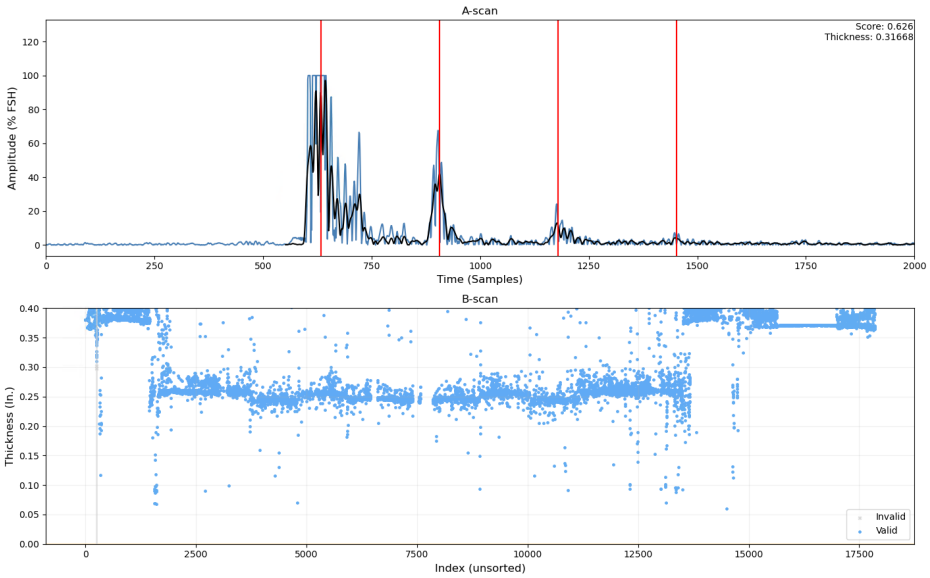
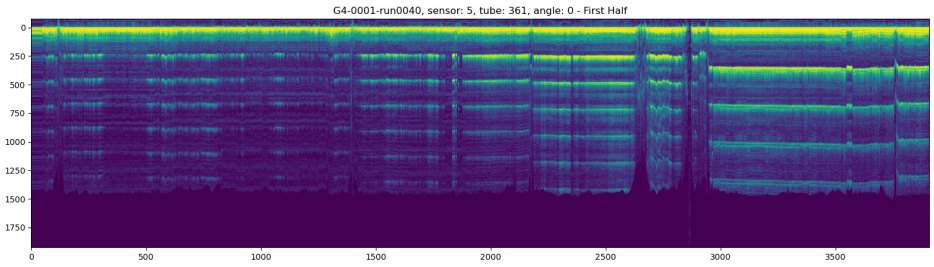
A-scan	
Corrosion Rate (LT)	0.001083 in/yr

Figure 39
CML 09

Location	Position 30.0 ft, Elevation 59.8 ft (thickness: 0.321”)
Indication	Mild Corrosion
B-scan	

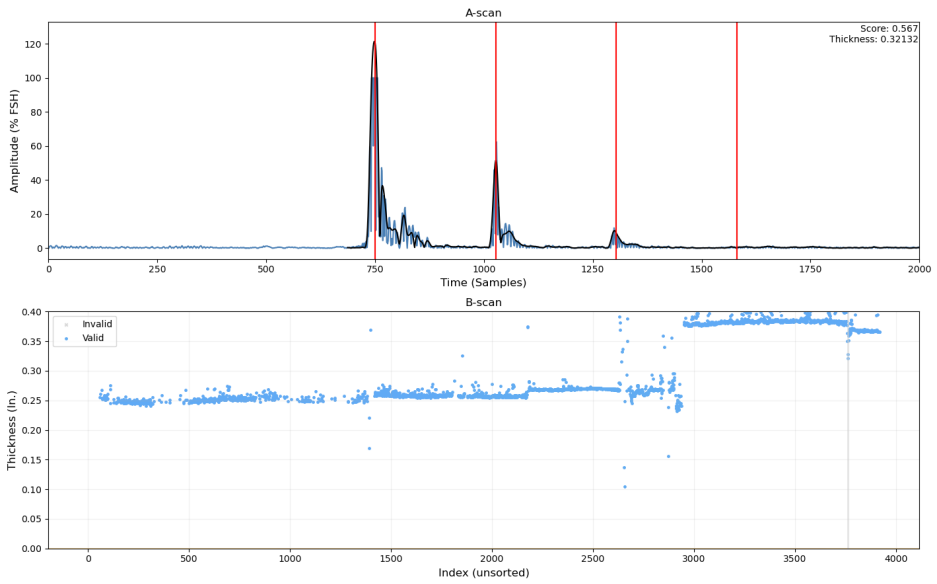
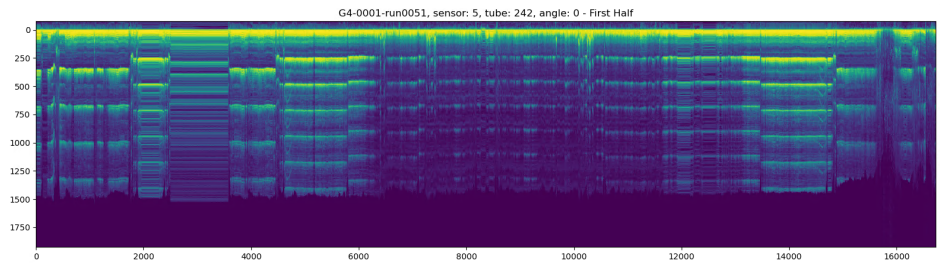
A-scan	
Corrosion Rate (LT)	0.0009 in/yr

Figure 40
CML 10

Location	Position 18.0 ft, Elevation 59.9 ft (thickness: 0.333”)
Indication	Mild Corrosion
B-scan	

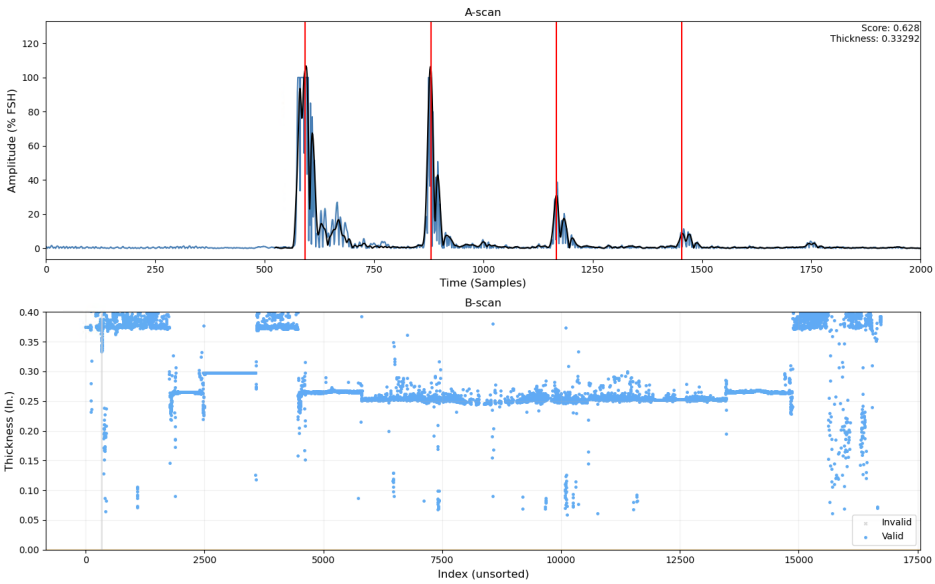
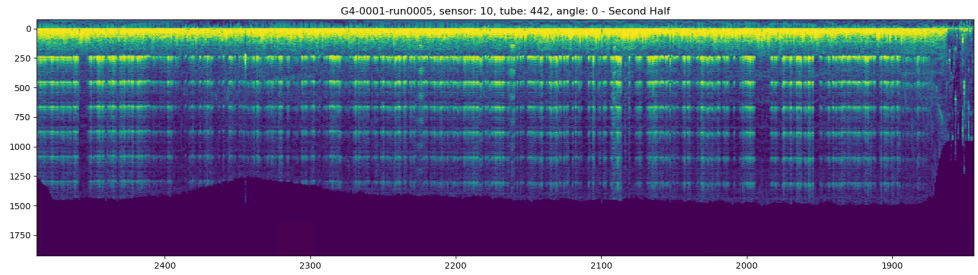
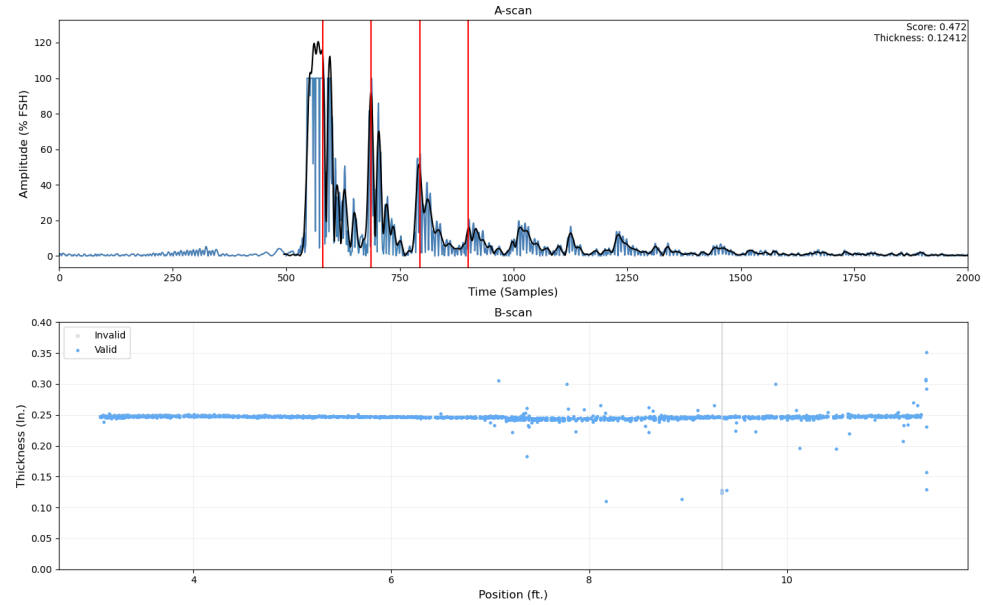
A-scan	
Corrosion Rate (LT)	0.0007 in/yr

Figure 41
CML 11

Location	Position 36.75 ft, Elevation 9.25 ft (thickness: 0.124”)
Indication	Inclusion
B-scan	

GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

A-scan	

PRELIMINARY REPORT - Gecko Job Number: 2021-02524

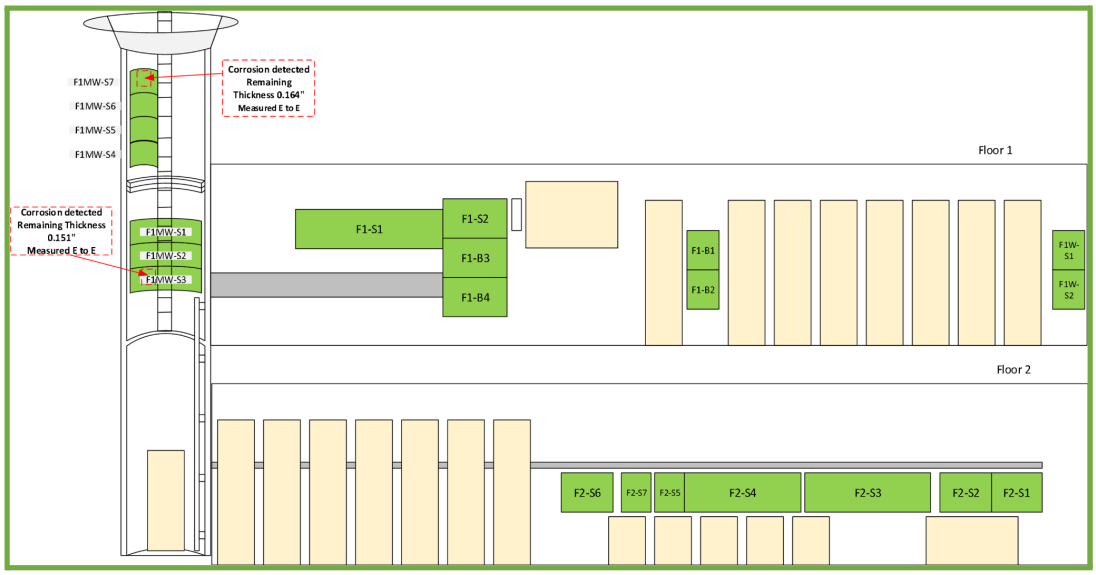
To access your entire inspection log on to the Gecko Portal ™ at portal.geckorobotics.com with your username and password. If you do not have a username/password or you are having issues with the Portal please email us at sales@geckorobotics.com.

8. PAUT Inspection Deliverables

Figures 42-46 detail the PAUT data collected in LER-1, LER-2, and PAS. Figure 42 maps the relative position of each of the scans taken in a comprehensive map, while Figures 43-46 provide a quantitative heat map describing the effective thickness of the steel liner.

8.1. Gecko Inspection Map:

Figure 42 - Gecko Inspection Map



8.2. Gecko C-scan:

Figure 43
Launch Equipment Room - 1

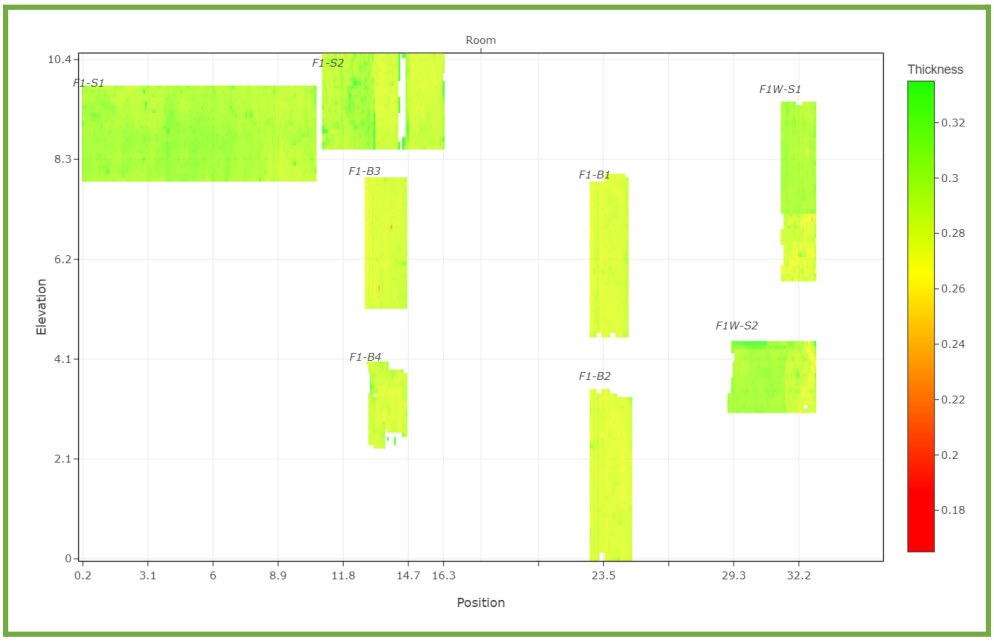
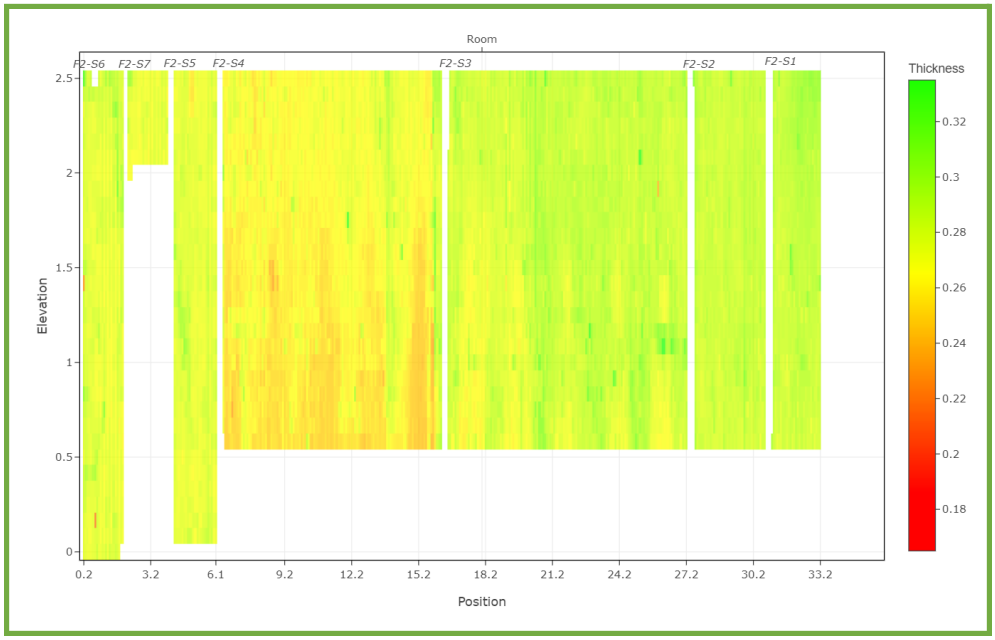
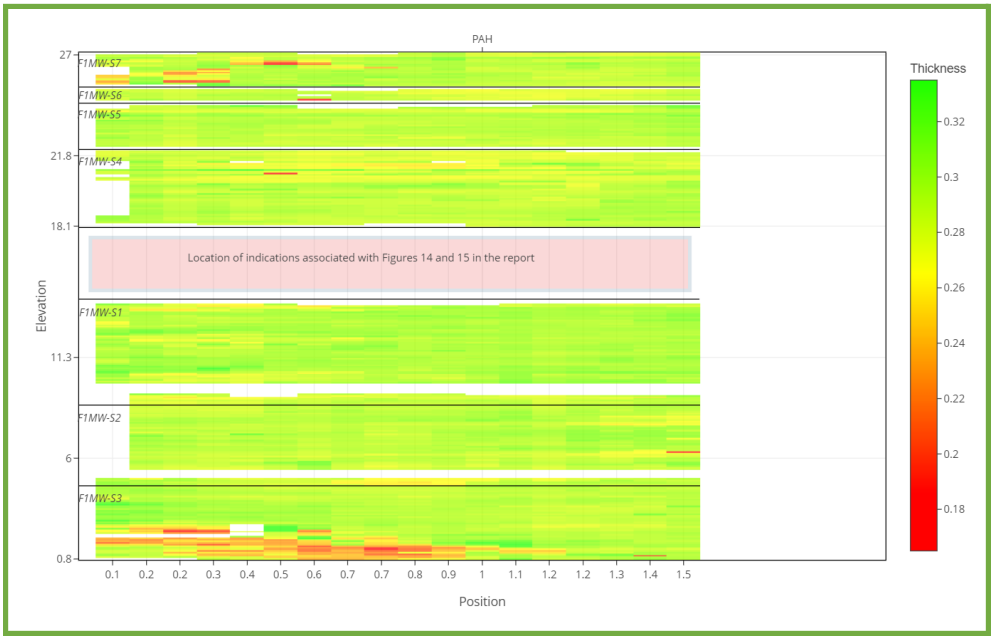


Figure 44
Launch Equipment Room - 2



GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

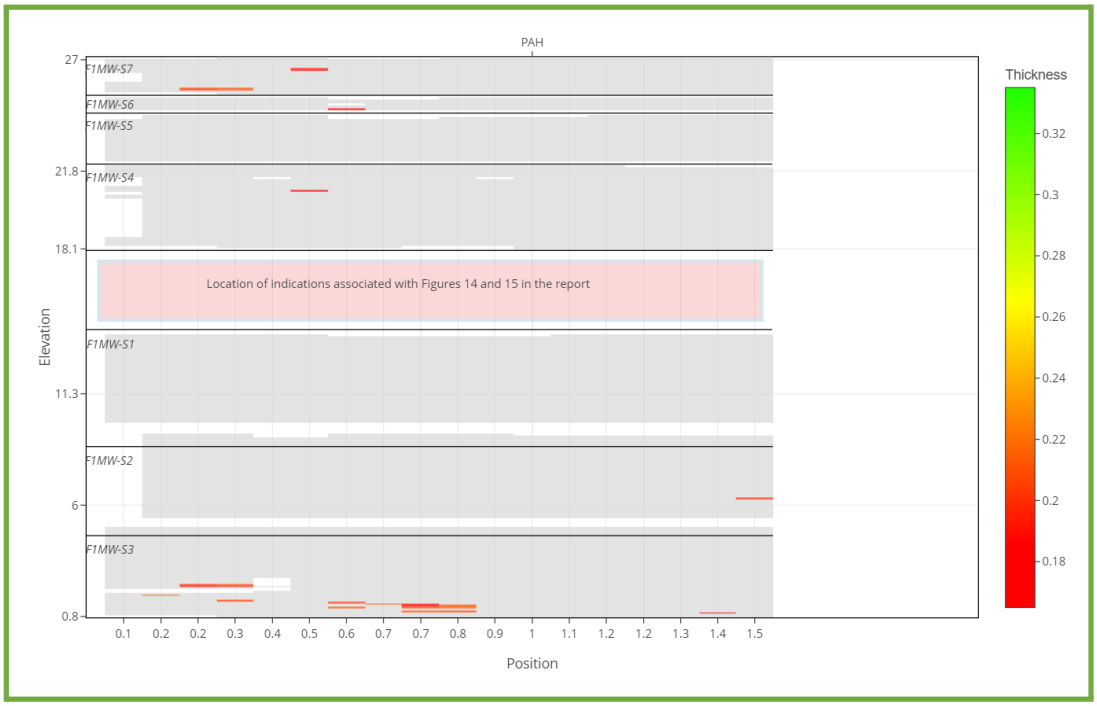
Figure 45
Personal Access System



PRELIMINARY REPORT - Gecko Job Number: 2021-02524

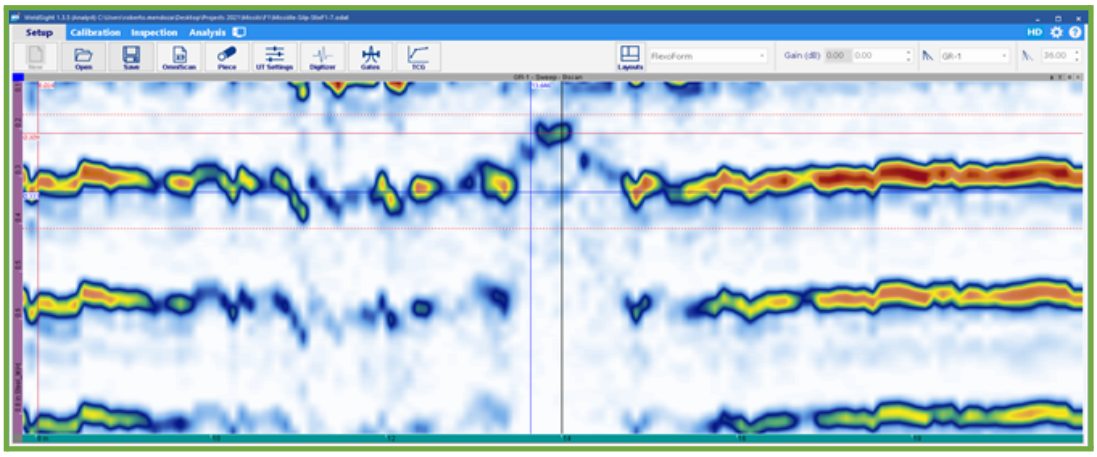
To access your entire inspection log on to the Gecko Portal ™ at portal.geckorobotics.com with your username and password. If you do not have a username/password or you are having issues with the Portal please email us at sales@geckorobotics.com.

Figure 46
Personal Access System - Areas 15% Below Nominal



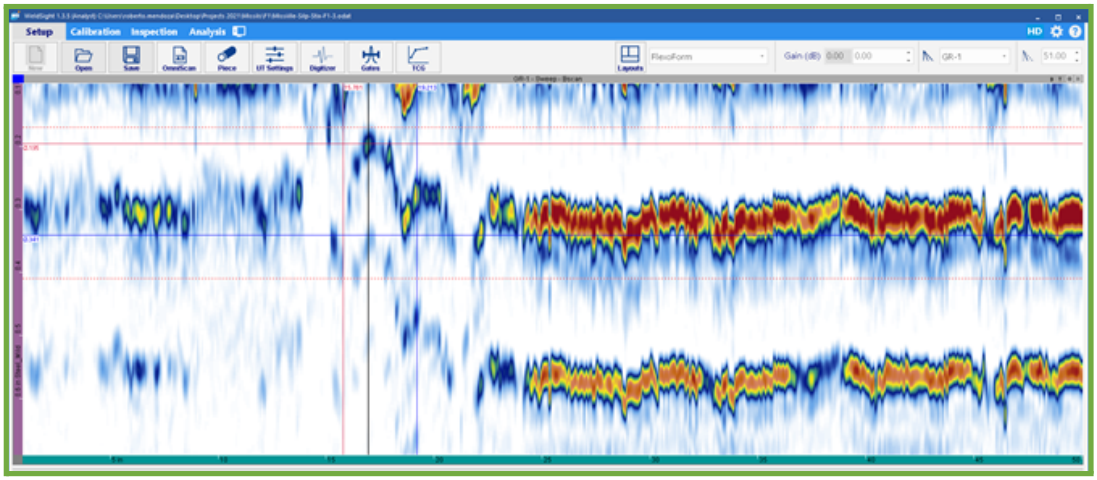
8.3. Personal Access System - B-scan Data

Figure 47
PAUT B-scan Image/ F1MW-S7 0.164 Remaining Thickness (Area 1)



GeckoRobotics
888.350.8960
Pittsburgh, PA • • • Houston, TX

Figure 48
PAUT B-scan Image/ F1MW-S3 0.151 Remaining Thickness (Area 2)



9. Equipment Information

RUG Equipment
Figure 49

Robot/DAQ Model		Serial Number	
TOKA 4.0.2 / AOS		CB-402-27 / MC32MN2P0571818	
Transducer Serial Number	**Sled Number**	**Frequency**	**Diameter**
U118ZF	1	10 MHz	0.125”
U1191V	2	10 MHz	0.125”
U1198G	3	10 MHz	0.125”
U11992	4	10 MHz	0.125”
U1199D	5	10 MHz	0.125”
U1199G	6	10 MHz	0.125”
U1199X	7	10 MHz	0.125”
U119DE	8	10 MHz	0.125”
U119KE	9	10 MHz	0.125”
U119QV	10	10 MHz	0.125”
U11A28	11	10 MHz	0.125”
U11ADQ	12	10 MHz	0.125”
U119B3	13	10 MHz	0.125”
U119G3	14	10 MHz	0.125”
U119HH	15	10 MHz	0.125”
U119IQ	16	10 MHz	0.125”
U119KK	17	10 MHz	0.125”
U119KV	18	10 MHz	0.125”
U119LY	19	10 MHz	0.125”
U119WG	20	10 MHz	0.125”
U119WZ	21	10 MHz	0.125”
U11A7K	22	10 MHz	0.125”
U11GJG	23	10 MHz	0.125”
U118XN	24	10 MHz	0.125”
Calibration Block Size		**Serial Number**	
1018 Steel 5 Step (0.100” - 0.500”)		19-3504	
Thermometer Model		**Serial Number**	
Fluke IR Thermometer		45963012MV	

Figure 50 - Calibration Records

Date	Cal Block Temperature (°F)	Inspection Surface Temperature (°F)
10/26/21	Ambient	Ambient
10/27/21	Ambient	Ambient
10/28/21	Ambient	Ambient

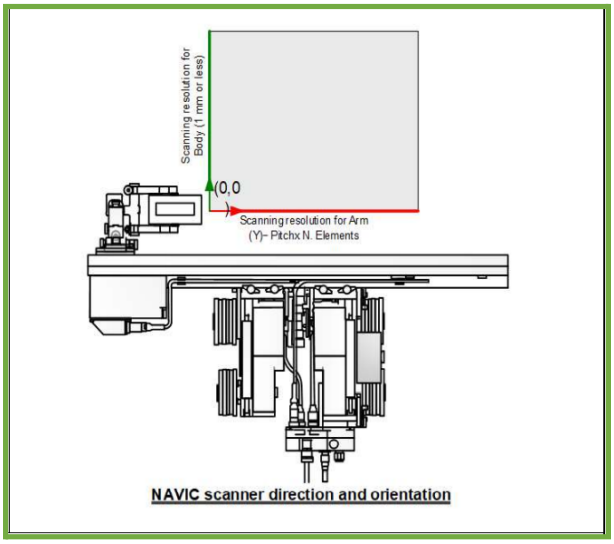
Figure 51 - Verification Times

Calibration Verification Times	
Date	**Times**
10/26/21	12:00p and 3:00p
10/27/21	8:30a and 3:00p
10/28/21	8:30a and 10:30a

Figure 53 - PAUT Equipment

Instrument: (Olympus-NDT)	☐ OmniScan MX2 ☐ OmniScan MX1 S/# : QC-0074481 Cal due: 10-01-2022							Software: MXU-M Version: 5.4				
	☒ OmniScan X3 ☒ EPOCH 650 S/# : 20193506 Cal due: 07-22-2022							Module: PA32128PR				
Scanner : ☒ Manual ☒ NAVIC ☒ Stix-Encoder								**Cables:** ☒ Coaxial cable ☒ 6' (Standard) ☐ Other				
Encoder Cal. : 20" (minimum 20")								**Couplant:** ☒ Potable Water ☒ Ultra-Gel II (Sonotech)				
Scan Resolution : ☒ 0.100" (< 3" T) ☐ 0.080" (> 3" T) ☐ Others								☐ Other				
Reference block : Step wedge 0.100 to 0.500"								**Calibration block** : ☒ ASME Sect. V 0.250"-0.500" ☒ Other : NAVSHIP (S/# 20985)				
Search unit												
Manufacturer	**Type**	**Serial #**	**Freq. (MHz)**	**Number of Element**	**Size of Element (mm)**	**Pitch (mm)**	**Gap (mm)**	**Active Aperture (mm)**	**Angular Range used**	**Angular Incremental change**	**Range of Element # used**	**Element Incremental change**
Olympus	5L60-A14	V3632	5	60	10	1.0	0.1	60	0 Linear	1	1-60	8
Olympus	DLA	V3676	7.5	64	0.52	0.6	0.08	30	40-70	1	1-16	1

Wedges			**Calibration**									
Manufacturer	**Part Number**	**Refracted angle**	**Reference level gain**	**Scanning Level gain**	**Transfer Value**	**TCG/ DAC**	**Reference Flaw Type**	**Reference Flaw size**	**Focal depth**	**Damp. (Ohm)**	**Reject.**	**PCS (TOFD)**
Olympus	SA14-0L	0°	12 dB	+ 0 dB	0 dB	TCG	N/A	0.040"	0.3"	--	0	--
Olympus	integrated	0°	15 dB	+0 dB	0 dB	TCG	N/A	0.040"	0.3"	--	0	--



NAVIC scanner direction and orientation

NDE AND GEOPHYSICS FOR INFRASTRUCTURE ASSESSMENT

– BEYOND VISUAL –

Olson ENGINEERING

Corporate Office:
12401 W. 49th Avenue
Wheat Ridge, CO 80033 USA
phone: 303.423.1212
fax: 303.423.6071

October 23, 2023

Gecko Robotics
100 S Commons Suite 145,
Pittsburgh, PA 15212

Attn: Mr. Ed Bryner
Director of Engineering
Tel: 888-350-8960
Cell: 410-610-1070
Email: ed.bryner@geckorobotics.com

Re: Report of Nondestructive Evaluation (NDE) Investigation
Steel-Lined Concrete Silo Wall Investigation
Delta 09 Silo
Wall, SD
Olson Job No. 7277A

Mr. Bryner,

We are pleased to submit this report regarding the nondestructive evaluation (NDE) investigation of the lower 52 feet of the cylindrical steel and concrete walls of the Delta 09 Silo outside of Wall, SD. The investigation was done to map out concrete conditions and thicknesses, and as well as locate areas of possible steel to concrete debonding on the silo wall. We understand that the primary objective of the investigation is to assess the internal condition of the concrete behind the steel facing plate. The results will be used to evaluate the concrete condition for comparison to other testing results already obtained at this site. The fieldwork was performed by Dennis Sack and Callia Cortese of Olson Engineering, with the help of onsite personnel from both Gecko Robotics and The National Park Service. The testing was conducted on September 18-19, 2023. Below is a detailed description of the methods performed as well as the results of the investigation.

Executive Summary

Olson Engineering performed Impact Echo (IE) and Spectral Analysis of Surface Waves (SASW) on the steel lined concrete silo wall in three major areas designated “Upper Wall”, “Lower Wall”, and “Floor”. The Upper Wall area was tested in all accessible areas from the top of concrete down to 20-26 feet below the top of concrete. The Lower Wall area was tested in three zones, including North, South, and Northwest, from the wall base to 6 feet above the base. The Floor area was tested in accessible areas of the round floor at the base of the silo. The testing was performed in a 2-foot grid in the Upper Wall area, a 1 to 2-foot grid on the Lower Wall areas, and a 1-2 foot grid on the floor.

The results of the IE and SW testing indicated a variety of conditions on the walls and floor. A total of 392 IE tests were conducted. Of these, 234 were "Sound", 67 showed "Thin" echoes (likely cracking near the back wall concrete), 14 showed "Very Thin" echoes (likely cracking shallower in the concrete) and 77 were debonded. A total of 258 points were tested with the SASW method (a looser grid was used in some of the lower wall and floor areas for this test). Of these, 131 were "Sound", 27 showed velocity drops near the front face, 41 showed velocity drops in the middle of the wall concrete, 22 showed velocity drops near the back side of the concrete, and 37 were found to be debonded. Note that the SASW test method is somewhat less sensitive to debonding than the IE test method. The overall results are presented graphically below, and in tabular format in Appendix A.

Project Background

Olson Engineering performed Impact Echo (IE) and Spectral Analysis of Surface Waves (SASW) to evaluate the integrity of the concrete behind the front steel in the silo, as well as to identify areas with steel to concrete debonding. The testing was conducted on all accessible wall areas that had concrete behind, as well as accessible areas of the silo floor. Based on drawings and the test results, it appears that the very top of the wall has a concrete thickness of 12-15 inches (top 2-3 feet). Below this, the expected thickness is nominally 18 inches down the limits of the upper wall area. The lower wall areas appeared to have a concrete thickness of 15-28 and the floor a nominal thickness of 30-50 inches. Note that a wide range of measured thicknesses was seen even for areas considered to be "sound". As noted, the primary objective of the investigation was to assess the condition of the concrete behind the steel, while also noting locations with steel to concrete debonding. A photo of typical testing on the upper wall area (from a Spider lift) is shown below in Figure 1.



Figure 1. Typical SASW Testing of the Upper Wall from the Spider Lift.

Impact Echo Results (IE)

The results of the IE testing indicated a variety of conditions to be present, with a majority of the column being in sound condition. The IE data was interpreted based on comparing the thickness echoes measured at each point to the average values found in apparent "sound" areas of the wall and floor areas. A statistical summary of the IE results is presented below in Table I. The actual results are presented below in graphical format, with tabular summaries presented in Appendix A. For the graphical presentations of the IE results (Figures 2-6), grey indicates Sound condition, yellow indicates Thin echoes, Red indicates Very Thin echoes, and black indicates steel to concrete debonding.

Table I – IE Test Results Summary

Area	Sound	Thin	Very Thin	Debonded
Upper Wall	103	23	5	40
Lower East	32	12	5	8
Lower NW	29	9	2	9
Lower South	32	11	2	14
Floor	38	12	0	6
Totals:	234	67	14	77

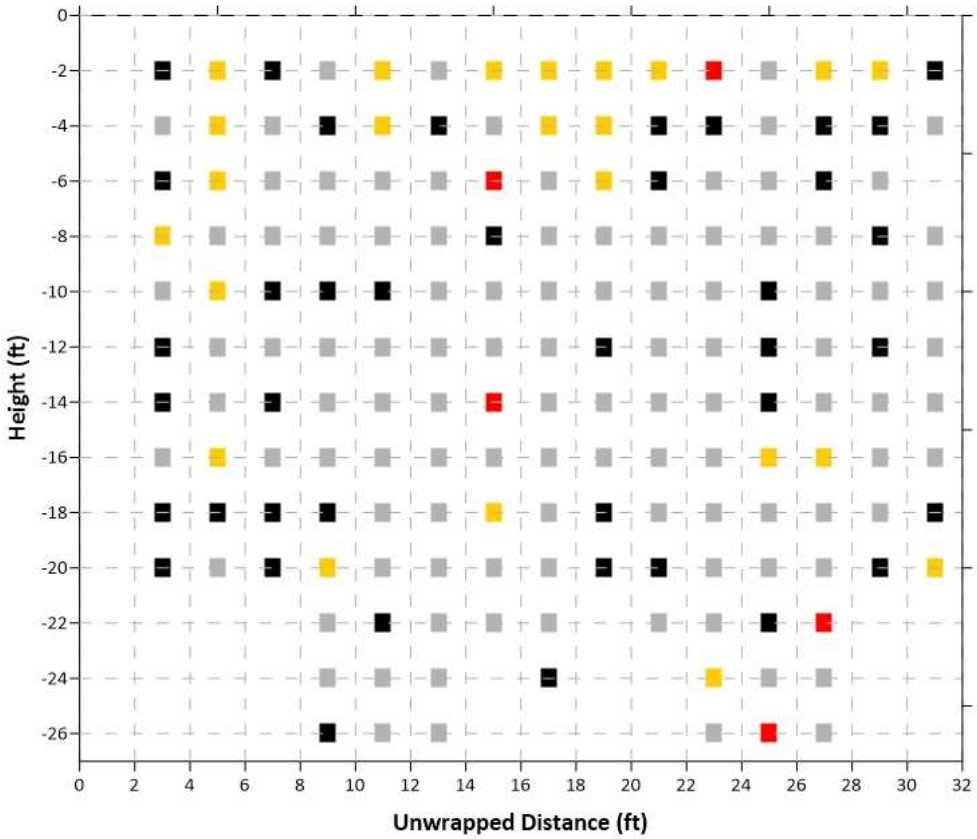


Figure 2. Upper wall IE results.

Grey = Sound
Yellow = Thin
Red = Very Thin
Black = Debonded

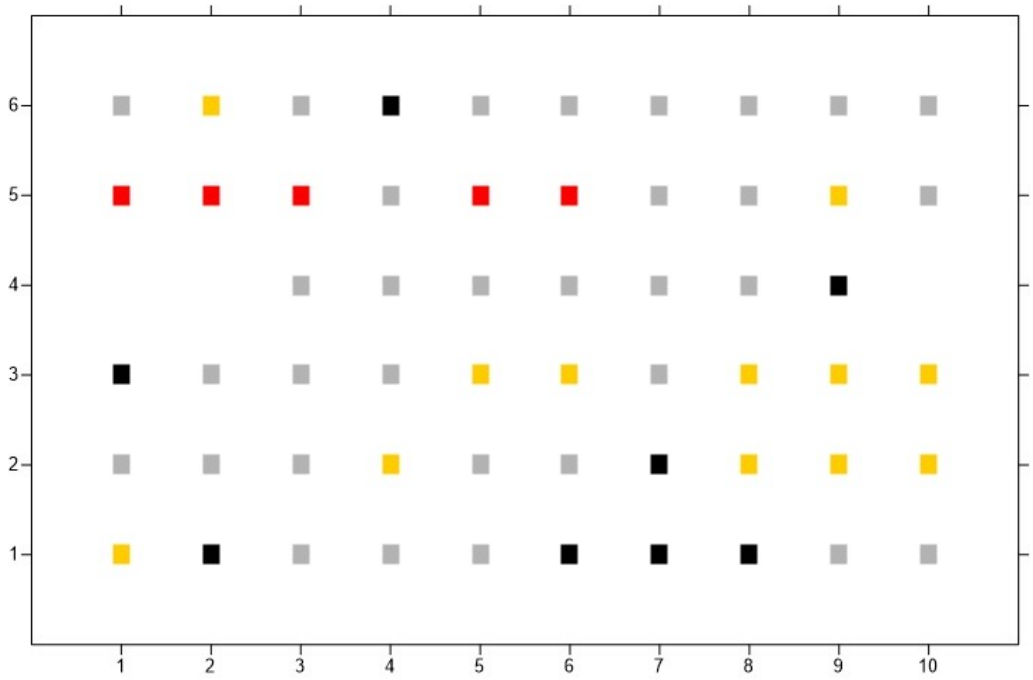


Figure 3 – Lower East Wall IE Results

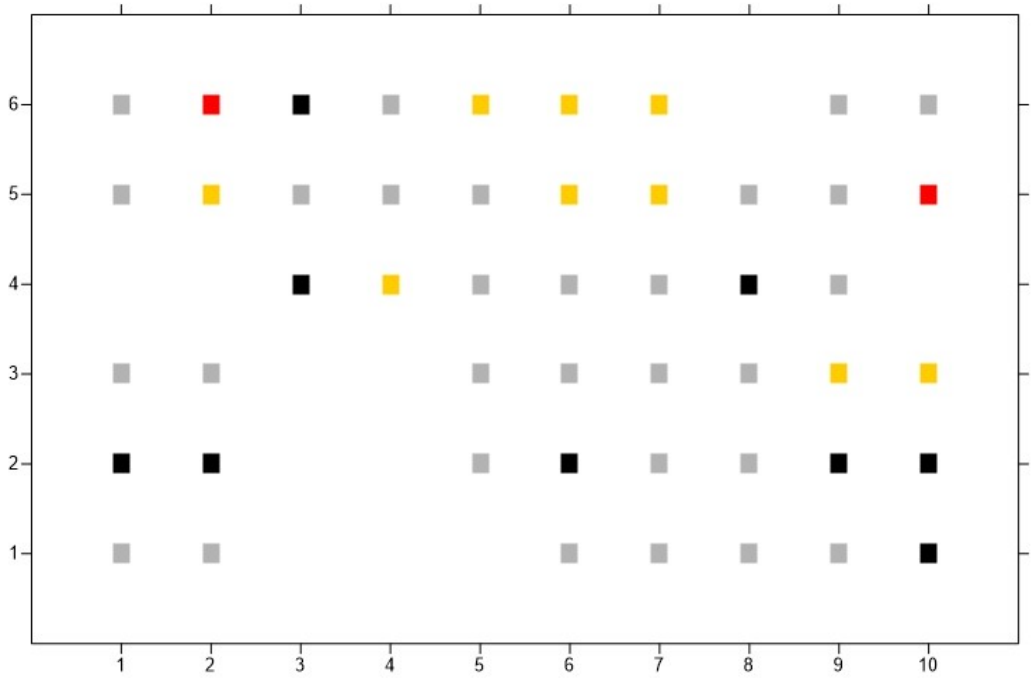


Figure 4 – Lower Northwest Wall IE Results

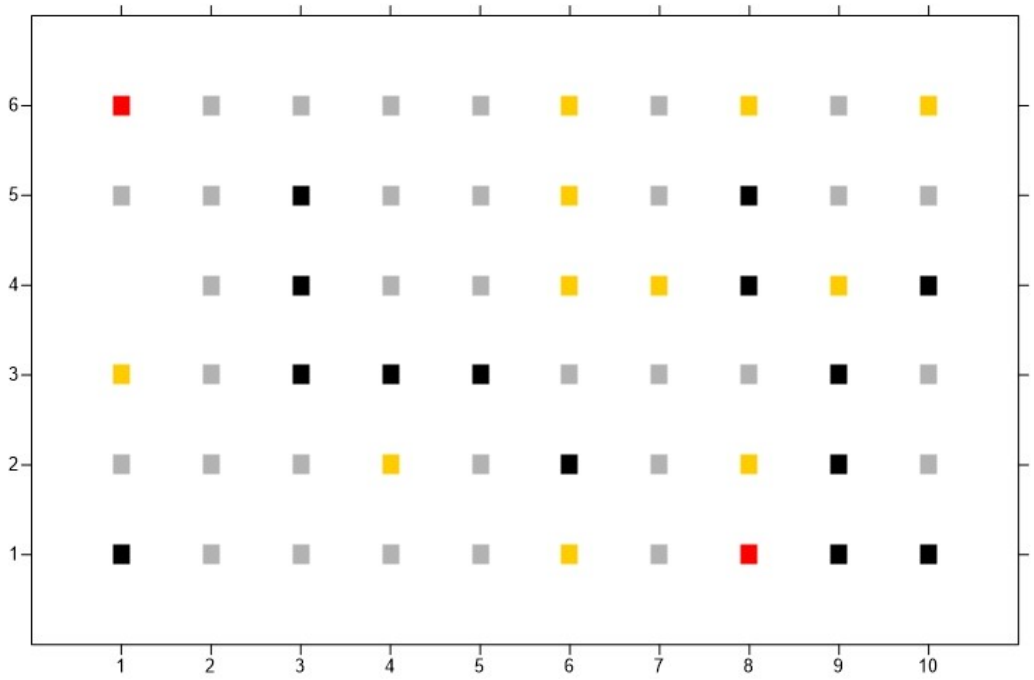


Figure 5 – Lower South Wall IE Results

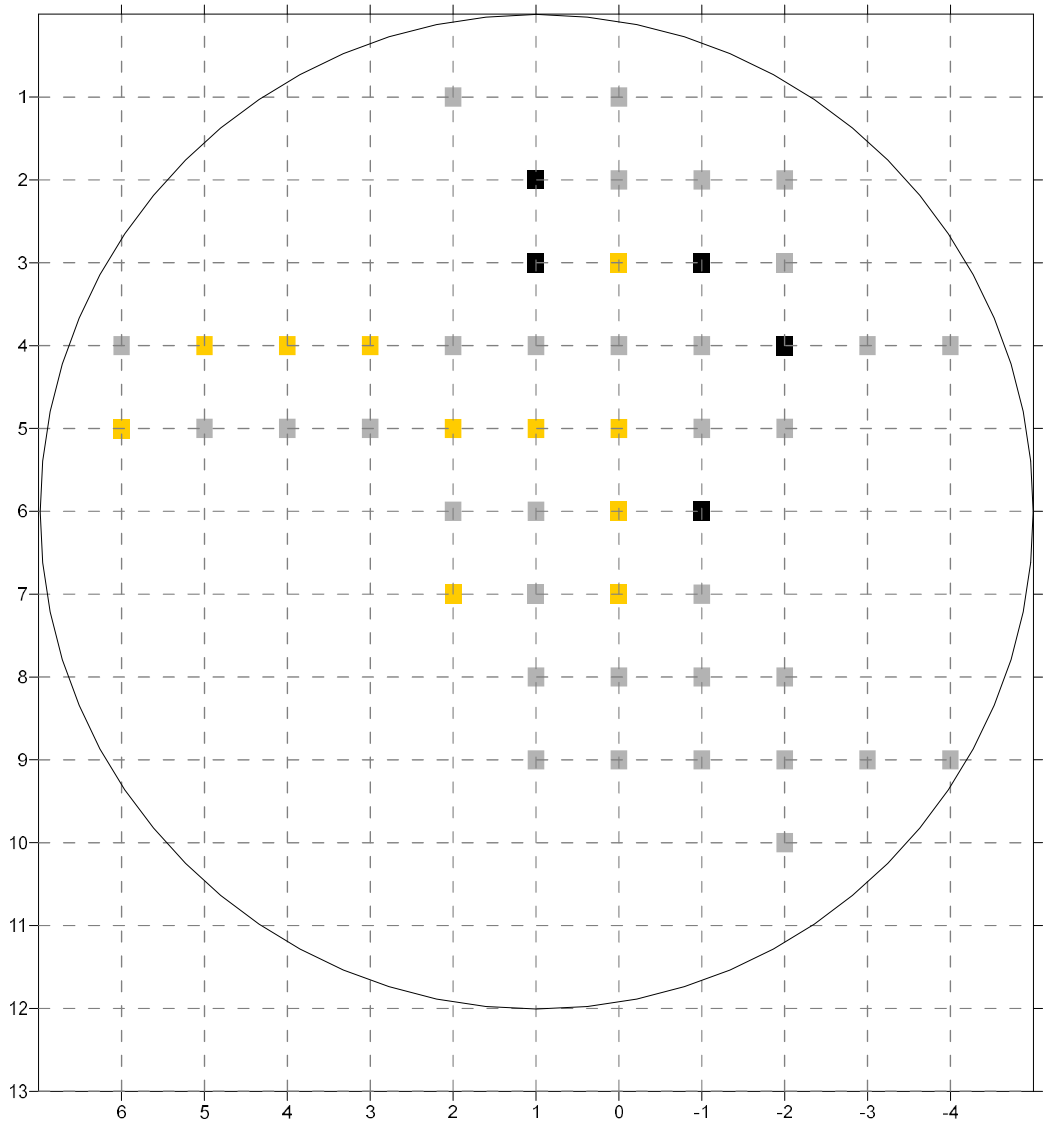


Figure 6 – Floor IE Results (North at top)

Spectral Analysis of Surface Waves (SASW)

The SASW testing method allows for the detection of perpendicular cracks (relative to the wall surface) or void/degraded concrete zones within the concrete. The SASW results are categorized based on the surface wave velocity of the concrete versus depth, and thus an interpretation of the material's condition along the depth can be assessed. Below is an example of a sound SASW test in the upper wall area.

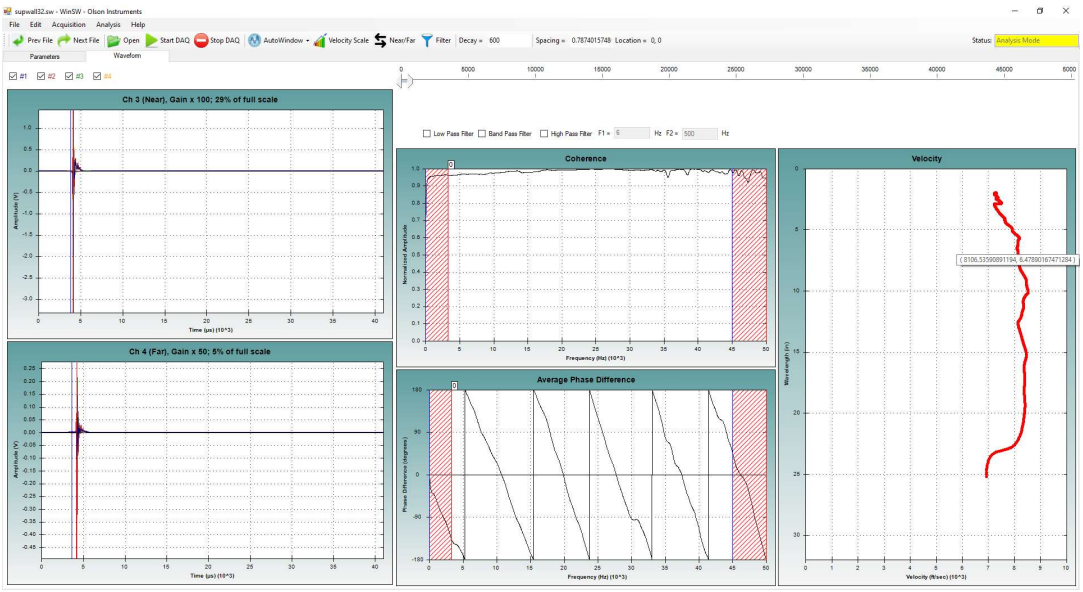


Figure 7. SASW Example of Sound Results. The leftmost plots are time vs. voltage response plots for both transducers, one being near the hammer impact and the other being the far one. Upper center plot is the Coherence. Lower center plot is the wrapped phase difference between the far and near transducers. The Velocity plot on the right shows velocites (in 1000's of ft/second) vs wavelength (in inches – approximate depth) is calculated from the phase plot and is plotted.

A Sound SASW test will result in a relatively constant surface wave velocity plot versus depth of the material, with the velocity being within the acceptable values for the testing material. As seen in Figure 7, the only drop in this plot is at about 23 inches, which is at about the expected concrete wall back side thickness. A poor SASW test result will show a velocity drop at some point in the plot shallower than the normal expected thickness.

A tabular summary of the SASW results in presented below in Table II. Graphical presentations of the results are presented below in Figures 8-12, while the overall results are presented in Appendix A. The results plots shown below are plots of the SASW results for each wall and floor area tested with grey being sound, yellow indicating a shallow drop (low velocity near the steel interface), orange indicating a deep drop (low velocity at the back side of the concrete or "Thin" concrete), red indicating a drop at mid-wall (low velocity zone sandwiched between apparently sound concrete at front and back), and black indicating steel to concrete debonding.

Table II – SASW Test Results Summary

Area	Sound	Shallow Drop	Middle Drop	Deep Drop	Debonded
Upper Wall	84	18	36	11	24
Lower East	31	6	1	8	3
Lower NW	3	2	1	0	4
Lower South	6	0	1	2	4
Floor	7	1	2	1	2
Totals:	131	27	41	22	37

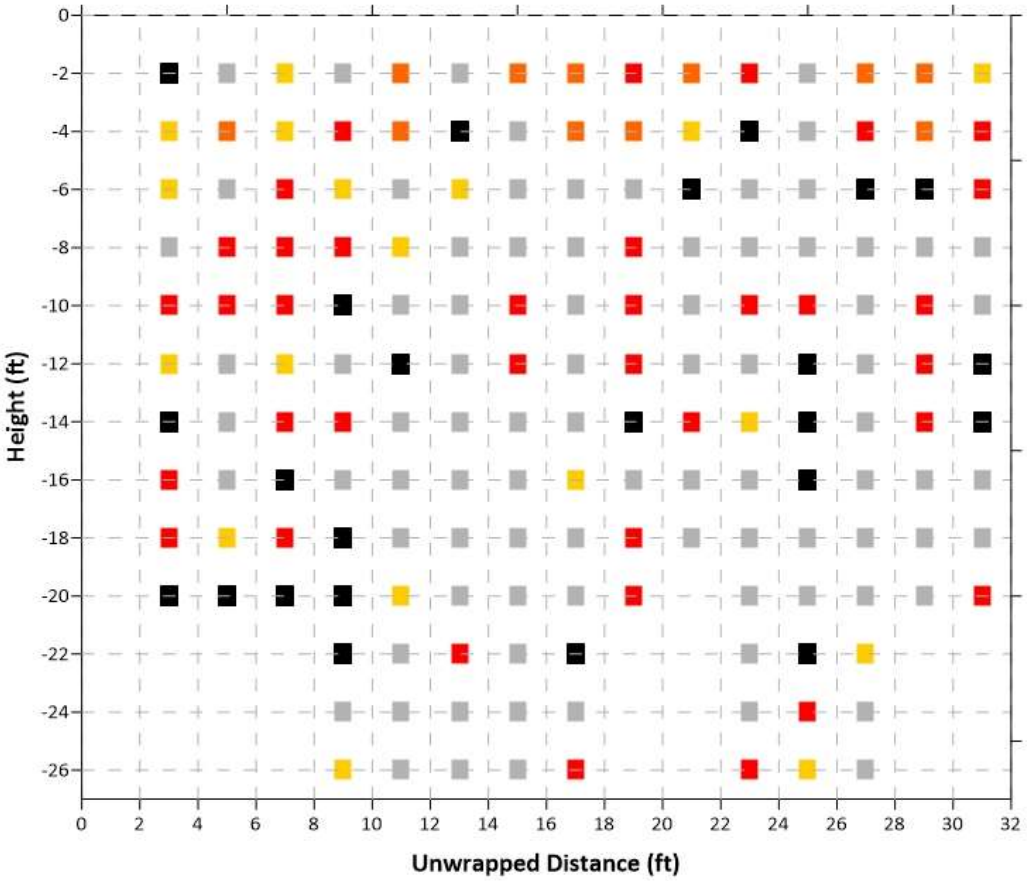


Figure 8. Upper Wall SASW Results

Grey = Sound
Yellow = Shallow Drop (front face)
Orange = Deep Drop (back side)
Red = Middle Drop (mid-wall)
Black = Debonded

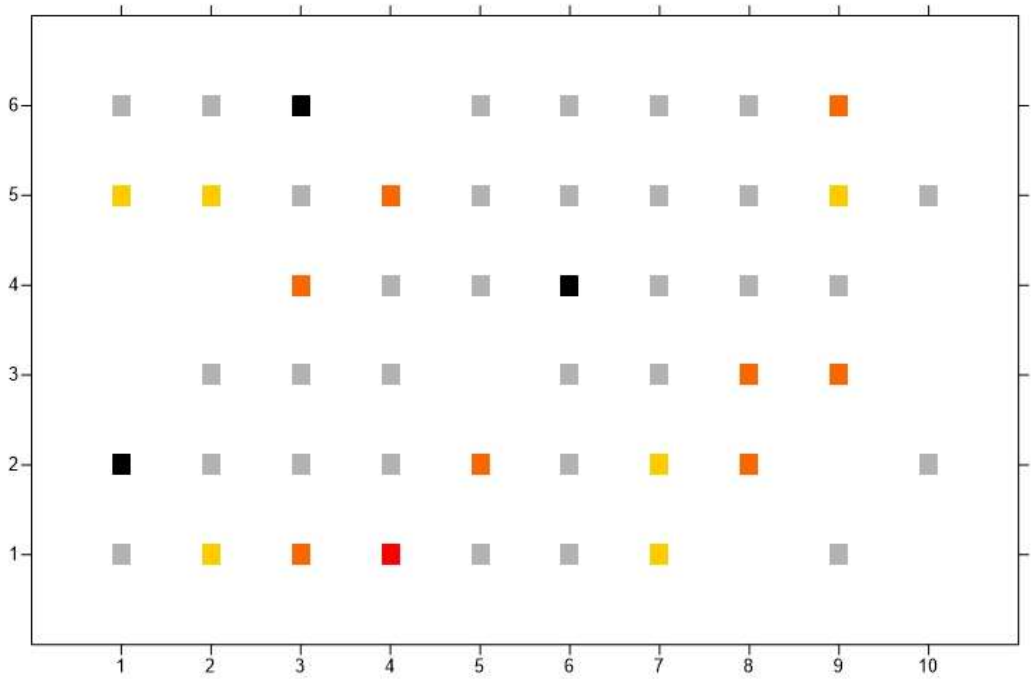


Figure 9 – Lower East Wall SASW Results

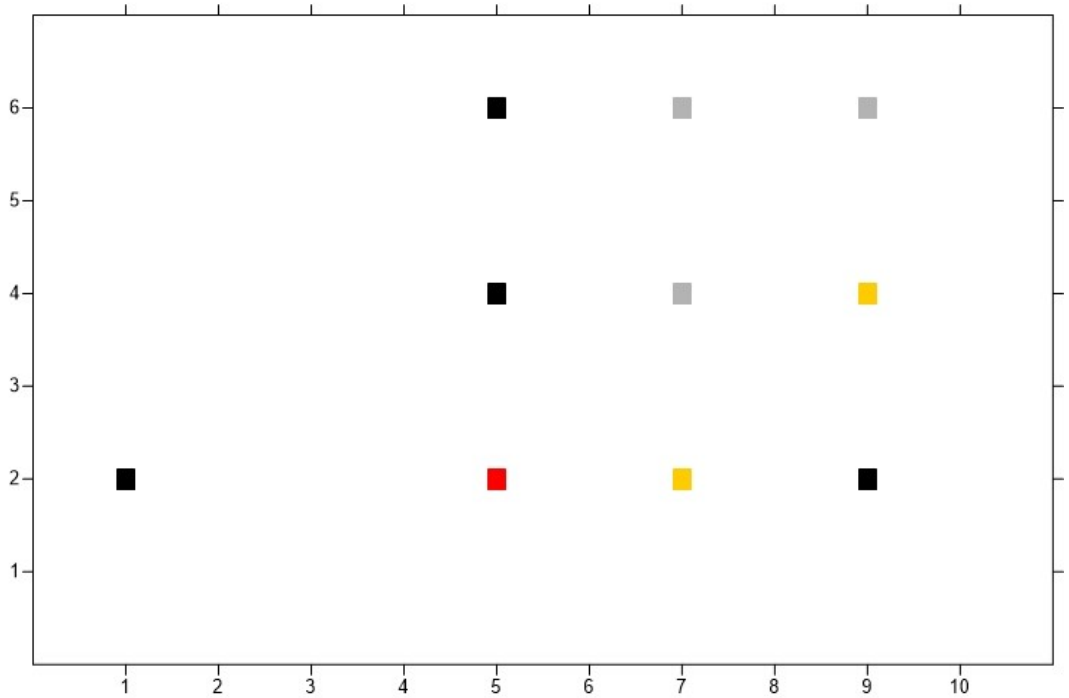


Figure 10- Lower Northwest Wall SASW Results

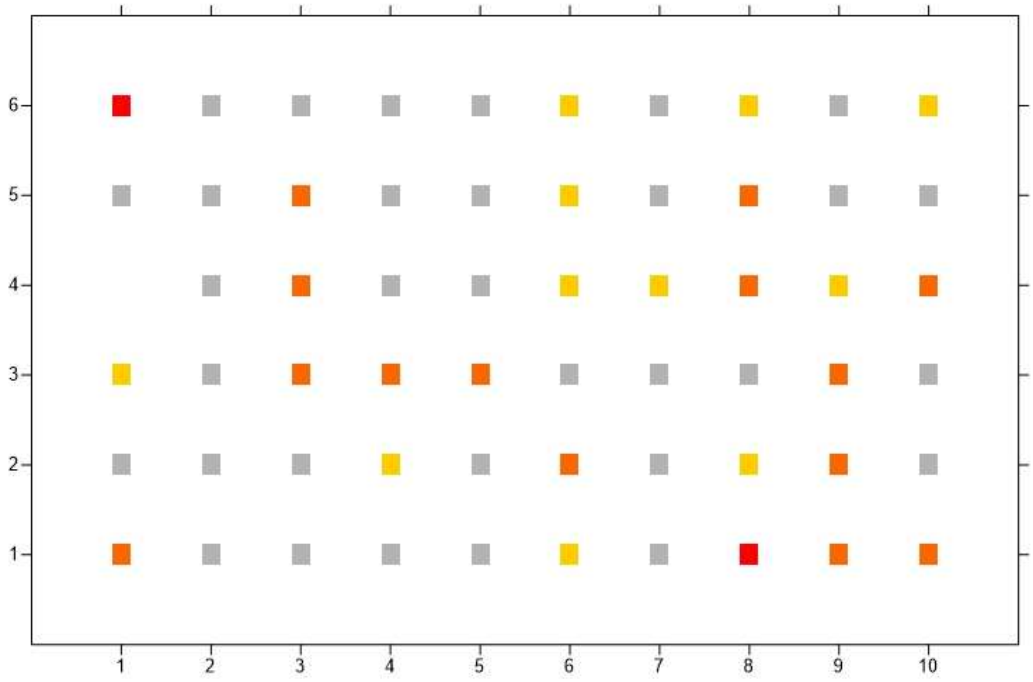


Figure 11 – Lower South Wall SASW Results

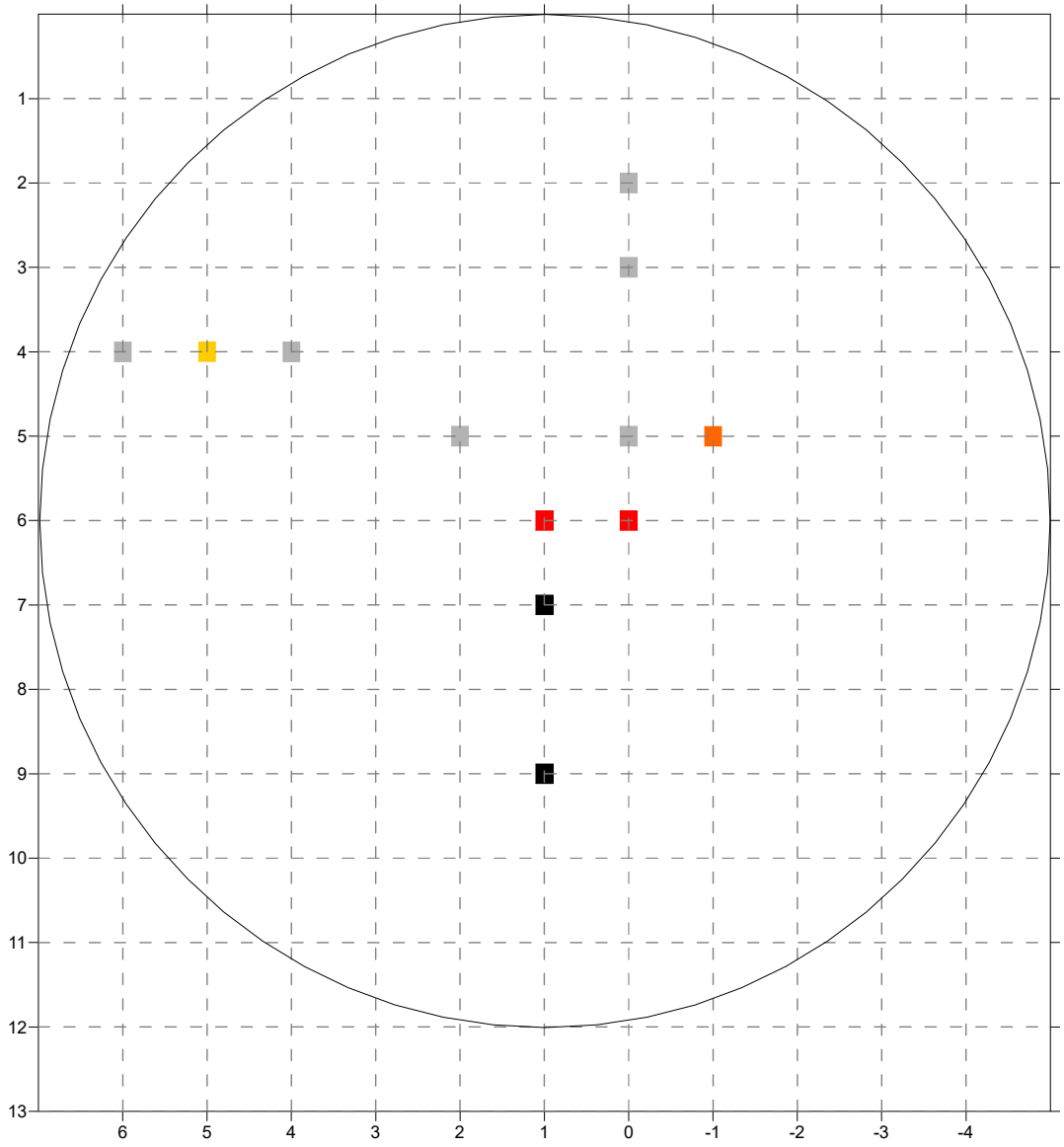


Figure 12 – Floor SASW Results

NONDESTRUCTIVE EVALUATION (NDE) TEST METHODS

Impact Echo (IE) Test Method (ASTM C1383)

The IE method involves impacting the concrete surface with a small hammer impactor or similar and identifying the reflected wave energy with a displacement or accelerometer receiver mounted on the surface near (within 50 mm, 2 inches) the impact point. A simplified diagram of the method is presented in Figure 13 for point-by-point testing with the IE-1 test head, with a photo of the actual test head on a wall presented in Figure 14. The hammer impacts the concrete or steel to excite the resonant echoes and the resulting voltage versus time signal response of the displacement transducer is recorded for each test. The resonant echoes are usually not apparent in the time domain. The resonant echoes are more easily identified in the frequency domain. Consequently, the time domain test data are processed with a Fast Fourier Transform (FFT) which allows identification of frequency peaks (echoes). The displacement spectrum of the receiver response is used to determine the resonant echo peaks. If the thickness of a structural member is known, the factored IE compressional wave velocity (V_P) and member echo thickness can be determined by the following equations:

$$V_P = 2*d*f/\beta \text{ and} \quad (1)$$

$$d = \beta*V_P/(2*f) \quad (2)$$

Where d = concrete thickness, f = resonant frequency peak. The above equation is modified by a β (Beta) factor of 0.96 for walls and slabs. A factored compressional wave velocity of 12,110 ft/s was used to calculate the depth of the dominant echo peaks in the IE results. The data was recorded on a Freedom Data PC from Olson Instruments.

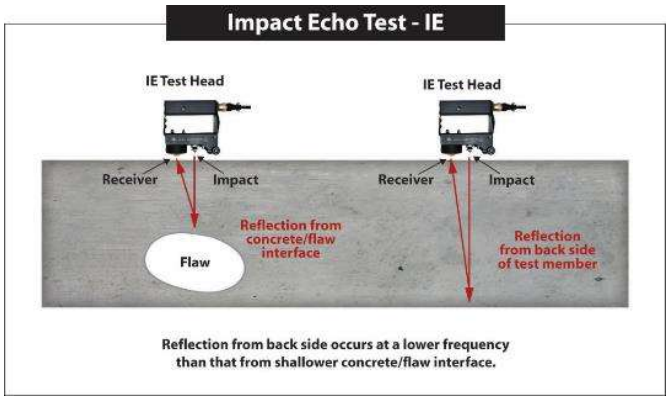


Figure 13. Illustration of Impact Echo (IE) Test Method.



Figure 14. IE Test head being used on the wall for testing.

Spectral Analysis of Surface Waves (SASW) Test Method

The SASW method is based upon measuring surface waves propagating in layered elastic media and is simply illustrated in Figure 15. A photo of actual SASW testing is presented in Figure 16. The ratio of surface wave velocity to shear wave velocity varies with Poisson's ratio. However, reasonable estimates of Poisson's ratio and mass density for concrete and other materials can be made. Therefore, knowledge of the surface wave velocity combined with reasonable estimates of mass density and Poisson's ratio allows calculation of shear moduli for low-strain amplitudes.

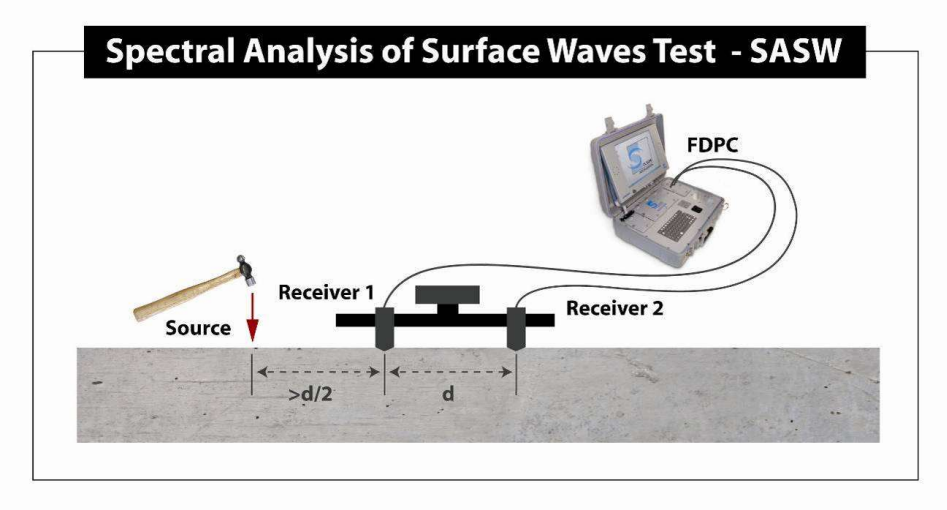


Figure 15. Spectral Analysis of Surface Waves (SASW) Test Diagram.

Surface wave (also termed Rayleigh; R-wave) velocity will vary with frequency in a layered system with differing material velocities. This variation in velocity with frequency is termed dispersion. A plot of surface wave velocity versus wavelength is called a dispersion curve. In a semi-homogeneous material such as concrete or asphalt the wavelength of the surface wave is approximately equal to the penetration depth, therefore the dispersion curve can be evaluated as a plot of material velocity versus depth from the test surface. However, during data interpretation it is important to understand that longer wavelength velocities are affected by all material between the associated wavelength (depth) and the test surface.

The distance between receivers affects the penetration depth of the test, typically wavelengths of 1.5 – 2.0 times the receiver spacing can be evaluated depending upon the noise level in the data. A metal impactor is typically used as an impact source to induce the measured surface waves. The impactor strike must be in-line with the two transducers in order to ensure that the wave travel distance between receivers is accurate. The impactor size is chosen based upon the frequencies of interest (desired penetration depth) and is therefore also correlated with the receiver spacing. For greater penetration wider receiver spacings and larger impact hammers are used.

Wavelength (λ), frequency (f), and wave velocity (V_r), are related as follows:

$$V_r = f*\lambda \quad (2)$$

The SASW testing and analyses included collection of field data in situ and the construction of experimental dispersion curves at each test point from the field data. The dispersion curve plots were used during data analysis to evaluate the bonding condition between the topping and structural slabs and the condition of both slabs. The phase information of the transfer function (cross power spectrum) between the two receivers for each frequency was the key spectral measurement.

The experimental dispersion curve is developed from the phase data for a given test point by knowing the phase (φ) at a given frequency (f) and then calculating the travel time (t) between receivers of that frequency/wavelength by:

$$t = \varphi / 360*f \quad (3)$$

Surface wave velocity (V_r) is obtained by dividing the receiver spacing (X) by the travel time at a frequency:

$$V_r = X / t \quad (4)$$

The wavelength (λ) is related to the velocity and frequency as shown in equation 2 above.

By repeating the above procedure for any given frequency, the surface wave velocity corresponding to a given wavelength is evaluated, and the dispersion curve is determined. The phase data was viewed on the PC data acquisition system in the field to ensure that acceptable data was being collected. The phase data were then returned to our office for further processing. The phase of the cross power spectrum (transfer function) between the two receivers are used to create the dispersion curves by masking unwanted (noisy or nonlinear) portions of the phase record from the data set for each test location and then performing the above calculations to determine the surface wave velocity for all relevant frequencies.

The SASW test can be used to locate delamination or debonded layers as well as deteriorated layers. The SASW tests evaluates the average velocity or condition between the two receivers, therefore the further apart the receivers (greater penetration depth) the larger the area evaluated. As in many kinds of testing, an increase in penetration depth also yields a loss in resolution (average over greater distance).



Figure 16. SASW testing being performed on the Lower Wall area.

CLOSURE

The field portion of this NDE investigation was performed in accordance with generally accepted testing procedures. If additional information is developed that is pertinent to the findings of this investigation or we can provide any additional information or consultation on potential repairs, please contact our office.

Respectfully submitted,
OLSON ENGINEERING, INC.

_____
Dennis Sack, P.E.
Sr. Vice President

(1 copy emailed)

APPENDIX A

IE AND SASW TEST RESULTS

Table A-1 – Upper Wall Results

Radial Distance (ft)	Distance Down (ft)	Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
3	2	61.5		Debond	5500	0-4	Rough
3	4	21.1			5000	0-2	
3	6	32.1		Debond	5000	0-5	
3	8	11.0		Thin	8700		Rough to 11
3	10	25.0			3700	2-7	Dipping
3	12	29.5		Debond	3500	0-3	Rising
3	14	52.7		Debond	2000	2-end	Dropping
3	16	16.8			4500	2-5	Dipping
3	18	72.6		Debond	4000	2-3	Dipping
3	20	61.5		Debond	3000	2-end	Dropping
5	2	10.5		Thin	7000		
5	4	12.7		Thin	8800		Drop at 15
5	6	14.3		Thin	7500		
5	8	16.2			4500	2-7	
5	10	10.3		Thin	4000	2-4	Dipping
5	12	19.9			7000		
5	14	27.8			7300		
5	16	13.9		Thin	7800		
5	18	35.1		Debond	3500	0-7	Rising
5	20	19.4			3000		Debonded
7	2	31.7		Debond	7000	0-3	Rising
7	4	17.3			5500	0-5	Rising
7	6	16.5			4000	4-7	Dipping
7	8	20.8			4000	3-6	Dipping
7	10	67.0		Debond	3500	2-5	Dipping
7	12	26.8			6000	0-2	Rising
7	14	30.7		Debond	5000	2-5	Dipping
7	16	17.1			3000	All Low	Debonded
7	18	54.6		Debond	4000	2-5	Dipping
7	20	39.9		Debond	2300	All Low	Debonded
9	2	17.3			6000		Rough
9	4	42.2		Debond	5500	7-10	Dipping
9	6	16.7			4000	0-3	Rising
9	8	19.7			4500	3-5	Dipping
9	10	41.0		Debond	2500	All Low	Debonded
9	12	18.0			7800		
9	14	17.8			4000	2-5	Dipping

Radial Distance (ft)	Distance Down (ft)	Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
9	16	18.9			6000		Rough
9	18	33.5		Debond	2000	All Low	Debonded
9	20	13.7		Thin	2500	All Low	Debonded
9	22	16.9			1500	All Low	Debonded
9	24	15.2			6400		
9	26	32.1		Debond	3000	0-5	Rising
11	2	10.4		Thin	7000		Drop at 12
11	4	10.1		Thin	7000		Drop at 11
11	6	15.2			8000		
11	8	16.4			6000	0-3	Rising
11	10	31.4		Debond	8000		
11	12	18.9			N/A		Debonded
11	14	17.6			7700		
11	16	17.8			7500		
11	18	18.0			7300		
11	20	18.4			6000	0-3	
11	22	37.8		Debond	7000		Rough
11	24	20.5			7300		
11	26	17.3			7500		
13	2	22.8			7200		
13	4	30.1		Debond	6000		ch2 debonded
13	6	15.5			5000	0-4	Rising
13	8	17.6			7600		
13	10	23.1	Poor Data		7900		
13	12	18.9			7700		
13	14	18.0			7300		
13	16	19.1			7500		
13	18	20.5			7800		
13	20	23.0			7500		
13	22	23.0			5000	2-5	Dipping
13	24	21.1			7000		
13	26	20.5			7000		
15	2	10.7		Thin	7000		Drop at 12
15	4	17.1			7200		
15	6	8.5	Poor Data	Very Thin	7700		
15	8	47.6		Debond	7500		

Radial Distance (ft)	Distance Down (ft)	Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
15	10	18.0			4500	2-4	Dipping
15	12	17.6			4000	2-3	Dipping
15	14	8.8		Very Thin	7000		
15	16	20.2			7800		
15	18	12.9		Thin	7800		
15	20	19.1			6300		
15	22	19.1			8000		
15	24			No Test	6000		Rough
15	26			No Test	7000		Rough
17	2	11.0		Thin	6900		Drop at 12
17	4	11.9		Thin	7800		Drop at 14
17	6	16.6			7300		
17	8	17.3			7300		
17	10	17.6			7400		
17	12	18.9			7800		
17	14	19.9			7200		
17	16	17.8			5500	0-3	Rising
17	18	15.9			7700		
17	20	22.0			7000		
17	22	20.2			2000	2-end	Dropping
17	24	50.8		Debond	7000		Rough
17	26			No Test	4500	2-5	Dipping
19	2	11.8		Thin	3000	2-4	Dipping
19	4	12.7		Thin	7000		Drop at 13
19	6	11.3		Thin	7300		
19	8	17.0			3300	2-5	Dipping
19	10	20.1			4500	3-7	Dipping
19	12	35.1		Debond	3500	2-3	Dipping
19	14	14.1			2000	All Low	Debonded
19	16	18.4			7300		
19	18	49.1		Debond	2000	2-3	Dipping
19	20	28.5		Debond	5000	7-9	Dipping
21	2	11.2		Thin	6800		Drop at 12
21	4	56.7		Debond	7000	0-2	Rising
21	6	42.1		Debond	2000	all low	Debonded
21	8	16.8			7500		
21	10	19.1			6500		Poor Data
21	12	17.8			7300		

Radial Distance (ft)	Distance Down (ft)	Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
21	14	17.8			3000	2-5	Dipping
21	16	18.9			7800		
21	18	17.3			7100		
21	20	47.6		Debond			No Test
21	22	19.1					No Test
23	2	7.9		Very Thin	4000	3-5	Dipping
23	4	32.8		Debond	4000	all low	Debonded
23	6	15.5			7600		
23	8	18.2			7800		
23	10	16.8			5000	2-4	Dipping
23	12	20.2			7800		
23	14	25.4			3500	0-5	Rising
23	16	21.7			7600		
23	18	20.2			7000		Poor Data
23	20	19.1			7800		Rough
23	22	24.6			8500		
23	24	14.5		Thin	8000		
23	26	19.3			3500	2-5	Dipping
25	2	23.0			7000		
25	4	20.9			7000		Rough
25	6	17.1			7300		
25	8	19.4			7600		
25	10	47.7		Debond	3000	1-3	Dipping
25	12	50.8		Debond	2000	all low	Debonded
25	14	42.1		Debond	3500	all low	Debonded
25	16	13.6		Thin	3500	All Low	Debonded
25	18	18.4			7600		
25	20	21.1			7800		
25	22	70.2		Debond	4000	all low	Debonded
25	24	20.8			4000	3-5	Dipping
25	26	9.7		Very Thin	4500	0-10	Rising
27	2	10.7		Thin	7500		Drop at 12
27	4	47.6		Debond	4000	3-6	Dipping
27	6	42.1		Debond	4200	All Low	Debonded
27	8	17.6			8200		
27	10	18.9			8500		
27	12	21.4			8200		
27	14	22.3			8500		

Radial Distance (ft)	Distance Down (ft)	Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
27	16	14.3		Thin	8000		
27	18	17.6			8000		
27	20	19.4			8800		
27	22	9.8		Very Thin	7000	0-3	Rising
27	24	23.8			6500		Poor data
27	26	16.7			8000		
29	2	10.9		Thin	8000		Drop at 12
29	4	47.6		Debond	7500		Drop at 11
29	6	29.5		Debond	4000	All Low	Debonded
29	8	56.7		Debond	7500		
29	10	20.5			5000	2-5	Dipping
29	12	47.6		Debond	4300	2-3	Dipping
29	14	15.7			4300	2-6	Dipping
29	16	18.9			8000		
29	18	20.2			8700		
29	20	42.1		Debond	8200		
31	2	81.9		Debond	4500	0-2	Rising
31	6	N/A	No Test		4000	2-5	Dipping
31	4	19.1			4700	3-5	Dipping
31	8	20.2			8500		
31	10	25.2			8000		
31	12	21.1			3500	All Low	Debonded
31	14	18.7			2000	All Low	Debonded
31	16	22.7			8400		
31	18	73.7		Debond	8300		
31	20	11.2		Thin	4500	2-6	Dipping

Table A-2 – Lower East Wall Results

Radial Distance South (ft)	Distance Up (ft)	IE Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
1	2	39.2			1800	All Low	Debonded
3	2	38.2			5000		
5	2	32.4			6000	6-end	Poor Data
7	2	42.5		Debond	3000	0-5	Rising
9	2	19.3		Thin			No Test
10	2	15.8		Thin	5000		
3	4	37.2			6000		Drop at 18
5	4	25.4			7000		Poor Data
7	4	29.9			6000		Drop at 30
9	4	42.5		Debond	6000		Poor Data
1	6	24.6			6500		Drop at 27
3	6	25.2			3800	All Low	
5	6	28.1			6500		Drop at 28
7	6	29.9			5000		
9	6	34.6			2500	2-end	Dropping
10	6	33.1					No Test
1	1	19.3		Thin	6000		
2	1	46.5		Debond	4000	0-3	Rising
3	1	30.3			7500	5-end	Dropping
4	1	39.4			4000	3-6	Dipping
5	1	29.1			6500		
6	1	135.3		Debond	6000		
7	1	165.5		Debond	5800	0-2	Rising
8	1	87.5		Debond			No Test
9	1	29.1			6300		
10	1	28.6					No Test
2	2	23.6			5500		
4	2	17.7		Thin	5800		
6	2	37.2			6000		
8	2	18.6		Thin	5800		Drop at 16
1	3	55.1		Debond			No Test
2	3	21.9			6500		
3	3	31.0			6200		

Radial Distance South (ft)	Distance Up (ft)	IE Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
4	3	23.1			6000		
5	3	10.3		Thin	N/A		Poor Data
6	3	19.3		Thin	5800		
7	3	28.6			5800		
8	3	16.9		Thin	6400		Drop at 14
9	3	12.3		Thin	6000		Drop at 11
10	3	11.7		Thin			No Test
4	4	32.4			5800		
6	4	28.1			4200	All Low	
8	4	31.0			6000		
1	5	7.5		Very Thin	5000	0-4	Rising
2	5	6.7		Very Thin	4000	0-2	Rising
3	5	9.1		Very Thin	5500		Poor Data
4	5	27.6			7000		Drop at 10
5	5	8.4		Very Thin	5300		
6	5	9.4		Very Thin	6200		
7	5	29.1			6100		
8	5	30.8			8000		Poor Data
9	5	18.6		Thin	5000	0-4	Rising
10	5	29.2			5800		
2	6	12.7		Thin	6000		Poor data
4	6	57.2		Debond			No Test
6	6	27.1			6600		
8	6	23.3			6000		Poor Data

Table A-3 – Lower Northwest Wall Results

Radial Distance East (ft)	Distance Up (ft)	IE Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
1	2	43.8		Debond	3500	All Low	Debond
5	2	37.2			3500	2-4	Dipping
7	2	21.3			3000	0-5	Rising
9	2	70.9		Debond	4000	All Low	Debond
10	2	49.6		Debond			No Test
3	4	70.9		Debond			No Test
5	4	30.4			N/A		Debond
7	4	29.2			6500		
9	4	31.7			4000	0-3	Rising
1	6	28.1					No Test
3	6	45.1		Debond			No Test
5	6	17.3		Thin	N/A		Debond
7	6	13.9		Thin	6500		
9	6	25.7			6000		
10	6	22.8					No Test
1	1	30.4					
2	1	37.2					
6	1	36.3					
7	1	21.0					
8	1	27.3					
9	1	29.2					
10	1	59.5		Debond			
2	2	74.4		Debond			
6	2	93.0		Debond			
8	2	29.1					
1	3	29.8					
2	3	34.6					
5	3	28.6					
6	3	28.4					
7	3	29.1					
8	3	27.1					
9	3	16.4		Thin			
10	3	16.4		Thin			
4	4	19.8		Thin			
6	4	20.7					
8	4	46.5		Debond			
1	5	21.9					

Radial Distance East (ft)	Distance Up (ft)	IE Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
2	5	19.6		Thin			
3	5	23.5					
4	5	21.3					
5	5	15.6					
6	5	10.1		Thin			
7	5	12.1		Thin			
8	5	31.7					
9	5	23.3					
10	5	5.5		Very Thin			
2	6	9.4		Very Thin			
4	6	24.0					
6	6	19.3		Thin			
8	6	20.0					

Table A-4 – Lower South Wall Results

Radial Distance West (ft)	Distance Up (ft)	IE Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
1	2	27.0			6200		Drop at 12
3	2	34.6			3000	All Low	Debond
5	2	21.6			2000	All Low	Debond
7	2	30.4			5900		
9	2	67.7		Debond	5800		
3	4	64.7		Debond	2000	All Low	Debond
5	4	29.8			6000	8-12	Dipping
7	4	15.5		Thin	5300		
9	4	14.7		Thin			No Test
1	6	7.9		Very Thin	N/A		Debond
3	6	28.1			6200		
5	6	27.6			6200	5-end	Poor Data
7	6	25.7			5600		
9	6	24.8			5500		
1	1	106.2		Debond			
2	1	37.2					
3	1	24.0					
4	1	26.1					
5	1	28.7					
6	1	19.8		Thin			
7	1	26.1					
8	1	8.9		Very Thin			
9	1	57.2		Debond			
10	1	55.1		Debond			
2	2	30.4					
4	2	15.3		Thin			
6	2	67.7		Debond			
8	2	19.2		Thin			
10	2	27.6					
1	3	10.8		Thin			
2	3	22.9					
3	3	46.5		Debond			
4	3	70.9		Debond			
5	3	59.5		Debond			
6	3	33.8					
7	3	23.3					
8	3	31.7					

Radial Distance West (ft)	Distance Up (ft)	IE Thickness (inches)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
9	3	48.0		Debond			
10	3	33.8					
2	4	27.1					
4	4	38.2					
6	4	13.5		Thin			
8	4	53.2		Debond			
10	4	46.5		Debond			
1	5	27.6					
2	5	20.1					
3	5	51.3		Debond			
4	5	34.6					
5	5	25.2					
6	5	11.0		Thin			
7	5	24.8					
8	5	46.5		Debond			
9	5	26.6					
10	5	16.2					
2	6	24.4					
4	6	25.2					
6	6	14.4		Thin			
8	6	12.6		Thin			
10	6	12.1		Thin			

Table A-5 – Floor Results

Distance W of N-S C/L (ft)	Distance South of 0,0 (ft)	IE Thickness (in)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
0	1	51.3					
2	1	57.2					
-2	2	33.1					
-1	2	57.2					
0	2	42.5			8000		
1	2	114.4		Debond			
-2	3	35.4					
-1	3	74.4		Debond			
0	3	29.3		Thin	8100		
1	3	62.0		Debond			
-4	4	36.6					
-3	4	46.5					
-2	4	87.5		Debond			
-1	4	42.5					
0	4	40.2					
1	4	43.8					
2	4	39.2					
3	4	22.9		Thin			
4	4	25.9		Thin	8000		
5	4	25.4		Thin	4000	0-15	Rising
6	4	33.8			7600		
-2	5	35.4					
-1	5	53.2			7000		Drop at 20
0	5	29.2		Thin	6500		
1	5	27.1		Thin			
2	5	19.1		Thin	7000		
3	5	39.2					
4	5	46.5					
5	5	40.2					
6	5	28.1		Thin			
-1	6	62.0		Debond			
0	6	22.5		Thin	4500	7-10	Dipping
1	6	36.3			5500	15-20	Dipping
2	6	43.8					
-1	7	55.1					
0	7	29.2		Thin			
1	7	36.3			N/A		Debond

Distance W of N-S C/L (ft)	Distance South of 0,0 (ft)	IE Thickness (in)	IE Notes	IE Condition	SASW Velocity (fps)	Low V Zones (inches)	SASW Notes
2	7	27.6		Thin			
-2	8	43.8					
-1	8	41.8					
0	8	43.8					
1	8	37.2					
-4	9	41.3					
-3	9	48.7					
-2	9	41.3					
-1	9	34.6					
0	9	41.8					
1	9	41.3			N/A		Debond
-2	10	39.2					
-1	10	40.5					
0	10	62.0		Debond			
1	10	42.5			8600		
-2	11	42.5					
-1	11	49.6					
0	11	38.2					
	11	21.9		Thin			

Page intentionally left blank

Appendix D. Site Investigation Report

Page intentionally left blank



National Park Service
U.S. Department of the Interior

Minuteman Missile National Historic Site
Phillip, South Dakota

Site Investigation Report

Delta 01 Launch Control Center and Delta 09 Launch Facility

October 13, 2023
Prepared By: Seven Generations Architecture + Engineering
In Consultation with:
Ratio Architects, H.F. Lenz Company, ARSEE, Terracon, Building Conservation Associates, and Precision Point Inc.

Under the direction of: The National Park Service: Regions 3, 4, 5

Page intentionally left blank

SEVEN GENERATIONS
ARCHITECTURE + ENGINEERING

October 13, 2023

RE: Delta-01/Delta-09 Historic Structure Report - Minuteman Missile National Historic Site (MIMI)

John Rosemurgy (COR)
National Park Service
25970 Red Jacket Road
Calumet, MI 49913

Dear Mr. Rosemurgy,

The HSR Team, consisting of representatives of Seven Generations Architecture and Engineering, RATIO Architects, H.F. Lenz Company, ARSEE Engineers, Precision Point LLC, and Terracon Consultants, conducted a site visit (October 4-5, 2023) to investigate and document the existing condition of the underground resources at Minuteman National Historic Site in Phillip, South Dakota. These resources included the Delta 01 Launch Control Center and Delta 09 Launch Facility.

The HSR team documented the interior of Delta 09 with a Leica scanner and, over the coming weeks, will use the point cloud and model generated by the scan as the basis for the Historic Structure Report. Existing drawings and reports provided by the NPS staff led by Ken Thompson and the stories provided by Mr. Jim Boensch and Al Hall are invaluable at the start of a project like this. Once the initial data gathered onsite is processed, the HSR team looks forward to continuing the conversation with Hall and Boensch in the form of an interview.

The HSR team has requested an updated list of current park maintenance and improvement priorities, as well as any documentation related to other relevant developments that have occurred since the site was transferred to the National Park Service.

Please accept the following Site Investigation and Outbrief Meeting Minutes as the deliverable outlined in the SOW under Phase II: Site Investigation.

Sincerely,

Alex Hokkanen
Project Manager

AH
P:\2023 Projects\231108 NPS MIMI HSR\03 PROJECT MANAGEMENT\C2 MEETINGS\MIMI Site Investigation Cover Letter.docx

600 E. Michigan Avenue, Suite B
Kalamazoo, MI 49007

P: 269.927.0144
W: 7GENAE.com

Page intentionally left blank

SEVEN GENERATIONS
ARCHITECTURE + ENGINEERING

AGENDA

Project: 140P6023F0037 MIMI Update HSR for Delta-01 and Delta-09
7GAE Project No. 231108

To: **National Park Service:** John Rosemurgy (COR)
Seven Generations AE: Alex Hokkanen
RATIO: David Kroll, Ben Ross
H.F. Lenz: Paul Petrilli
ARSEE: Dan Calabrese
PPI: Drew Seward, Zachary Marakovits
Terracon: Josh Vogel

Meeting Date: October 3, 2023 – October 6, 2023

Time: 8:00AM-4:30PM Daily

Location: Minuteman Missile National Historic Site

Purpose: Site Investigation

Note: Times are subject to change based on the availability of Park personnel, minimize disruption to Park operations, and the visitor tour schedule.

Tuesday, October 3, 2023 [Team Travel]
[HSR Team Travel to Wall, SD]

Wednesday, October 4, 2023 [Team Onsite]
8:00AM HSR Team Arrives at Visitor Center
8:15AM-9:00AM Inbrief – Full Team
- Inspection Plan and Staggered Investigation (Space Limitations)
- Site Safety Briefing

9:30AM-5:30PM Site Inspection
5:30PM Adjourn for the Day

Thursday, October 5, 2023 [Team Onsite]
8:00AM HSR Team Arrives at Visitor Center
8:30AM-9:00AM Mid-Visit Check in – Full Team
- Outstanding Items to Verify
- Questions or Clarification for the NPS Staff/Volunteers

9:30AM-4:30PM Site Inspection
12:30PM Outbrief Teleconference
2:00PM Adjourn for the Day

Friday, October 6, 2023 [Team Travel]
[HSR Team Travel]

AH
P:\2023 Projects\231108 NPS MIMI HSR\03 PROJECT MANAGEMENT\C2 MEETINGS\2023 10 03-06 MIMI Update HSR - Site Investigation Agenda.docx

600 E. Michigan Avenue, Suite B
Kalamazoo, MI 49007

P: 269.927.0144
W: 7GENAE.com

Part of Bodwé Professional Services

Page intentionally left blank

SEVEN GENERATIONS
ARCHITECTURE + ENGINEERING

MEETING MINUTES

Project: 140P6023F0037 MIMI Delta-01 LCC/Delta-09 LF Update HSR
7GAE Project No. 231108

Meeting Date: October 04-05, 2023

Time: Day One: 8:00am – 5:00pm MT / Day Two: 8:00am – 1:30pm MT

Date Issued: October 13, 2023

Attendees: **National Park Service:** John Rosemurgy (COR – Remote), Ken Thompson (MIMI), Jim Boensch (MIMI), Alex Carrier (MIMI/BADL), Al Hall (Volunteer), Doug Bessette (MIMI), Cheryl Ferguson (MIMI)
Seven Generations AE: Alex Hokkanen (PM)
RATIO: Dave Kroll (Architecture), Ben Ross (Architecture)
H.F. Lenz: Paul Petrilli (Mechanical), Tyler Trostle (Electrical)
ARSEE: Dan Calabrese (Structural)
Terracon: Josh Vogel (Environmental)
Precision Point: Zachary Marakovits (Laser Scanning)

Purpose: Site Investigation – Underground Resources at MIMI Delta 01 and Delta 09

SUMMARY OF FINDINGS BY DISCIPLINE

Historic Architecture

1. Observed and photographed existing conditions at Delta-01 (below-ground) and Delta-09.
2. Identified draft categories of thematically related character-defining features as discussed with COR.
3. Talked with Al Hall and Jim Boensch regarding changes to both resources.
   a. The HSR team will want to schedule separate follow-up virtual meetings with Al and Jim to review changes, ask additional questions, and confirm terminology of character-defining features.
4. Observed and photographed areas for discussion with BCA prior to their paint analysis site visit (Spring 2024).
   a. We will meet with BCA to review this evidence and identify priority areas for sampling.

Mechanical, Electrical, Plumbing

5. Delta-09 Soft Support Building
   a. Observed and photographed existing mechanical, electrical and plumbing systems which include:
      1) Air-cooled brine chiller which provided chilled water/glycol to the launch control racks located in the Delta-09 Missile Silo.
      2) Intake air dampers and exhaust/recirculation duct work which provided cooling air for the condenser section of the brine chiller. Dampers are arranged to allow heat to be recirculated into the Support Building to provide heat during the winter.
      3) Air compressor and pneumatic damper operators for ventilation control.
      4) Sump pump for removal of water from the Soft Support Building and adjacent areaways.
      5) Electric heater to provide supplemental heat when heat rejection from the brine chiller is either not adequate or not available.
      6) Fuel oil transfer pumps, day tank and distribution piping for standby generator.

600 E. Michigan Avenue, Suite B
Kalamazoo, MI 49007

P: 269.927.0144
W: 7GENAE.com

Part of Bodwé Professional Services

7) Electric Service entrance to the site and associated disconnecting means serving the Delta-09 Soft Support Building and Delta-09 Missile Silo. Ken Thompson (NPS) indicated that the main service disconnect was in poor condition and had suffered from major corrosion and rust due to past flooding. The main service disconnect was not opened for an internal assessment of its current condition due to safety concerns and because a shutdown of both the Delta-09 Soft Support Building and Delta-09 Missile Silo would be required.
8) Main Distribution Panel 'LDA', Branch Panel 'LDC' and Branch Panel 'LLA'. Ken Thompson (NPS) assisted with the removal of panelboard front enclosure covers so a thorough assessment could be conducted on the internal electrical components and their current condition. For each piece of electrical distribution, the following was photographed, investigated and assessed:
   i. Internal busbar assemblies
   ii. Main lugs
   iii. Overcurrent protection devices and lugs
   iv. Enclosures

9) Emergency Distribution including the Automatic Transfer Switch and decommissioned diesel fired 75KW generator set. The associated generator cranking panel and battery charger enclosure were also investigated.
10) Existing lighting, receptacles, and decommissioned security panels were also photographed and investigated for current conditions.

b. Ken Thompson (NPS) indicated rust and water damage was caused via condensation and flooding that occurred due to failure of the sump pump in the early 2010's.

6. Delta-09 Missile Silo
   a. Observed and photographed existing mechanical, electrical and plumbing systems in the Delta-09 Missile Silo which include:
      1) Chilled water/glycol piping entering the missile silo at Level 02 which connects to the air-handling unit that cools the control racks.
      2) Air-handling unit and ductwork system connecting to the control racks to feed cold air directly to the racks to cool the control boards.
      3) Electric launch tube heater which provided warm air directly to the launch tube to keep it at 60°F at all times.
      4) Dehumidifier which was installed in 2010 by the National Park Service to prevent condensation and resultant rusting within the silo.
      5) Weep holes to allow water to enter the Silo to relieve hydrostatic pressure on the launch tube, floor drains and piping which run down to a sump pump at the bottom of the Silo.
      6) Heater that was installed when the Viewing Structure was built to prevent frosting on the inside of the glass.
      7) Branch Panel 'LDB' on the second level of the launch facility. Panel 'LDB' currently serves general loads such as mechanical equipment, lighting, and receptacles.
      8) Existing lighting, receptacles, decommissioned security panels and control racks.
   b. Ken Thompson (NPS) indicated that a current project within the NPS MidWest Region was underway to replace the humidifier with one with more capacity; however, Ken stated that unit currently installed was the largest that could physically fit into the Silo. As a treatment alternative, we will look at the possibility of retrofitting the original air-handling equipment with dehumidification capabilities. The would be combined with options to modify the brine chiller in the Soft Support Building.

Structural

7. Delta-09 Soft Support Building - Exterior

a. We discussed the usage of the support building with Al Hall (retired Air Force who was stationed at Delta-09). Al said that the support building was expendable in a nuclear attack and thus the "soft" description in its name.
b. The exposed concrete surfaces were visually assessed and damaged conditions were documented. Acoustic sounding using a hammer was performed across randomly selected surfaces to identify delaminations in the concrete.
    1) Previously treated and untreated cracks were documented and delaminated concrete within the 2-1/2 inch wear slab was noted. i
    2) The waterproofing layer between the concrete wear slab and structural roof slab was not visible; however, the gap between the two slabs was found to be caulked tight, which restricts water from freely exiting the split-slab system at the waterproofing layer.
c. Ken Thompson (NPS) reported that they are on a two-year rotation for installation of a penetrating sealer on the exposed concrete surfaces. He said they are using Prosoco SureKlean Weather Seal Siloxane PD and they apply it with a roller.
d. Ken Thompson reported that his crews have gravity fed epoxy to address select untreated cracks in the concrete. The cracks that have been filled with sealant were done by others.
e. Possible treatments:
    1) Remove and replace concrete topping slab and waterproofing system.
    2) Rout and seal cracks and possibly also inject cracks with hydrophobic resin.

8. Delta-09 Soft Support Building - Interior
    a. The exposed concrete surfaces inside the soft support building (below grade) were visually assessed. Select wall surfaces were randomly selected for hammer sounding in addition to wall surfaces near the floor slab that had paint coating damage. No delaminations were found during the sounding survey.
    b. The concrete floor slab is in good condition with one small spall (less than 1 SF) that could remain untreated.
    c. Surface rust was visible on the steel angle framing at the two infill panels on the east side of the support building roof structure.
    d. Active moisture leaks were observed in the concrete roof slab approximately 3 feet south of the concrete beam that spans east-west. Calcium and mineral deposits from the concrete have formed stalactites in multiple locations along the leaking crack.
    e. Black organic growth was visible on the underside of the concrete roof slab.
    f. Possible treatments:
        1) Inject actively leaking cracks with hydrophobic resin.
        2) Rework the interior conditioning to mitigate organic growth (see MEP).
        3) Painting to protect exposed steel surfaces.
9. Delta-09 Missile Silo – Glass Enclosure Structure (c. 2000s)
    a. The wall construction below the window framing appeared to consist of concrete on the exterior and EIFS on the interior of the enclosure. This will be reviewed further when the enclosure drawings are provided. The concrete surfaces had spider web cracking in various locations. Those areas were sounded with a hammer and found to be in sound condition.
    b. Possible treatments:
        1) Require further review of existing drawings.
10. Delta-09 Missile Silo – Closure Door and Tracks
    a. The exposed concrete surfaces were visually assessed and damaged conditions were documented. This included concrete surfaces accessible both outside and inside the glass enclosure.

1) Delaminated and cracked concrete was noted at the front (south end) of the closure door adjacent to and within the plug detail. In addition, a narrow strip of concrete along the northern edge of the closure door inside the glass enclosure was noted. Because that area is located inside the glass enclosure and sheltered from exposure to moisture, the delaminated strip of concrete could remain untreated.
2) Narrow to hairline shrinkage cracks were observed to be widespread across the skyward face of the closure concrete.
3) The concrete adjacent to the steel rails and plates in the closure and maintenance tracks is generally in sound condition with a small delamination (about 1 SF) on the west side of the west closure track.

b. Rusted steel surfaces on the underside of the closure door steel framing were observed. Similarly, rust has formed on the surface of the steel rails embedded in the concrete closure and maintenance tracks.
c. A debris catch was added to the back (north face) of the closure door in the 1970s. The intent of the steel catch was to collect any debris that would have been on the top of the door when it opened so to prevent it from contacting the missile upon exiting the launch tube.
d. Possible treatments:
1) Concrete patching to address spalled and delaminated conditions.
2) Crack treatment (injection, routing and sealing) in exposed concrete.
3) Penetrating sealer with corrosion inhibitor on exposed concrete surfaces.
4) Waterproof traffic-bearing membrane system on exposed concrete surfaces.
5) Painting to protect exposed steel surfaces.

11. Delta-09 Missile Silo – Launch Facility Structure (exterior)
a. The exposed concrete "roof" surfaces were visually assessed and damaged conditions were documented. Acoustic sounding using a hammer was performed to identify delaminations in the concrete.
1) Previously treated and untreated cracks were observed across the roof concrete. Some cracks were treated with sealant while most were repaired by Ken's team using epoxy.
2) Delaminated concrete was not observed throughout much of the exposed roof concrete; however, narrow stretches at slab transitions/joints were noted (i.e., transition to the glass enclosure construction, concrete around access hatch steel, and along the construction joint between the silo roof concrete and adjoining launcher jack pad slab-on-grade to the north).
3) The sealant joint around the access hatch steel should be replaced when adjacent repairs are performed.
4) The original barrier poles and railing around the access hatch were replaced in the 1980s with the current pole and railing structure that includes steel sleeves embedded in the concrete roof.

b. Possible treatments:
1) Concrete patching to address spalled and delaminated conditions.
2) Replacement of sealant joints in the concrete.
3) Crack treatment (injection, routing and sealing) in exposed concrete.
4) Penetrating sealer with corrosion inhibitor on exposed concrete surfaces.
5) Waterproof traffic-bearing membrane system on exposed concrete surfaces.
6) Painting to protect exposed steel surfaces.

12. Delta-09 Missile Silo – Launch Facility Structure (interior)
a. Extending approximately 80 feet into the ground, the interior of the launch tube (silo) and service levels were visually assessed from the accessible service level platforms and the two-man vertical

access lift inside the silo itself. Our observations are separated between the first and second service levels and the silo launch tube where the training missile is on display.

b. First and Second Service Levels
   1) Sounding of the steel plate liner was performed using a hammer at random locations throughout the interior. Both sound and hollow audible conditions were observed during the hammer sounding survey. Due to the presence of the steel liner, voids or delaminations behind the steel liner plate were not visible. An ultrasound survey of the interior of the structure has been performed and that report will be reviewed once it becomes available.
   2) Corrosion of the steel plate across the walking surface on the second level was especially noted around the fan equipment and adjacent to the electrical room. The paint coating on the adjacent steel columns, base plates, and connection hardware was failing and corrosion was visible. Using a Check-Line Ultrasonic Micrometer wall thickness gauge, we determined that the floor plate and steel column base plates have not been compromised from corrosion with readings consistent with the values shown in the Parsons-Staven drawings.
   3) Weep slots were cast into the backup concrete and were diagonally sloped downward, draining through the silo launch tube liner plate and into the silo itself. These weep slots are typically located near the second level elevation. Some of the slots were found to be blocked with debris while others were open and daylight could be seen through them.
   4) The neutralizer pit and adjacent drain on the second level were found to be holding water. The site staff used a shop vacuum to remove the water from both locations. Gravel and debris were found in the base of the neutralizer pit after removing the water. Ken reported that the pipe connecting the two was blocked in addition to the pipe extending from the drain to the inside face of the silo. He will snake and camera both at a later date.

c. Silo Launch Tube
   1) Sounding of the steel plate liner was performed using a hammer at random locations throughout the interior. Both sound and hollow audible conditions were observed during the hammer sounding survey. Due to the presence of the steel liner, voids or delaminations behind the steel liner plate were not visible. An ultrasound survey of the interior of the structure has been performed and that report will be reviewed once it becomes available.
   2) Using a Check-Line Ultrasonic Micrometer wall thickness gauge, we verified the steel liner plate in three separate locations across the height of the silo to be 1/4 inch thick, which is consistent with the Parsons-Staven drawings.
   3) Failed and chipped paint coatings were visible throughout the interior of the silo, particularly where moisture leached out the weep slots and down the face of the steel liner plate. One of the weeps was actively leaching moisture at the time of our visit. Use of the vertical access lift was also observed to cause chipping of the paint coating on the liner as the lift moved up and down against the surface.
   4) Moisture stains running down the inside face of the silo near the top at the north end were observed. A point of moisture infiltration was not apparent on the exterior of the glass enclosure structure and the stains may predate the enclosure structure.

d. Possible treatments:
   1) Steel plate liner/backup concrete below grade – treatment options pending review of Gecko ultrasound testing results.
   2) Clean and reopen weep slots and piping at drains to allow for uninhibited drainage.
   3) Painting to protect exposed steel surfaces.

Environmental

13. 31 paint samples were taken at Delta 01 and Delta 09. They were submitted to the laboratory and received on Monday, October 9, 2023. Results are expected to be sent to Terracon by October 17th.
14. 63 asbestos samples were taken at Delta 09. They were submitted to the laboratory and received on Monday, October 9, 2023. Results are expected to be sent to Terracon by October 17th.
15. An Asbestos and Lead Report will be submitted to Seven Gen on or before October 24th.

Laser Scanning, Point Cloud Generation, and Modelling

16. The bulk of the laser scanning took place on Wednesday with follow-up scans taken on Thursday to ensure that there were no gaps in the data collected. Precision Point to follow with model in early November.

Action Items:

1. Produce Site Investigation Report (Due to NPS on October 13).

Requests for Additional Information

1. Does the NPS have an overarching goal in mind for the NHS that the recommendations provided in the updated HSR could work toward over the next 15, 20, 30 years?
2. Does the NPS have a target year for the next capital project expenditure at MIMI?
3. A list of maintenance activities or other improvement projects (as available and applicable to the underground resources at Delta 09)
    a. e.g., Applying the penetrating sealer every couple of years.

Next Deliverable: December 01, 2023 (80% Draft HSR)
Next Meeting: 80% Review Teleconference Friday January 26, 2024

- See attached Project Schedule for additional deliverable and meeting details.

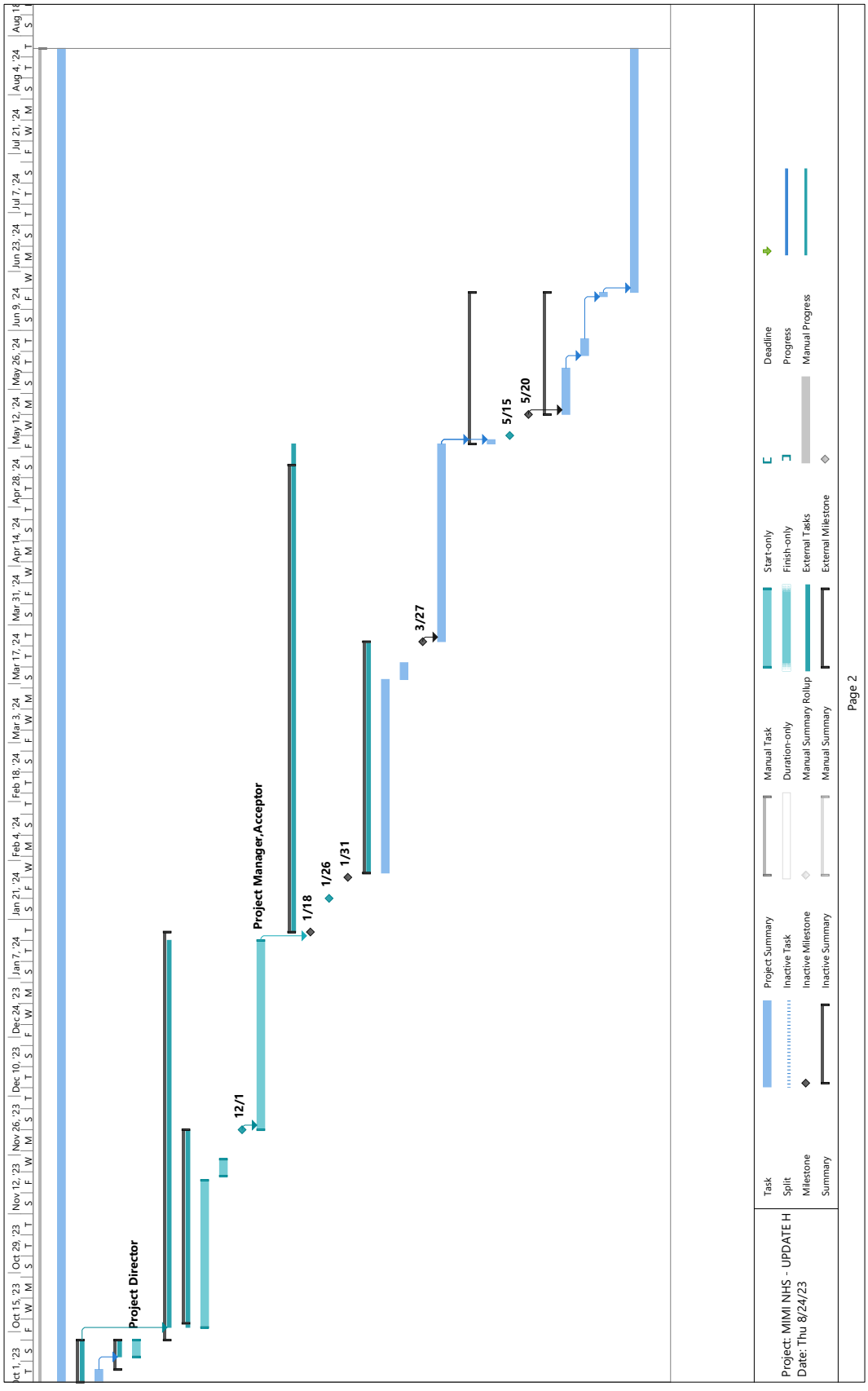
The items above are our understanding of the items discussed. Please review and provide any revisions or additions.

AH
P:\2023 Projects\231108 NPS MIMI HSR\03 PROJECT MANAGEMENT\C2 MEETINGS\2023 10 04-05 Site Investigation Minutes.docx



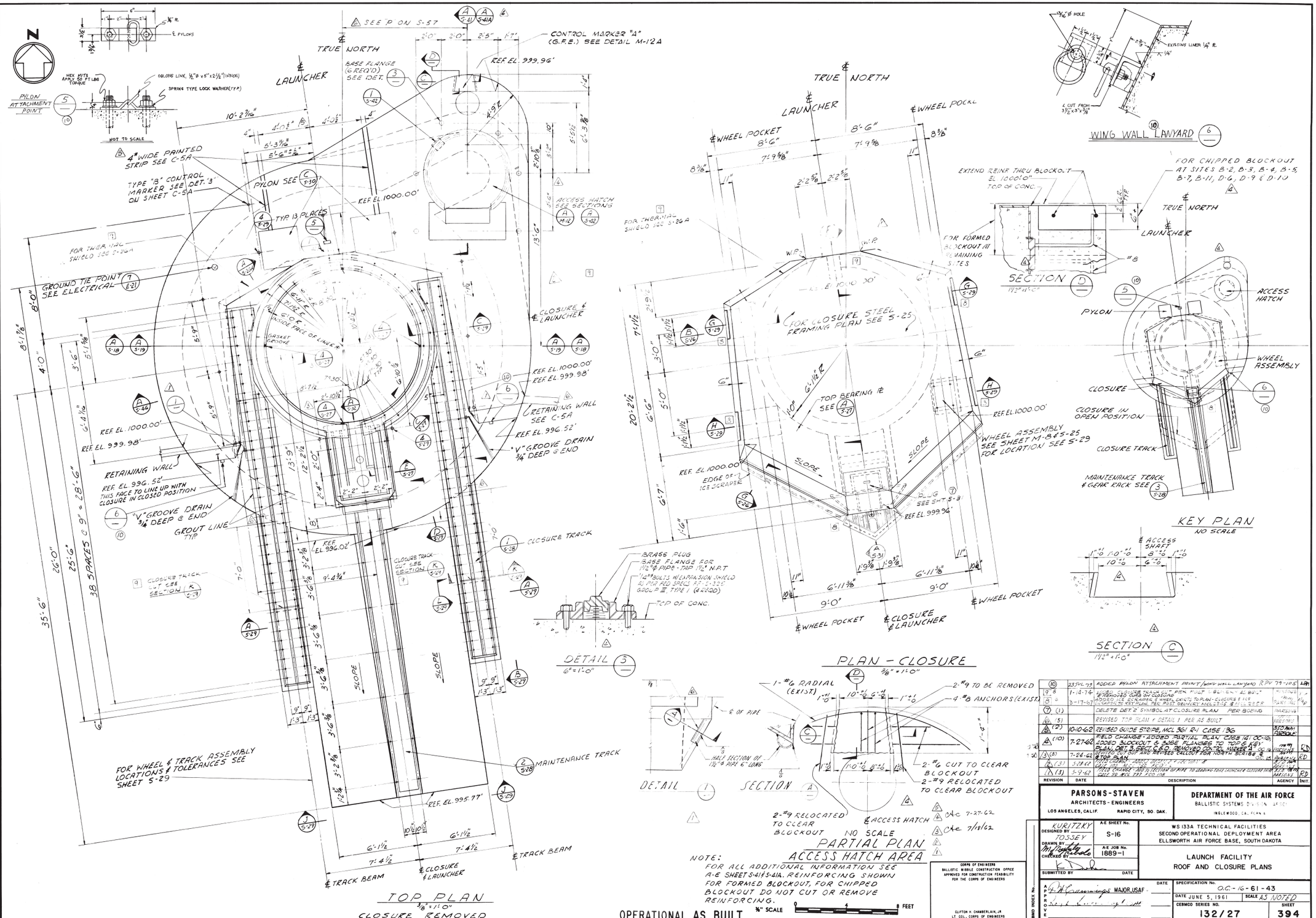
ID	Task Mode	Task Name	Duration	Start	Finish
0		**MIMI NHS - UPDATE HSR (DELTA-01, DELTA 09)**	**429 days**	**Tue 6/13/23**	**Thu 8/15/24**
1		Period of Performance (PoP)	429 days	Tue 6/13/23	Thu 8/15/24
2		**PHASE II - SITE INVESTIGATION**	**10 days**	**Tue 10/3/23**	**Fri 10/13/23**
3		Site Investigation (HSR Team Onsite)	3 days	Tue 10/3/23	Fri 10/6/23
4		**Site Investigation Report**	**7 days**	**Fri 10/6/23**	**Fri 10/13/23**
5		Site Visit Meeting Minutes	4 days	Mon 10/9/23	Fri 10/13/23
6		**PHASE III - 80% DRAFT HSR**	**97 days**	**Fri 10/13/23**	**Thu 1/18/24**
7		**80% Report Production**	**46 days**	**Mon 10/16/23**	**Fri 12/1/23**
8		80% Report Production	35 days	Mon 10/16/23	Mon 11/20/23
9		QAQC (Internal)	4 days	Mon 11/20/23	Fri 11/24/23
10		Deliver 80% Draft to NPS [Elec. And Bound]	0 days	Fri 12/1/23	Fri 12/1/23
11		NPS Review Period I	45 days	Fri 12/1/23	Mon 1/15/24
12		**PHASE IV - 95% DRAFT HSR**	**111 days**	**Thu 1/18/24**	**Wed 5/8/24**
13		80% Draft Comments Received From NPS	0 days	Thu 1/18/24	Thu 1/18/24
14		**Comment Review Teleconference (Virtual)**	**0 days**	**Fri 1/26/24**	**Fri 1/26/24**
15		Return Completed Comments to NPS	0 days	Wed 1/31/24	Wed 1/31/24
16		**95% Report Production**	**55 days**	**Thu 2/1/24**	**Wed 3/27/24**
17		95% Report Production	46 days	Thu 2/1/24	Mon 3/18/24
18		QAQC (Internal)	4 days	Mon 3/18/24	Fri 3/22/24
19		Deliver 95% Draft to NPS [Print and Digital]	0 days	Wed 3/27/24	Wed 3/27/24
20		NPS Review Period II	47 days	Wed 3/27/24	Mon 5/13/24
21		**PHASE V - FINAL DELIVERABLES**	**36 days**	**Mon 5/13/24**	**Tue 6/18/24**
22		95% Draft Comments Received From NPS	1 day	Mon 5/13/24	Tue 5/14/24
23		**95% Comment Review Teleconference (Virtual)**	**0 days**	**Wed 5/15/24**	**Wed 5/15/24**
24		Return Completed Comments to NPS	0 days	Mon 5/20/24	Mon 5/20/24
25		**Final Report Production**	**29 days**	**Mon 5/20/24**	**Tue 6/18/24**
26		Final Report Production	11 days	Mon 5/20/24	Fri 5/31/24
27		QAQC (Internal)	4 days	Mon 6/3/24	Fri 6/7/24
28		Final Deliverables to NPS [Print and Digital]	1 day	Mon 6/17/24	Tue 6/18/24
29		**PROJECT CLOSEOUT**	58 days	Tue 6/18/24	Thu 8/15/24

14 MIMI: Site Investigation Report


Project Director
12/1
Project Manager,Acceptor
1/18
1/26
1/31
3/27
5/15
5/20
Project: MIMI NHS - UPDATE H
Date: Thu 8/24/23
Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress
Page 2

Appendix E. Existing Condition Drawings

Page intentionally left blank



REVISION	DATE	DESCRIPTION	AGENCY	INIT.
(10)	23JUL-79	ADDED PYLON ATTACHMENT POINT/WING WALL LANYARD RPV 79-105	LM	
(9)	1-14-74	"AS BUILT" CHANGES		
(8)	3-17-67	REMOVED CURB SECTION PER PILOT "AS IS & AS BUILT" CORRECTED CLEARANCE DIMS. (INCL TO PLAN-CLOSURE & FOR GRAPHITE KEYPLAN) ADDED DEPARTURE NOTE & SHT. REFS		
(7)	(1)	DELETE DET 2 SYMBOL AT CLOSURE PLAN PER BOEING		
(6)	(5)	REVISED TOP PLAN & DETAIL 1 PER AS BUILT		
(5)	(2)	10-10-62 REVISED GUIDE STRIPE, MCL 361 R-1 CASE 136		
(4)	(10)	7-27-62 "AS BUILT" CHANGE - ADDED PARTIAL PLAN CASE 141 OC-10 LOADED BLOCKOUT & PIPE FLANGES TO TOP OF AS BUILT PLAN, DET 3, SHT S-5 & S-5A REMOVED CONTROL MARKER A TO CONFORM TO AS BUILT		
(3)	(3)	7-26-62 TOP PLAN - ADDED DIMENSIONS & REVISED CALLOUT FOR NORTH SCRIBE &		
(2)	(3)	5-28-62 TITLE CHANGE - ADDED DEPARTURE # 2 & DEPARTURE # 3		
(1)	(3)	5-9-62 TITLE CHANGE - ADD SECTION OF PIPE TO LOADING EDGE FLANGE & CUSTOMER ITEM		

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION, AFSC
INGLEWOOD, CALIFORNIA

DESIGNED BY KURITZKY
DRAWN BY TOSSEY
CHECKED BY
SUBMITTED BY DATE

A-E SHEET No. S-16
A-E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

Llaunch FACILITY
ROOF AND CLOSURE PLANS

APPROVED: H. H. Cummings MAJOR, USAF — DATE

SPECIFICATION No. O.C.-16-61-43
DATE JUNE 5, 1961 SCALE AS NOTED
CEBMCO SERIES NO. 132/27
SHEET 394

AFBMD INDEX No.

"AS BUILT" DRAWING CERTIFICATION — CORPS OF ENGINEERS

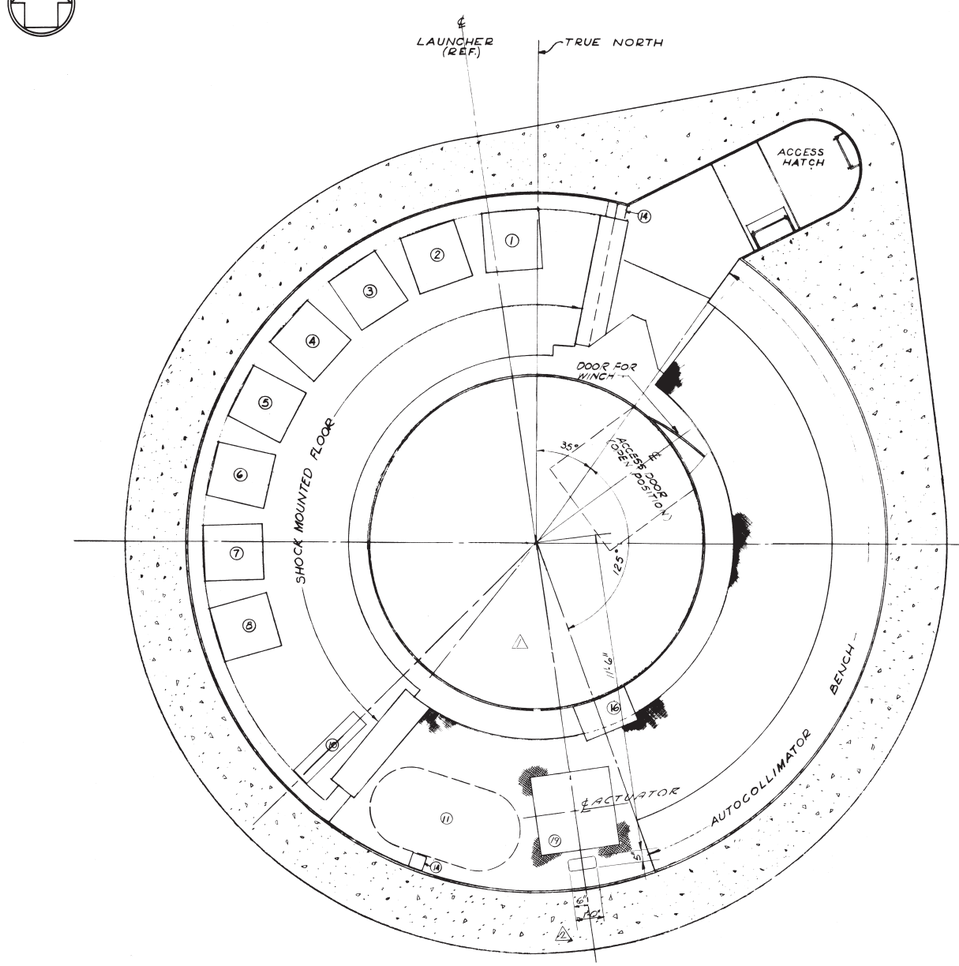
FLIGHT A	4-2-63	FLIGHT F	2-7-63	FLIGHT K	1-28-63	Corps of Engineers
FLIGHT B	11-19-62	FLIGHT G	5-22-63	FLIGHT L	1-16-63	
FLIGHT C	3-7-63	FLIGHT H	4-8-63	FLIGHT M	3-11-63	
FLIGHT D	12-11-62	FLIGHT I	1-3-63	FLIGHT N	2-12-63	
FLIGHT E	1-25-62	FLIGHT J	2-19-63	FLIGHT O	2-20-63	

CORPS OF ENGINEERS
BALLISTIC MISSILE CONSTRUCTION OFFICE
APPROVED FOR CONSTRUCTION FEASIBILITY FOR THE CORPS OF ENGINEERS

CLIFTON H. CHAMBERLAIN, JR
LT. COL. CORPS OF ENGINEERS
CHIEF ENGINEERING DIVISION

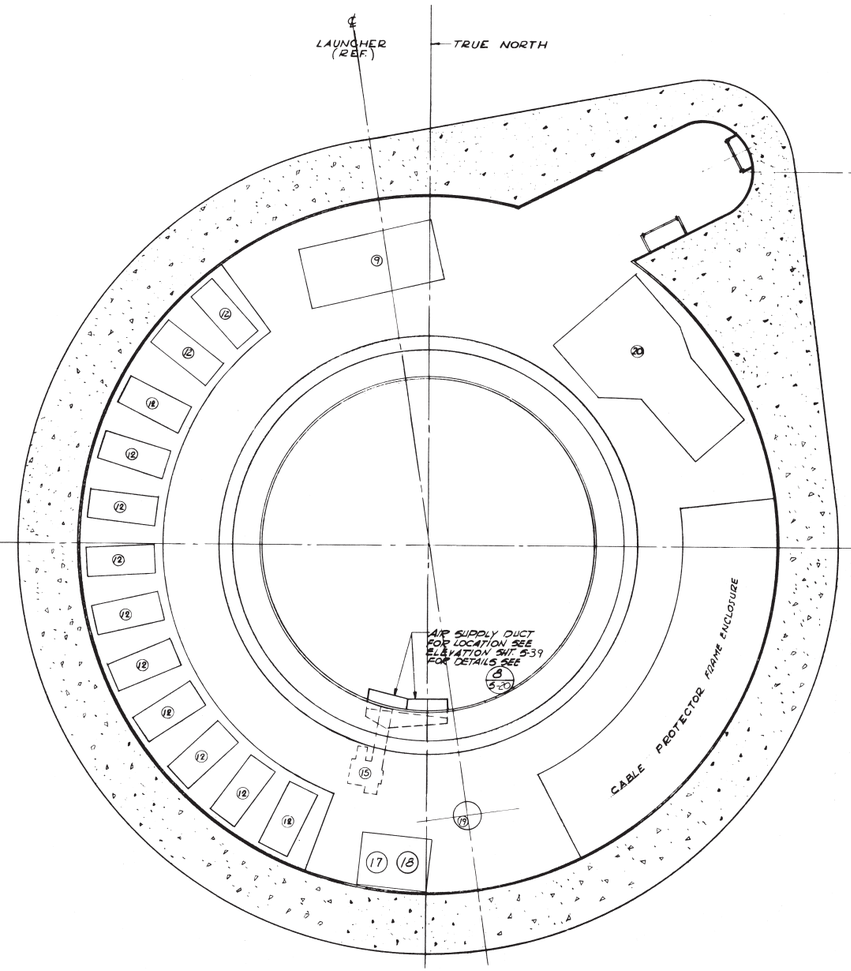
OPERATIONAL AS BUILT

Page intentionally left blank



LAUNCHER EQUIPMENT LAYOUT FIRST LEVEL

1/2" = 1'-0"



LAUNCHER EQUIPMENT LAYOUT SECOND LEVEL

1/2"=1'-0"

NO	EQUIPMENT LIST	CONTR FURN.	CONTR INSTL.	GOVER. FURN.	GOVER. INSTL.
20	AIR CONDITIONING UNIT			•	•
19	CLOSURE ACTUATOR SPACE			•	•
18	W/S POWER DISTRIBUTION PANEL	•	•		
17	EMERGENCY TEST CONTACTOR	•	•		
16	UMBILICAL RETRACTION			•	•
15	LAUNCH TUBE FAN			•	•
14	TELEPHONE JACK (2 REQD)			•	•
13					
12	BATTERIES (12 TOTAL)			•	•
11	G AND C TANKS (2 REQD)	•	•		
10	UMBILICAL J" BOX			•	•
9	MOTOR GENERATOR			•	•
8	G AND C COOLER			•	•
7	G AND C COUPLER RACK			•	•
6	SEQUENCER AND MONITOR RACK			•	•
5	SCN/CTE RACK			•	•
4	SCN/DPE RACK			•	•
3	SECURITY AND POWER RACK			•	•
2	AUXILIARY GROUND POWER RACK			•	•
1					

OPERATIONAL AS BUILT

1/2" SCALE 0 2 4 6 FEET

△CHC 8-17-61

CORPS OF ENGINEERS
BALLISTIC MISSILE CONSTRUCTION OFFICE
APPROVED FOR CONSTRUCTION FEASIBILITY
FOR THE CORPS OF ENGINEERS
CLIFTON H. CHAMBERLAIN, JR
LT. COL. CORPS OF ENGINEERS
CHIEF ENGINEERING DIVISION

△CHC 8-30-61

"AS BUILT" DRAWING CERTIFICATION - CORPS OF ENGINEERS

△ FLIGHT A	6-28-62	Drawn as built 7-6-63	△ FLIGHT F	3-30-63	Drawn as built 7-6-63	△ FLIGHT K	1-23-63	Drawn as built 7-6-63
△ FLIGHT B	11-19-62		△ FLIGHT G	5-22-63		△ FLIGHT L	1-16-63	
△ FLIGHT C	3-27-63		△ FLIGHT H	6-3-63		△ FLIGHT M	5-11-63	
△ FLIGHT D	12-11-62		△ FLIGHT I	1-3-63		△ FLIGHT N	4-15-63	
△ FLIGHT E	1-23-63		△ FLIGHT J	2-12-63		△ FLIGHT O	6-27-63	

REVISION	DATE	DESCRIPTION	AGENCY	INIT.
		AIR AS-B		
(1)	8-30-61	ADDED 12'x6'0" OPENG. IN FIRST LEVEL OC-3	AFBSD	W.J.
	8-17-61	REMOVED 67°30' ANGLE FROM 1ST LEVEL MS-4 227	AFBSD	W.J.

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION (AFSC)
INGLEWOOD, CALIFORNIA

DESIGNED BY TREBOLO
DRAWN BY WIPPLER
CHECKED BY
SUBMITTED BY
A-E SHEET No. S-17
A-E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

LAUNCH FACILITY
LAUNCHER EQUIPMENT ROOM
1st & 2nd LEVELS, EQUIPMENT LAYOUT

APPROVED: DATE
MAJOR, USAF
DESIGNED: DATE JUN 17 1961
SPECIFICATION No. OC-3-61-43
DATE JUNE 5, 1961
SCALE AS NOTED
CEDMCO SERIES 132/28
SHEET 395

APPROVED INDEX No.

Page intentionally left blank

N

℄ LAUNCHER

TRUE NORTH

SEE "P" ON S-57 (12)

8.16-HOLE LOCATION FOR ½"ø HIGH STRENGTH BOLTS; DRILL 9/16"ø HOLES. 2.83-HOLE LOCATION FOR ¾"ø DIAM. GROUNDING BOLTS; DRILL 7/16"ø HOLES. TOLERANCES ANGULAR = ¼° DECIMAL ± .03" (4)

¾" FLOOR PLATE ABRASIVE ROLLED STEEL

ACCESS SHAFT PASSAGEWAY FOR DETAILS OF FLOOR ℗, CHAINS, & MISC. ITEMS SEE (1) S-53 (2) S-53

FOR MONORAIL FRAMING SEE

FOR LADDER SEE DETAIL (1) S-43

FOR LADDER SEE DETAIL (6) S-43

LANYARD ATTACHMENT MCL 6342

2¼"ø HOLE IN FLOOR ℞

1/2"ø DRILLED HOLE

MAINTAIN 6" CLEARANCE FROM VERTICAL TABLES 1 1/4" CLEARANCE FROM AIR DUCT SEE DWG. E-17

BB13 BELOW

5'-6"

13'-6"

TYPE II

TYPE V

TYPE IA

TYPE III

TYPE II

TYPE I

TYP.

TYPE I

TYPE I

SIM.

67°24'

35°

7'-0" R.

6'-9" R.

6'-3"

6'-3"

5'-3"

CENTER AIR VENT OPENING BETWEEN FLOOR FRAMING OPENING SIZE 6"x 16"

1" (REF)

MOUNTING ℞ FOR POWERED AZIMUTH DRIVE SEE BOTTOM OF MOUNTING ℞ 0'-2" ABOVE ELEV. OF TOP OF 1¼" PIPE RAIL (3) S-37

LAUNCHER TUBE LINER SEE SHEET S-39

FOR LOCATION AND CALL OUT OF RAIL SEE SECTION (A) S-39

¼" LINER PLATE (A) S-39

¼" WELD STUDS ANCHORED @ 12" OC EA WAY STARTING 3" FROM EDGE OF ℞ (TYP)

4'-3" HOPIT SLOT IN 12 WF 27 ℞ OF SWAY DAMPER (TYP) (2) S-22B (2) S-38

℄ SWAY DAMPER SEE DET. (1) M-9 TYP. 4 PLACES

"OPENING IN FLOOR PLATE (2) S-22B (2) S-38 4 PLACES

SITE B-3 ONLY

SITE A-9 ONLY

TANK SUPPORTS

TANK INSERTS SEE P-12

1'-2⅜" ± ⅛" DIA. HOLE TO BE CUT IN FLOOR PLATE. FOR LOCATION SEE FRAMING PLAN.

¼" CHK'D FLOOR ℞

OPENING IN FLOOR PLATE FOR CLOSURE ACTUATOR (B) S-22B

(5) S-37

(6) S-37

(N) S-37

(P) S-37

(D) S-37

(A) S-37

(A) S-38

(A) S-22

(B) S-22

(C) S-22

(G) S-53

(A) S-53

(A) S-36

(2) S-35

(9) S-35

(8) S-35

(1) S-23 S-34

(1) S-22

(2) S-22

(3) S-37

(2) S-37

(1) S-37

(1) M-9

(2) S-22B (2) S-38

(1) S-43

(6) S-43

(1) S-53 (2) S-53

(3) S-35

(1) S-39

(A) S-39

(B) S-22B

(A) S-38

(A) S-53

(G) S-53

(2) S-35

(A) S-36

(A) S-37

(3) S-37

(5) S-37

(N) S-37

(P) S-37

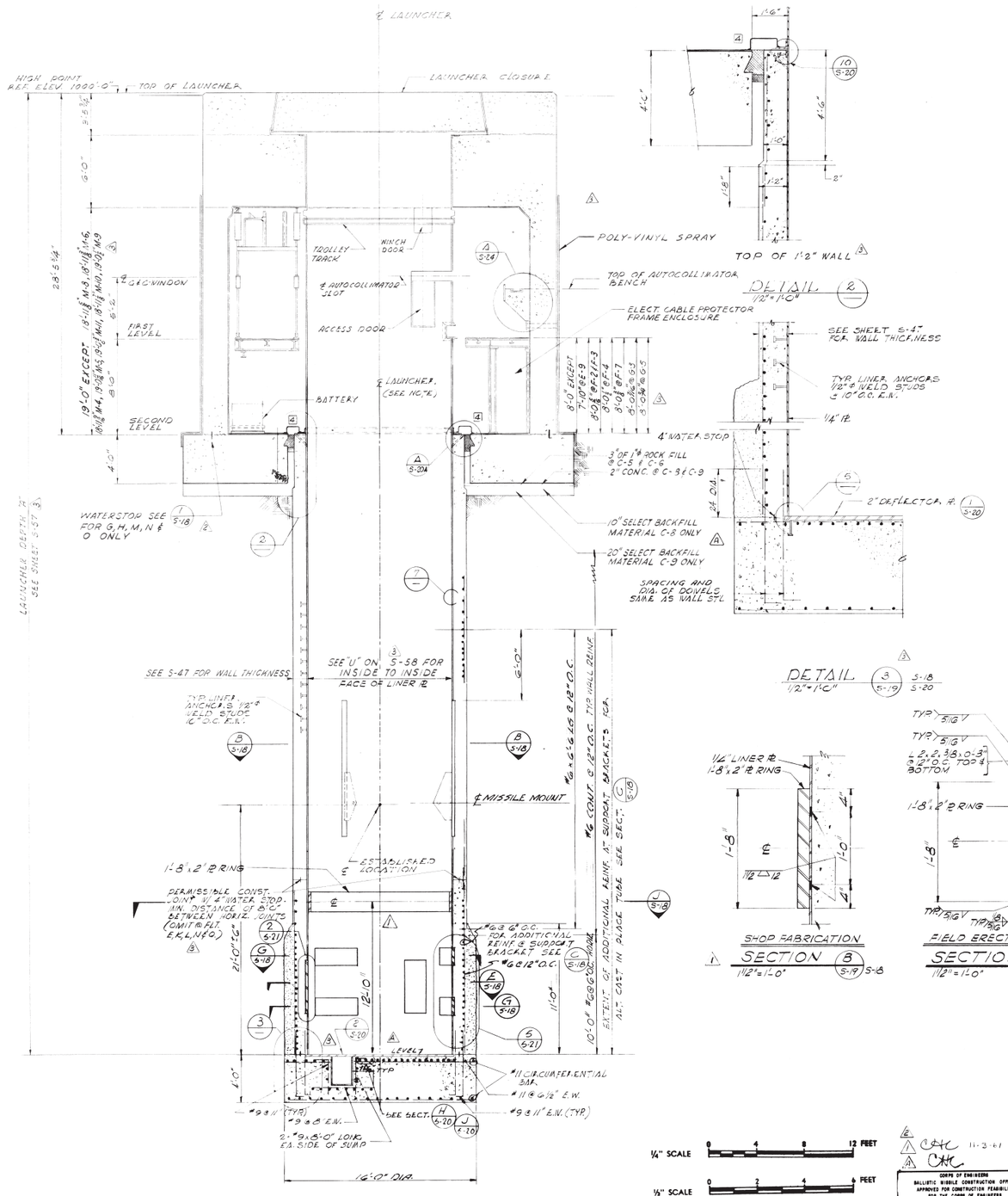
(A) S-38

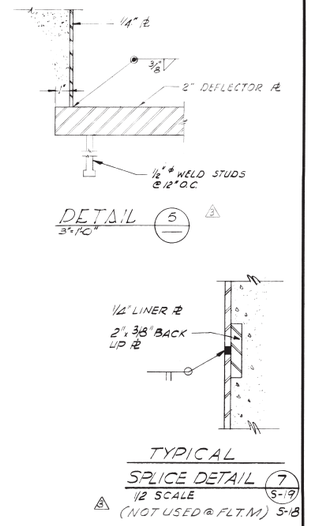
(A) S-22

(B) S-22B

(C) S-22

Page intentionally left blank





OPERATIONAL **AS BUILT**

"AS BUILT" DRAWING CERTIFICATION - CORPS OF ENGINEERS

FLIGHT A	4-2-63	FLIGHT F	3-29-63	FLIGHT K	4-2-63
FLIGHT B	11-19-62	FLIGHT G	3-29-63	FLIGHT L	4-16-63
FLIGHT C	3-7-63	FLIGHT H	4-8-63	FLIGHT M	5-11-63
FLIGHT D	12-11-62	FLIGHT I	4-5-63	FLIGHT N	4-16-63
FLIGHT E	1-23-63	FLIGHT J	4-8-63	FLIGHT O	4-29-63

REVISION	DATE	DESCRIPTION	AGENCY	INIT.
4 (3)	1-14-74	REVISED RATTLE PLACE SECT. A & DET. E, PER POST DELIVERY AS BUILT	PARSONS	JTB
3 (16)		DELETED INTERIOR TEXT, DETAILS 1, 2 & 6, REVISED SECTIONS A & C, DETAILS 3, 5 & 8 PER AS BUILT	PARSONS	
2 (13)	4-7-62	FIELD CHANGE ADD PROTECTOR ON SECT. A & CAST-IN-PLACE SECT.	SEC. 3/8	RD
1 (8)	11-6-61	ADD 2" DEFLECTOR @ TOP OF CAST IN PLACE SECTION - ADD SECT. "C"	PARSONS	
A (4)	7-14-61	REVISED SIDE CAST & ALT CAST IN PLACE SECTIONS, REVISED DET. "E"	PARSONS	

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION (AFSC)
INGLEWOOD, CALIFORNIA

DESIGNED BY SHIGEMURA / ALTALONDA
DRAWN BY
CHECKED BY
SUBMITTED BY DATE

A/E SHEET No. S-19
A/E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

LAUNCH FACILITY
LAUNCHER SECTIONS
WET CONDITION

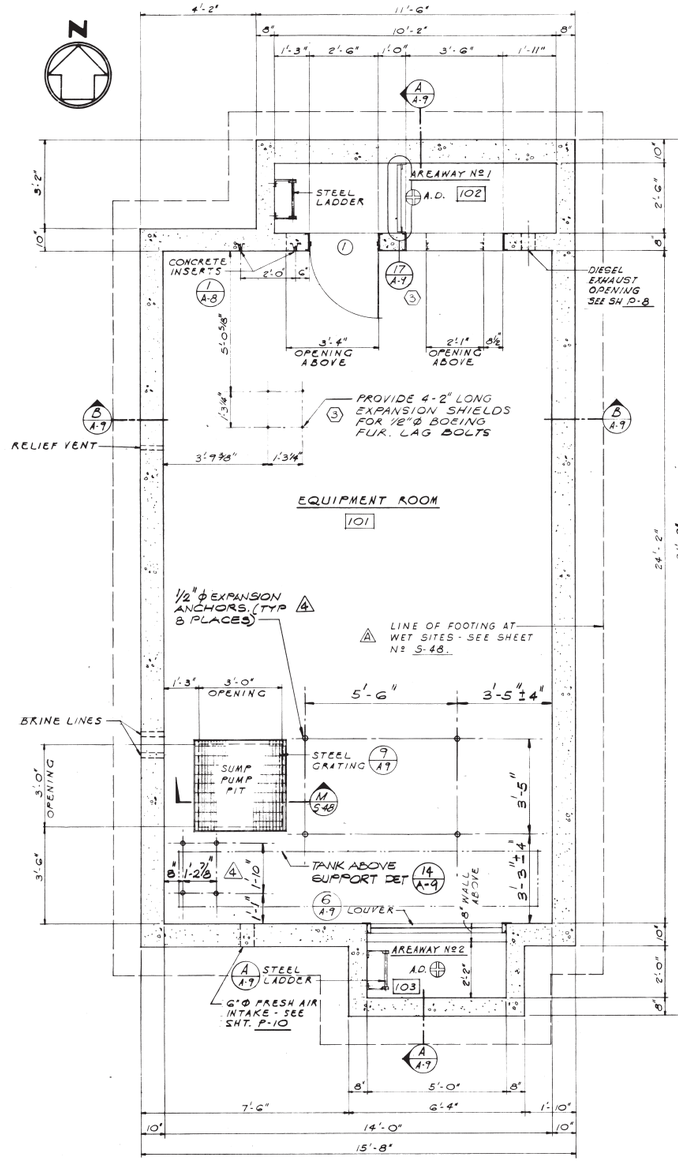
CORPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE APPROVES FOR CONSTRUCTION FEASIBILITY FOR THE CORPS OF ENGINEERS
CLIFTON H. CHAMBERLAIN, JR. LT. COL., CORPS OF ENGINEERS CHIEF ENGINEERING DIVISION
11-3-61

APPROVED
MAJOR, USAF DATE
DATE
RECOMMENDED
DATE JUN 17 1963

SPECIFICATION No. FIELD CHANGE CASE 106-61-43
DATE JUNE 5, 1961
SCALE AS NOTED
CEDICO SERIES NO. 132/30
SHEET 307

ARMO INDEX No.

Page intentionally left blank

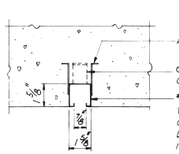


FLOOR PLAN

1/2" = 1'-0"

ROOF PLAN

1/2" = 1'-0"



CONCRETE INSERT DETAIL 1 A-8 / A-9

3" = 1'-0"

ROOM FINISH SCHEDULE

ROOM OR AREA NUMBER	DESCRIPTION	FLOOR: CONCRETE	FLOOR: HARDENED CONCRETE	WALL: CONCRETE	WALL: INSULATION FROM 7'-6" TO 8'-0"	WALL: 3/4" PAINTED WAINSCOT	CEILING: INSULATION OVER STEEL GRATING	CEILING: STEEL GRATING	CEILING HEIGHT	REMARKS
101	EQUIPMENT ROOM		●	●		●		●	—	
102	AREAWAY Nº 1	●		●				●	—	
103	AREAWAY Nº 2	●		●				●	—	

DOOR SCHEDULE

NO.	TYPE	DOOR OPNG WIDTH	DOOR OPNG HEIGHT	THICKNESS	MATERIAL	FRAME DETAILS: HEAD	FRAME DETAILS: JAMB	FRAME DETAILS: SILL	LOUVER	HARDWARE	REMARKS
1	A	2'-6"	7'-0"	1 3/4"	HOLLOW METAL	2 A-9	3 A-9	—	—	HW-7	WEATHER STRIPPING & FLIGHT 'E' ONLY (3)

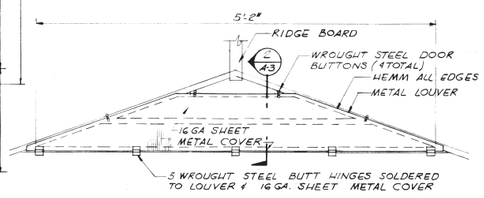
A

DOOR TYPE

NO SCALE

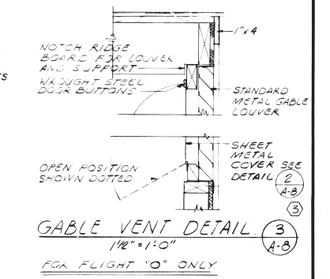
GENERAL NOTES

1. FOR SCHEDULE OF WET OR DRY SITES SEE LAUNCHER SCHEDULE COLUMN "LAUNCHER SUPPORT BUILDING SOIL CONDITIONS - WET OR DRY" ON SHEET S-47.



DETAIL 2 A-8 (3)

1 1/2" = 1'-0"



GABLE VENT DETAIL 3 A-8 (3)

1/2" = 1'-0"

FOR FLIGHT "O" ONLY

REVISION	DATE	DESCRIPTION	AGENCY	INIT.
(3)		ADDED WEATHERSTRIPPING TO DOOR #1 EQUIPMENT ROOM & STRAIGHT 5" SILL TO EQUIPMENT ROOM. ADDED METAL SIDING PARTITION IN AREAWAY FOR ADDED LOUVER COVER DETAILS.		
(2)		ADDED JOINTS ON ROOF PLAN, PER AS BUILT	PARSONS	
1	8-12-66	ADDED FLIGHT 'E' SELECTED INSULATION 8'-0" TO 7'-6" & 3/4" PAINTED WAINSCOT. CHANGE GI-062 TO GI-062 SALE	PARSONS	PWG
1	7-14-61	ADDED DETAIL'S REFERENCE. REVISED OUTLINE OF FOOTING FOR WET SITES. ADDED GRAPHIC SCALE.	PARSONS	

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION (AFSC)
INGLEWOOD, CALIFORNIA

DESIGNED BY BOLOTIN
DRAWN BY KEARSEY
CHECKED BY BOLOTIN
SUBMITTED BY

A-E SHEET No. A-8
A-E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

LAUNCH FACILITY
SUPPORT BUILDING
FLOOR AND ROOF PLANS AND SCHEDULES

APPROVED: [illegible] MAJOR, USAF DATE 7 1961
APPROVED: [illegible] Capt, USAF DATE 7 1961
DRAWING INDEX No.

SPECIFICATION No. ENG-04-548-61-43
DATE JUNE 5, 1961
SCALE AS NOTED
GEMCO SERIES NO. 132/10
SHEET 377A

CORPS OF ENGINEERS
BALLISTIC MISSILE CONSTRUCTION OFFICE
APPROVED FOR CONSTRUCTION FEASIBILITY FOR THE CORPS OF ENGINEERS
CLIFTON H. CHANDLER, JR.
LT. COL., CORPS OF ENGINEERS
CHIEF ENGINEERING DIVISION

3" SCALE 0 1 2 3 4 5 6 7 8 9 10 11 1 FOOT

1/2" SCALE 0 2 4 6 FEET

OPERATIONAL AS BUILT

AS BUILT DRAWING VERIFICATION — BASED ON SURVEYS

		DATE			DATE
FLIGHT A	AWN 4-2-63		FLIGHT F	3-27-63	Boeing Whitecliffe (STAVEN)
FLIGHT B	11-19-62		FLIGHT G	5-28-63	
FLIGHT C	3-7-63	Boeing Whitecliffe LTR 4-8-63	FLIGHT H	4-8-63	Boeing Whitecliffe LTR 4-8-63
FLIGHT D	12-11-62		FLIGHT I	1-3-63	
FLIGHT E	1-23-63		FLIGHT J	2-19-63	
			FLIGHT K	1-28-63	Boeing Whitecliffe LTR 4-8-63
			FLIGHT L	1-16-63	
			FLIGHT M	3-11-63	
			FLIGHT N	4-15-63	
			FLIGHT O	4-29-63	

Page intentionally left blank

BASE STRUCTURE WALL SCHEDULE	
SITE	"W"
J-1	20"
ALL OTHER SITES	18"

REINFORCING FOR ALL BASE STRUCTURES IS THE SAME SIZE & SPACING

| "AS BUILT" DRAWING CERTIFICATION — CORPS OF ENGINEERS | | |

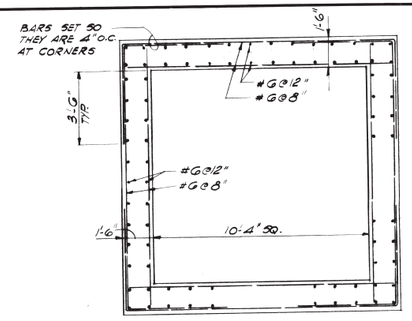
Page intentionally left blank

ACCESS SHAFT SCHEDULE

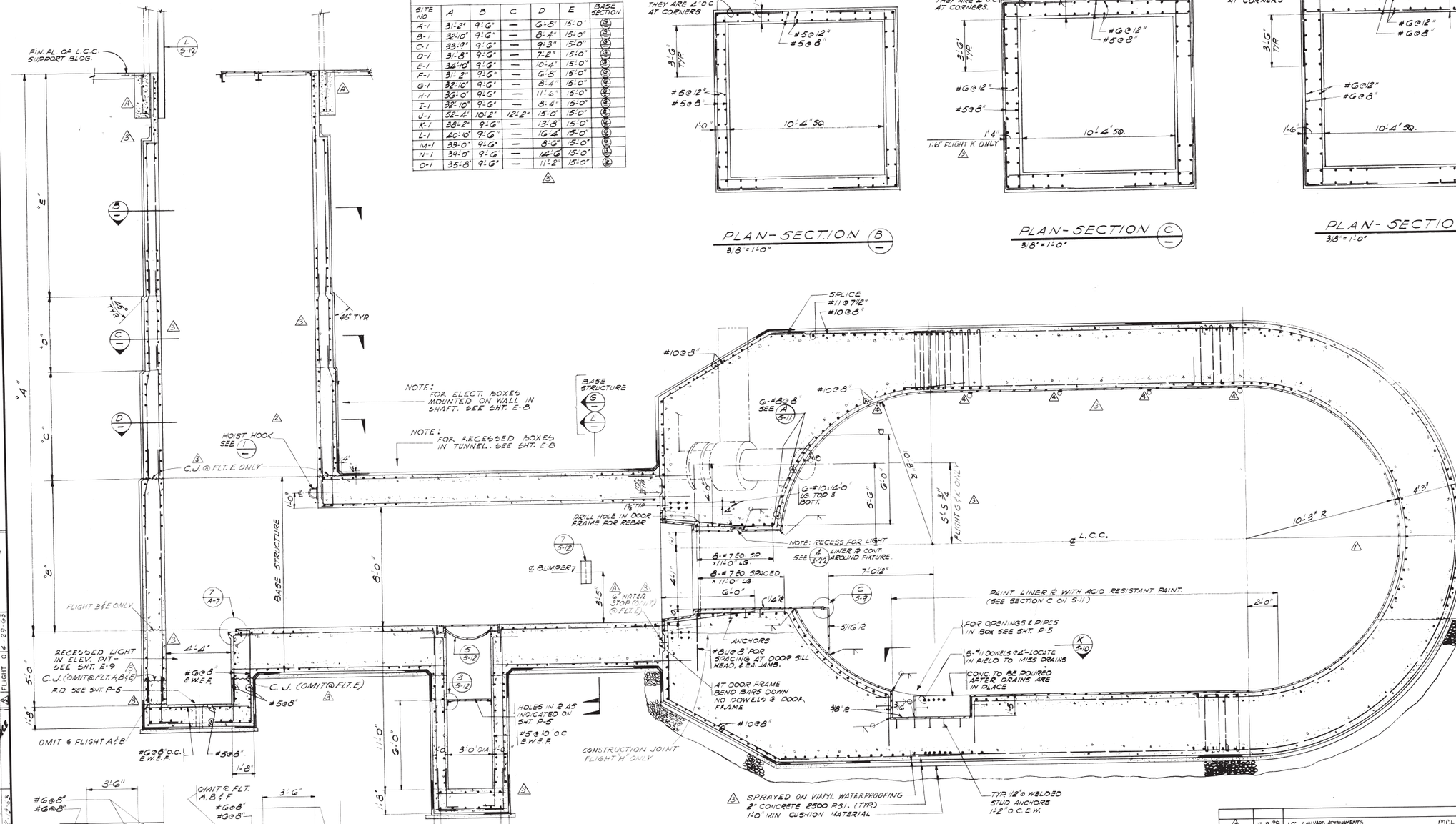
SITE NO	A	B	C	D	E	BASE SECTION
A-1	31-2"	9'-6"	—	6'-8"	15'-0"	G
B-1	32-10"	9'-6"	—	8'-4"	15'-0"	G
C-1	33-9"	9'-6"	—	9'-3"	15'-0"	G
D-1	34-8"	9'-6"	—	7'-2"	15'-0"	G
E-1	34-10"	9'-6"	—	10'-4"	15'-0"	G
F-1	31-2"	9'-6"	—	6'-8"	15'-0"	G
G-1	32-10"	9'-6"	—	8'-4"	15'-0"	G
H-1	32'-0"	9'-6"	—	11'-6"	15'-0"	G
I-1	32'-10"	9'-6"	—	8'-4"	15'-0"	G
J-1	52'-4"	10'-2"	12'-2"	15'-0"	15'-0"	G
K-1	38'-2"	9'-6"	—	13'-8"	15'-0"	G
L-1	40'-10"	9'-6"	—	16'-4"	15'-0"	G
M-1	33'-0"	9'-6"	—	8'-6"	15'-0"	G
N-1	39'-0"	9'-6"	—	14'-6"	15'-0"	G
O-1	35'-8"	9'-6"	—	11'-2"	15'-0"	G

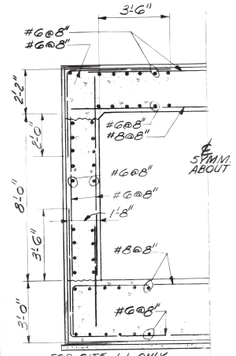
PLAN-SECTION (B) 3/8" = 1'-0"

PLAN-SECTION (C) 3/8" = 1'-0"



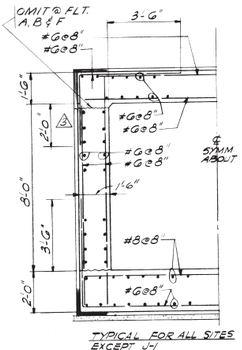
PLAN-SECTION (D) 3/8" = 1'-0"





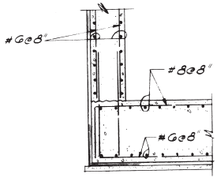
FOR SITE J-1 ONLY

SECTION (E) 5-3 5-2

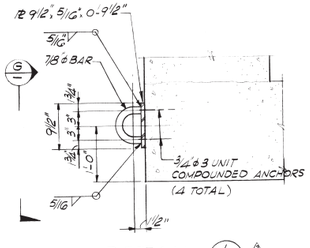


TYPICAL FOR ALL SITES EXCEPT J-1

SECTION (G) 3/8"=1'-0" 5-3 5-2

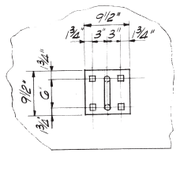


SECTION (F) 3/8"=1'-0" 5-3 5-2



DETAIL (I) 5-3 5-2 5-12

SECTION (A) 3/8"=1'-0" 5-3 5-2



ELEVATION (G) 1"=1'-0"

OPERATIONAL AS BUILT

Date 9-22-61

COPS OF ENGINEERS BALLISTIC MISSILE CONSTRUCTION OFFICE APPROVED FOR CONSTRUCTION FEASIBILITY FOR THE CORPS OF ENGINEERS

CLIFTON H. CHAMBERLAIN, JR. LT. COL. CORPS OF ENGINEERS CHIEF ENGINEERING DIVISION

⅜" SCALE 0 4 8 FEET

"AS BUILT" DRAWING CERTIFICATION - CORPS OF ENGINEERS

FLIGHT A	4-20-63	FLIGHT K	1-28-63
FLIGHT B	11-9-62	FLIGHT L	1-16-63
FLIGHT C	3-7-63	FLIGHT M	5-11-63
FLIGHT D	12-11-62	FLIGHT N	6-15-63
FLIGHT E	1-23-63	FLIGHT O	4-29-63
FLIGHT F	3-7-63		
FLIGHT G	2-22-63		
FLIGHT H	4-8-63		
FLIGHT I	1-3-63		
FLIGHT J	1-7-63		

REVISION	DATE	DESCRIPTION ADD #1	AGENCY	INIT.
(4)	7-18-88	LCC LANYARD ATTACHMENTS MCL (634)	RIVET MUE	LPA
(16)		REPAIR DAMAGED WATERPROOFING AT CONST. JOINTS AT FLIGHT H AND WATERPROOFING AT FLIGHT K AS RELATED TO REPAIR	AFSC	
(3)	2-12-61	FIELD CHANGE ADD HOIST HOOK ON SECT A ADD DET	AFSC	
(17)	9-22-61	REMOVED RADIATION OFFICE PLATFORM OC-G	PARSONS	
(5)	7-14-61	REVISED TOP OF ACCESS SHAFT & ADDED WATER STOP	PARSONS	

PARSONS-STAVEN
ARCHITECTS - ENGINEERS
LOS ANGELES, CALIF. RAPID CITY, SO. DAK.

DEPARTMENT OF THE AIR FORCE
BALLISTIC SYSTEMS DIVISION (AFSC)
INGLEWOOD, CALIFORNIA

DESIGNED BY: WILKINSON
DRAWN BY:
CHECKED BY:
SUBMITTED BY: DATE

A-E SHEET No. S-3
A-E JOB No. 1889-1

WS 133A TECHNICAL FACILITIES
SECOND OPERATIONAL DEPLOYMENT AREA
ELLSWORTH AIR FORCE BASE, SOUTH DAKOTA

LAUNCH CONTROL FACILITY
LAUNCH CONTROL CENTERS
SECTIONS AND DETAILS

APPROVED: [illegible] MAJOR, USAF DATE
APPROVED: [illegible] Capt USAF DATE

SPECIFICATION No. FIELD CHANGE CASE 50-61-43
DATE JUNE 5, 1961 SCALE AS NOTED
CEBMCO SERIES NO. 132/14 SHEET 381

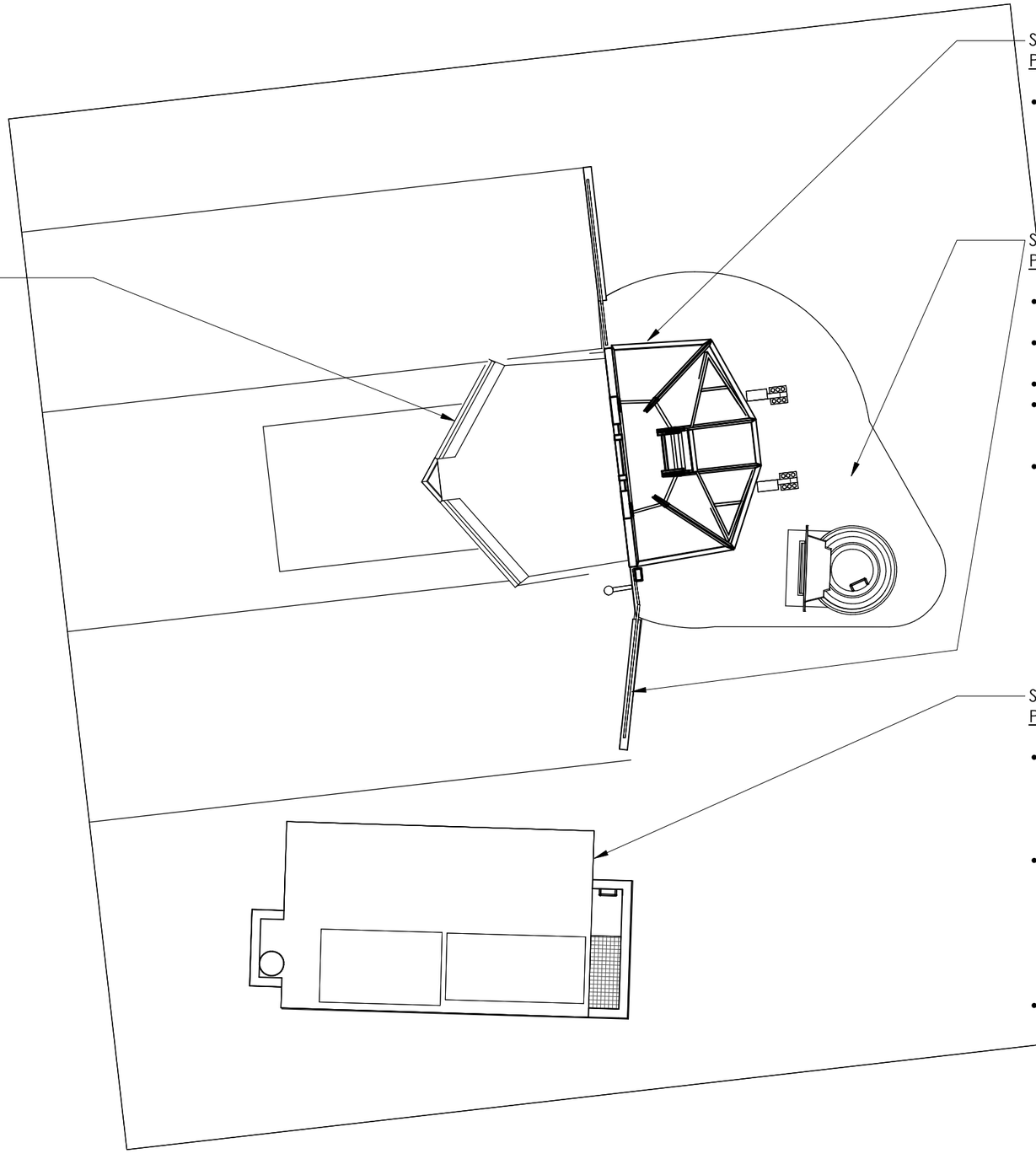
Page intentionally left blank

Appendix F. Treatment Drawings

Page intentionally left blank

RUCTURAL (CLOSURE DOOR AND TRACKS)
IORITY: SERIOUS

PERFORM HORIZONTAL CONCRETE PATCHING AND CRACK REPAIRS.
[BEST COATING OPTION] INSTALL HI-SOLIDS MEMBRANE SYSTEM ON TOP OF THE EXPOSED CONCRETE SURFACES.
[ALTERNATIVE COATING OPTION] IN LIEU OF A HI-SOLIDS WATERPROOFING MEMBRANE SYSTEM, A CLEAR, PENETRATING WATER REPELLENT SEALER WITH CORROSION INHIBITOR PROPERTIES CAN BE REGULARLY APPLIED TO THE EXPOSED CONCRETE SURFACES.



STRUCTURAL (GLASS VIEWING STRUCTURE)
PRIORITY: SERIOUS

- INSTALL A CLEAR, PENETRATING WATER REPELLENT SEALER WITH CORROSION INHIBITOR ACROSS THE EXPOSED CONCRETE SURFACES.

STRUCTURAL (LAUNCH FACILITY STRUCTURE)
PRIORITY: SERIOUS

- CRACK INJECTION REPAIRS IN CONCRETE RETAINING WALLS EACH SIDE OF STRUCTURE
- PERFORM HORIZONTAL CONCRETE PATCHING AND CRACK REPAIRS.
- REMOVE AND REPLACE SEALANT JOINTS.
- [BEST COATING OPTION] INSTALL HI-SOLIDS MEMBRANE SYSTEM ON TOP OF THE EXPOSED CONCRETE SURFACES.
- [ALTERNATIVE COATING OPTION] IN LIEU OF A HI-SOLIDS WATERPROOFING MEMBRANE SYSTEM, A CLEAR, PENETRATING WATER REPELLENT SEALER WITH CORROSION INHIBITOR PROPERTIES CAN BE REGULARLY APPLIED TO THE EXPOSED CONCRETE SURFACES.

STRUCTURAL
PRIORITY: SERIOUS

- [BEST OPTION] REMOVE AND REPLACE CONCRETE WEAR SLAB AND WATERPROOFING SYSTEM ABOVE THE STRUCTURAL ROOF SLAB. INSTALL HI-SOLIDS MEMBRANE SYSTEM ON TOP OF NEW WEAR SLAB.
- [GOOD OPTION] ORIGINAL CONCRETE WEAR SLAB TO REMAIN AND CONCRETE DAMAGE TO BE PATCHED AND CRACKS TREATED. INSTALL HI-SOLIDS MEMBRANE SYSTEM ON TOP OF REPAIRED WEAR SLAB (NOTE ORIGINAL WATERPROOFING LAYER BELOW THE WEAR SLAB REMAINS).
- [ALTERNATIVE OPTION] IN LIEU OF A HI-SOLIDS WATERPROOFING MEMBRANE SYSTEM BEING APPLIED TO THE WEAR SLAB SURFACE, A CLEAR, PENETRATING WATER REPELLENT SEALER WITH CORROSION INHIBITOR PROPERTIES CAN BE REGULARLY APPLIED TO THE CONCRETE SURFACE.

1 SITE PLAN
SCALE: 3/32" = 1'-0"

0' 4' 8' 16' 32'

SEVEN GENERATIONS
architecture +engineering

600 E. Michigan Ave., Suite
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)
NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS
24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:
DECEMBER 1, 2023

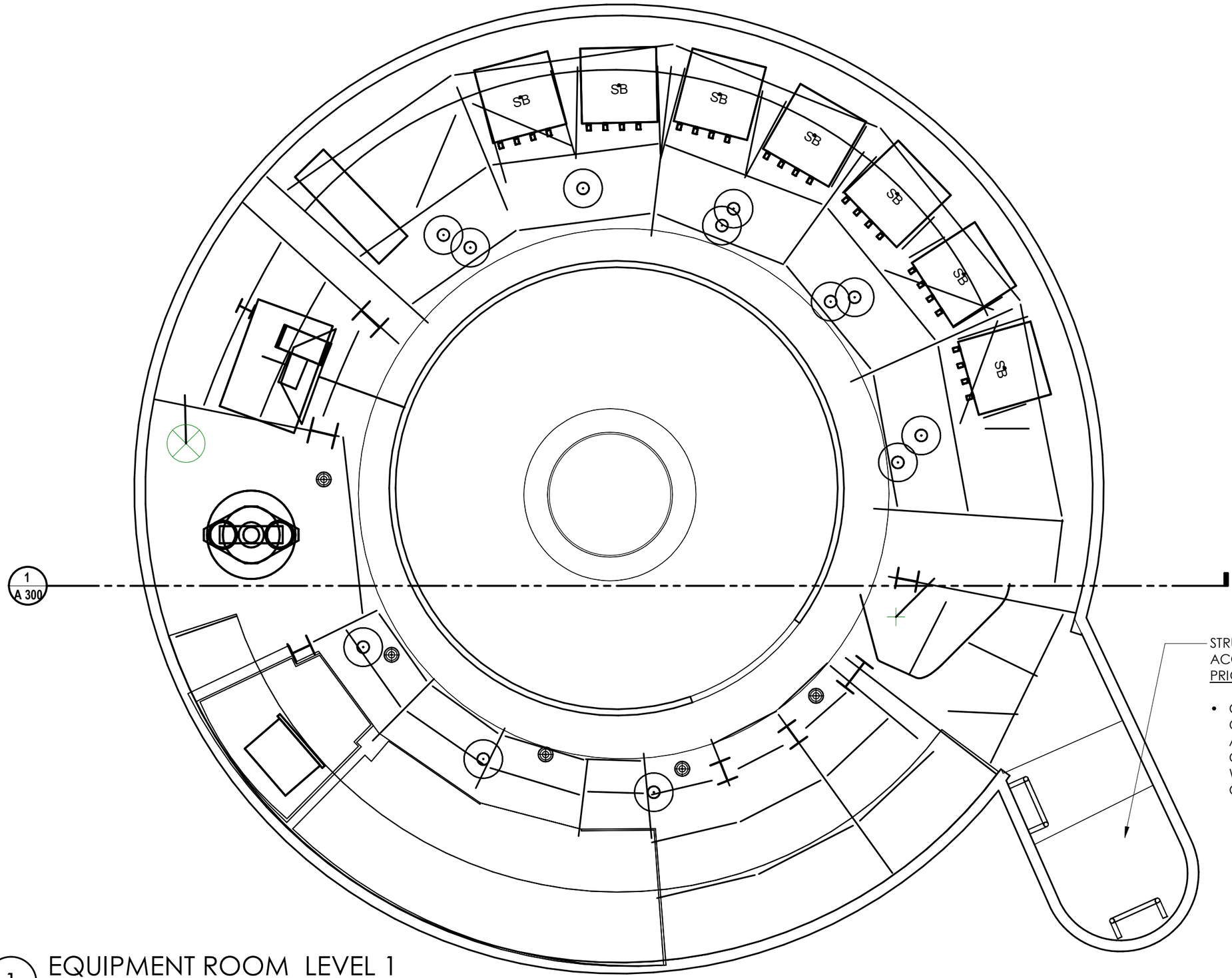
PMIS NUMBER:
257125
NPS DRAWING NUMBER:
–

SHEET TITLE
SITE PLAN

SHEET NO.
LS 100

THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED.
©SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

Page intentionally left blank



1 EQUIPMENT ROOM LEVEL 1

SCALE: 3/8" = 1'-0"

SEVEN GENERATIONS
architecture +engineering

600 E. Michigan Ave., Suite B
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)

NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS

24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:
DECEMBER 1, 2023

PMIS NUMBER:
257125

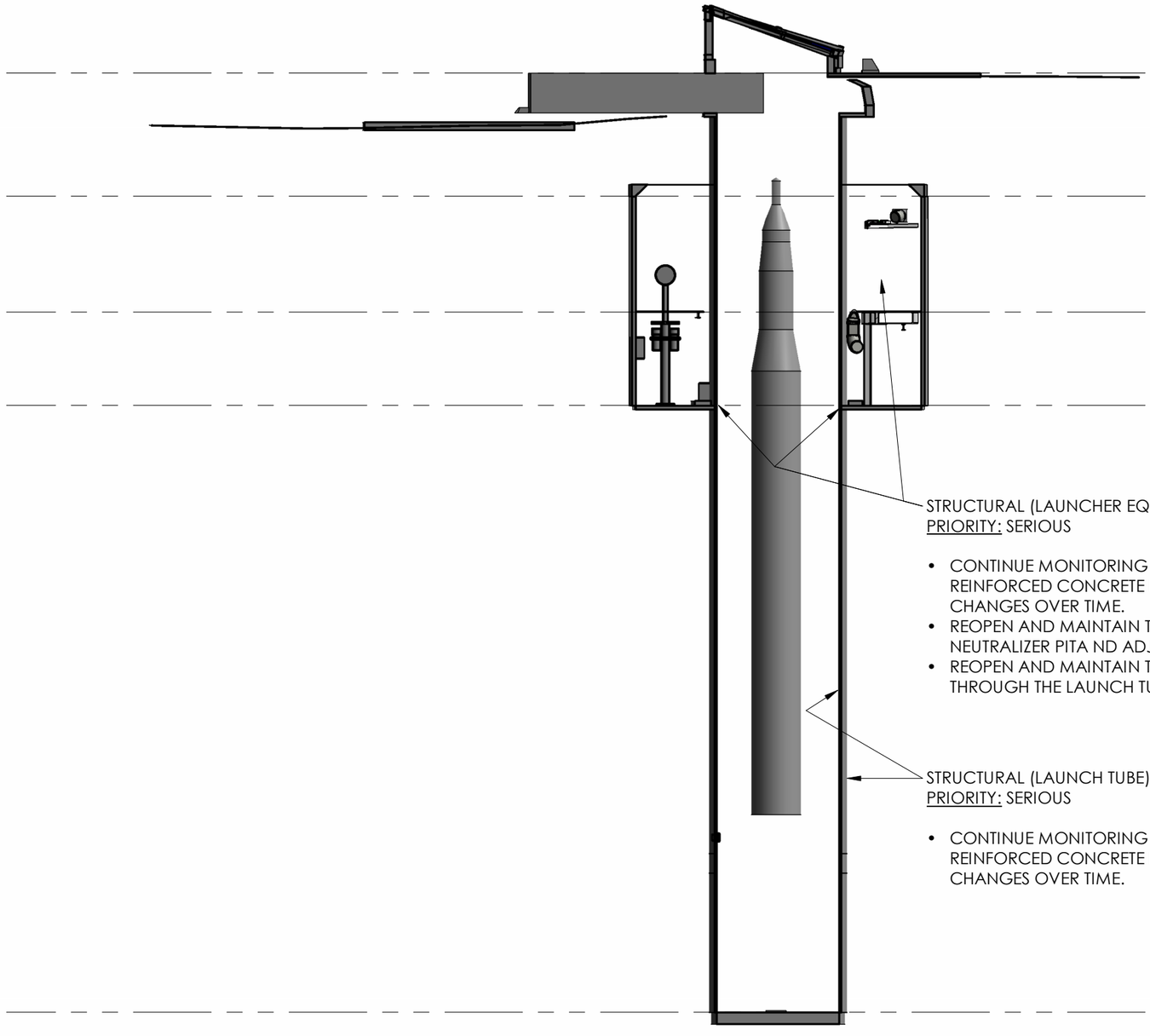
NPS DRAWING NUMBER:
–

SHEET TITLE
EQUIPMENT ROOM

SHEET NO.
A 101

THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED.
© SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

Page intentionally left blank



TOPO Grade
ELEV. -2'-0"
(890.00)

Mech Room
ELEV. -12'-6 1/2"
(879.46)

Equipment Room Level 1
ELEV. -22'-5 1/2"
(869.54)

Equipment Room Level 2
ELEV. -30'-5 1/2"
(861.54)

STRUCTURAL (LAUNCHER EQUIPMENT ROOM)
PRIORITY: SERIOUS

- CONTINUE MONITORING OF STEEL PLATE LINER AND REINFORCED CONCRETE BACKUP WALL TO DOCUMENT CHANGES OVER TIME.
- REOPEN AND MAINTAIN THE DRAIN OPERATION OF THE NEUTRALIZER PITA ND ADJACENT FLOOR DRAIN ON LEVEL 2.
- REOPEN AND MAINTAIN THE OPEN NATURE OF ALL WEEP HOLES THROUGH THE LAUNCH TUBE STEEL WALL AT LEVEL 2.

STRUCTURAL (LAUNCH TUBE)
PRIORITY: SERIOUS

- CONTINUE MONITORING OF STEEL PLATE LINER AND REINFORCED CONCRETE BACKUP WALL TO DOCUMENT CHANGES OVER TIME.

Sub Level 3
ELEV. -82'-5"
(809.58)

1 DELTA-09 SILO SECTION

SCALE: 3/32" = 1'-0"

0' 4' 8' 16' 32'

SEVEN GENERATIONS
architecture +engineering

600 E. Michigan Ave., Suite B
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)
NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS
24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:
DECEMBER 1, 2023

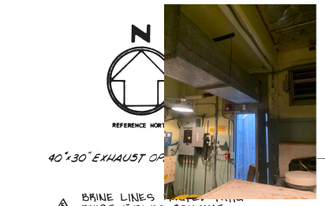
PMIS NUMBER:
257125
NPS DRAWING NUMBER:
–

SHEET TITLE
BUILDING SECTION

SHEET NO.
A 300

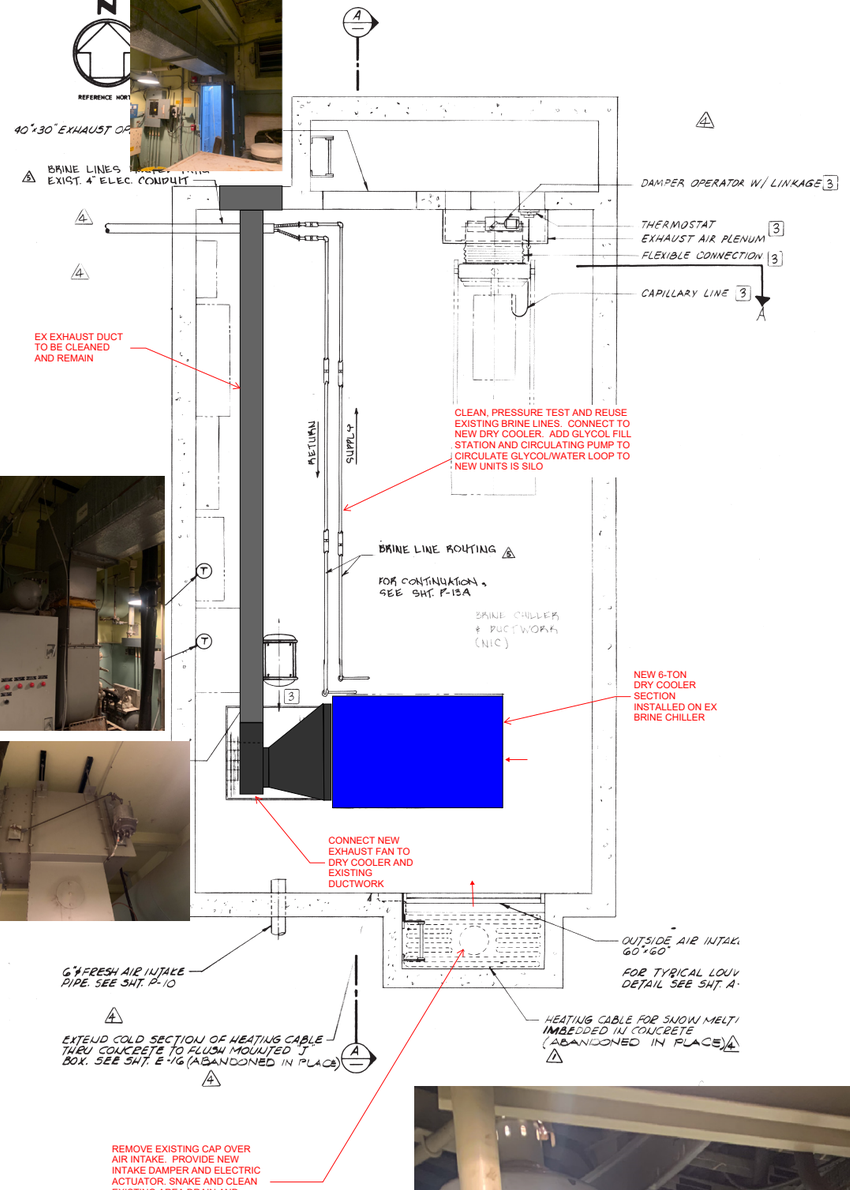
THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED. © SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

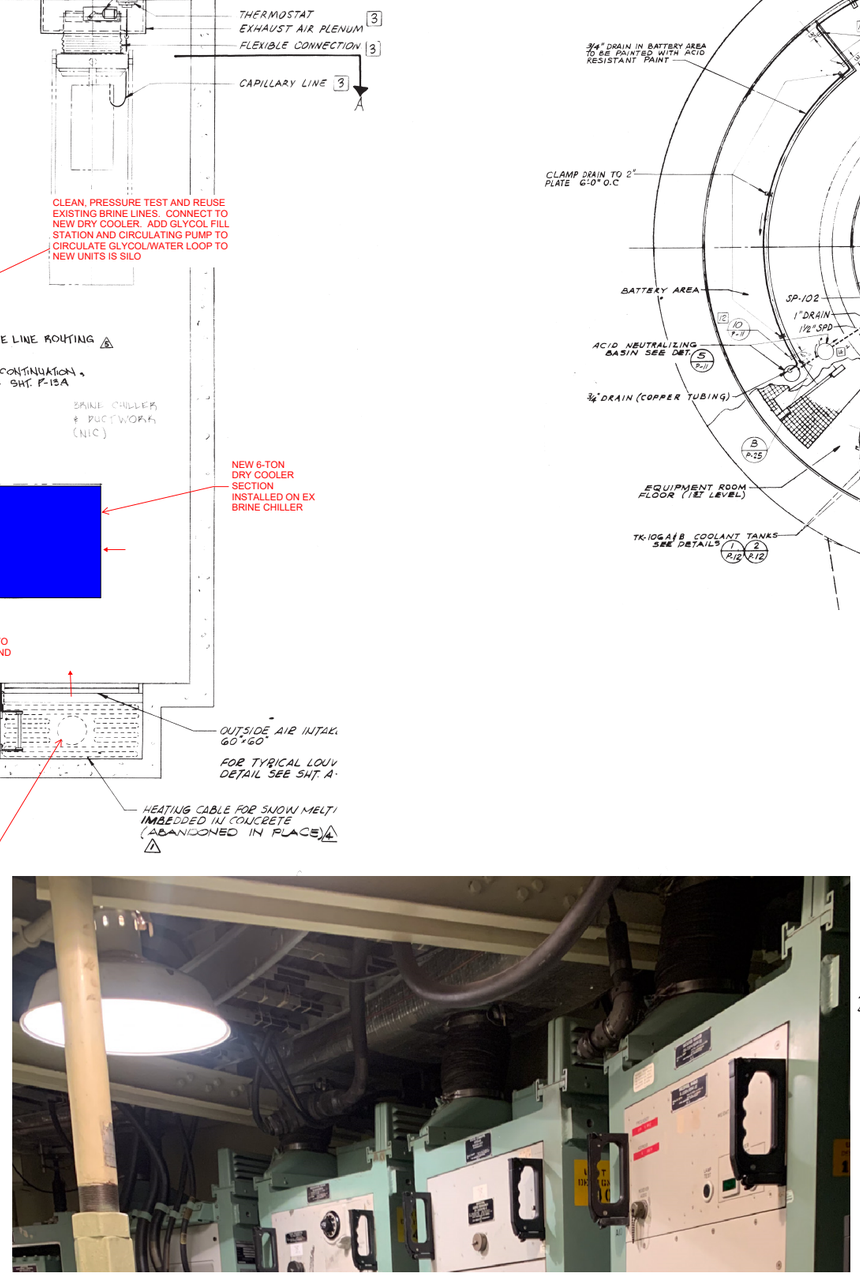
Page intentionally left blank

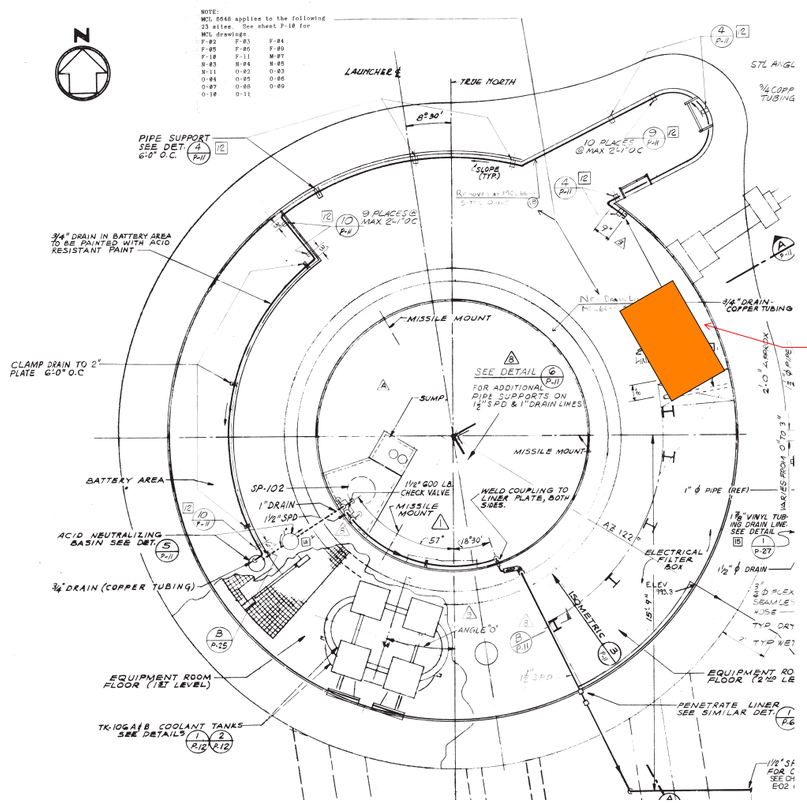


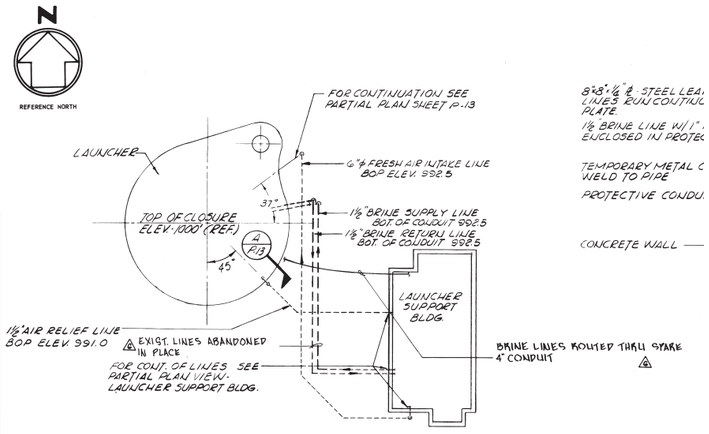












PLOT PLAN
1" = 10'

SEVEN GENERATIONS
architecture +engineering

600 E. Michigan Ave., Suite B
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)

NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS
24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:

PMIS NUMBER:
257125

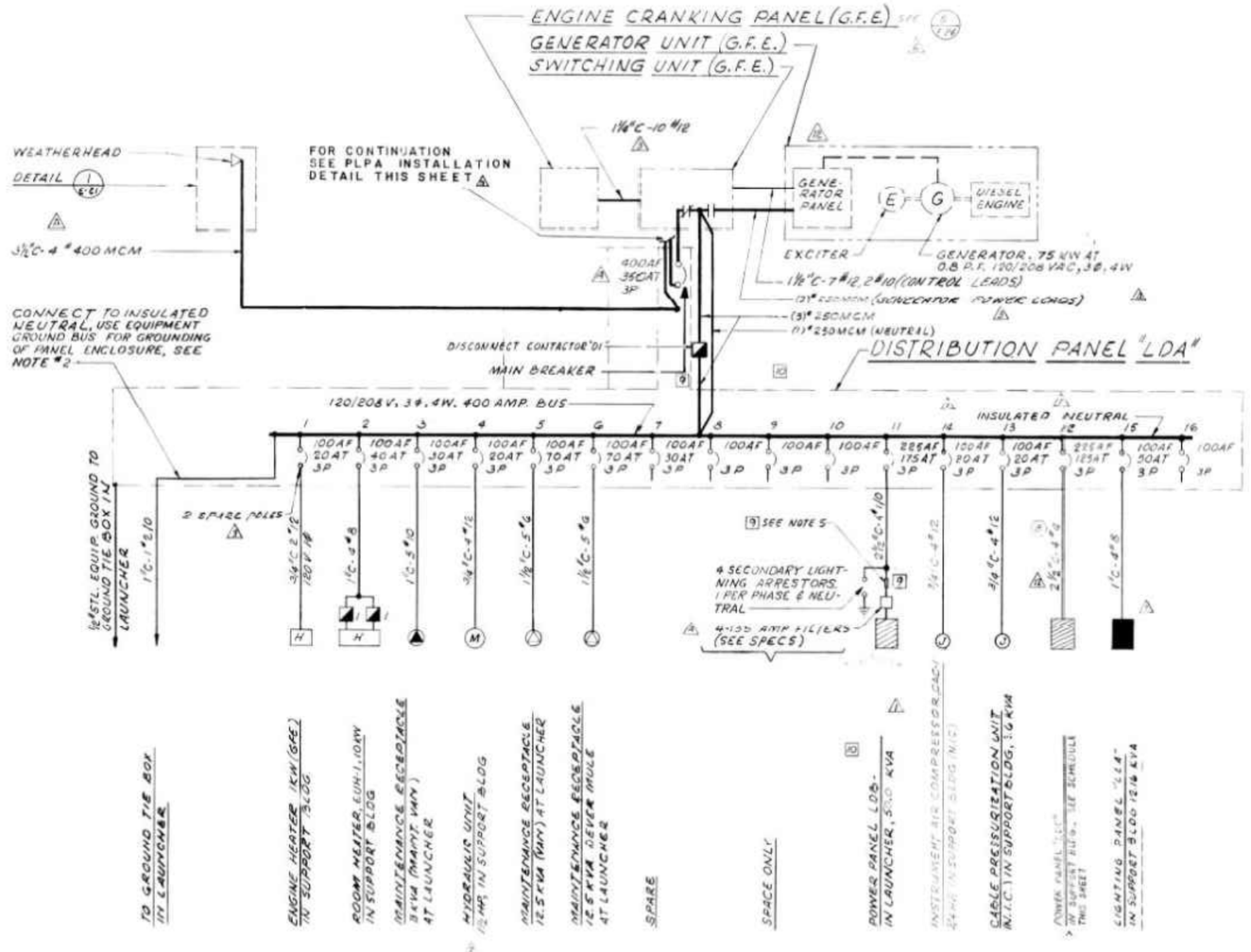
NPS DRAWING NUMBER:
–

SHEET TITLE

SHEET NO.
MSK1

THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED.
© SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

Page intentionally left blank



1 EXISTING SINGLE LINE DIAGRAM - ELECTRICAL

Scale: NOT TO SCALE

EX DISTRIBUTION PANEL 'LDA'

VOLTAGE: 208 /120V AIC 22,000 AMPS
WIRES: 4 PHASE: 3 MOUNTING: SURFACE BUSING 400 AMPS
SERVIE ENTRANCE RATED: YES

CKT #	ITEM SERVED	CIRCUIT BREAKER RATING - AMPERES POLE	TRIP	FRAME	COMMENTS	LOAD
1	EX ENGINE HEATER (1KW)	1	20	100		
2	EX UNIT HEATER, EUH-1 (10KW)	3	40	100		
3	EX MAINT. RECEPTACLE (LAUNCHER)	3	30	100		
4	EX HYDRAULIC UNIT	3	20	100		
5	EX MAINT. RECEPTACLE (LAUNCHER)	3	70	100		
6	EX MAINT. RECEPTACLE (LAUNCHER)	3	70	100		
7	EX SPARE	3	30	100		
8	EX PROVISIONAL SPACE	3	-	100		
9	EX PROVISIONAL SPACE	3	-	100		
10	EX PROVISIONAL SPACE	3	-	100		
11	EX PANEL 'LDB' (LAUNCHER)	3	175	225		
12	EX PANEL 'LDC' (SOFT SUPPORT)	3	125	225		
13	EX CABLE PRESSURIZATION UNIT	3	20	100		
14	EX AIR COMPRESSOR, CAC-1	3	20	100		
15	EX PANEL 'LLA' (SOFT SUPPORT)	3	100	100		
16	EX PROVISIONAL SPACE	3	-	100		
17	EX MAIN (NORMAL FEED TO ATS)	3	100	100		

EX PANEL 'LLA'

BUSING 100 AMPS VOLTAGE 208 /120V 3 -Ph 4-W
S.C.R. 10,000 AIC MOUNTING SURFACE MANUFAC: FEDERAL PACIFIC
CATALOG #: AF-863205
MAIN DEVICE MLO TYPE: NHB

NO	DESCRIPTION	CB/P	CB/P	DESCRIPTION	NO
1	EX LIGHTS	20/1	20/1	EX SUMP PUMP, SERVICE DRAINAGE	2
3	EX RECEPTACLES	20/1	20/1	EX THERMOSTAT HEAT CABLE	4
5	EX FUEL PUMP, P-101	20/1	20/1	EX SUMP PUMP, SP-103	6
7	EX SPARE	20/1	20/1	EX SPARE	8
9	EX SPARE	20/1	20/1	EX SPARE	10
11	EX SPARE	20/1	20/1	EX S.I.N. TELEPHONE	12
13	EX SPARE	20/1	20/1	EX CHARGER	14
15	EX OUTDOOR CAMERA RECEPT	20/1	20/1	EX SPARE	16
17	EX FLOODLIGHT AND CONTACTOR	20/1	20/1	EX SECURITY PANEL	18

SEVEN GENERATIONS
architecture +engineering

600 E. Michigan Ave., Suite B
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)

NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS
24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:

PMIS NUMBER:
257125

NPS DRAWING NUMBER:
–

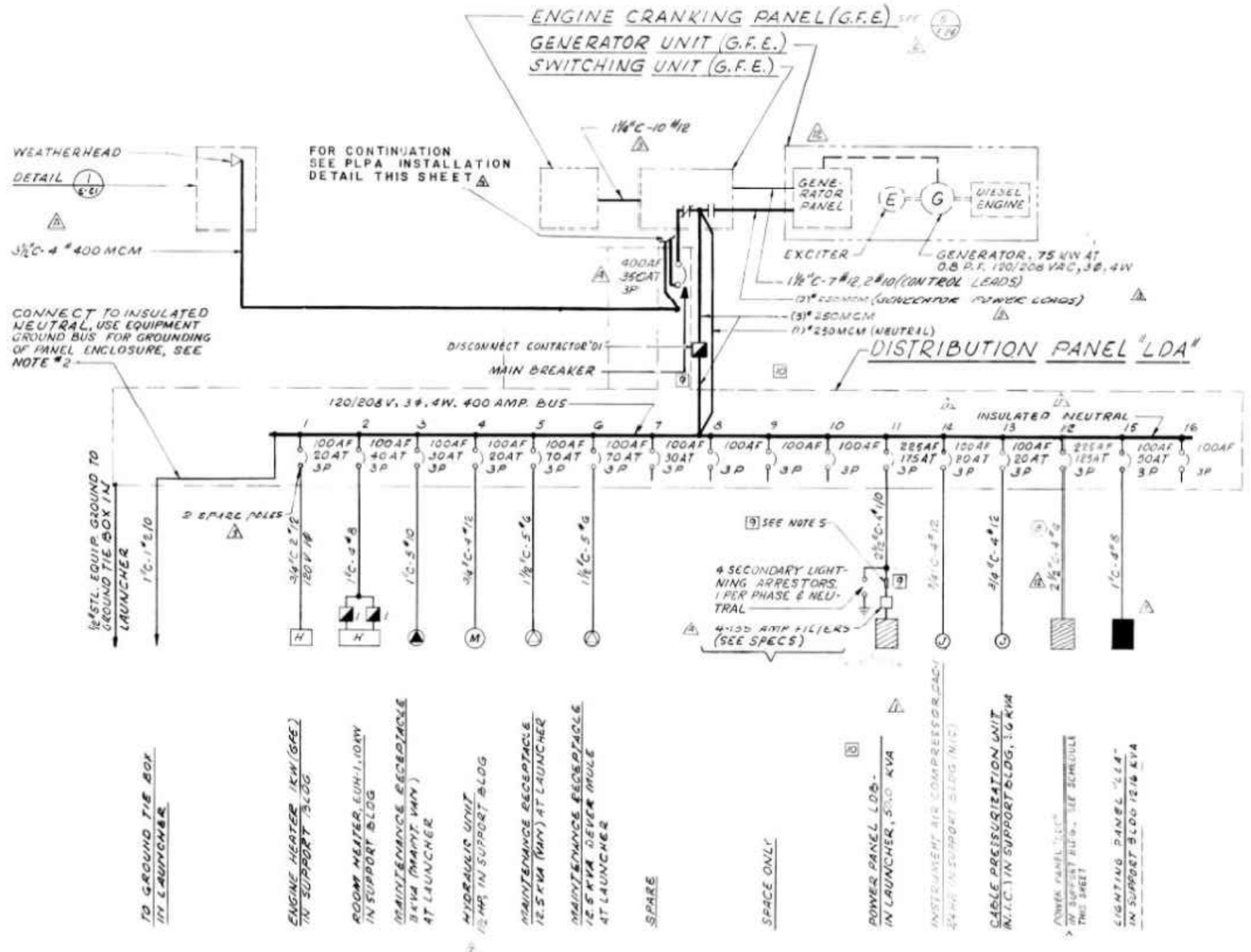
SHEET TITLE

SHEET NO.

ESK1

THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED.
© SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

Page intentionally left blank



1 EXISTING SINGLE LINE DIAGRAM - ELECTRICAL

Scale: NOT TO SCALE

EX DISTRIBUTION PANEL 'LDA'

VOLTAGE: 208 /120V AIC 22,000 AMPS
WIRES: 4 PHASE: 3 MOUNTING: SURFACE BUSING 400 AMPS
SERVIE ENTRANCE RATED: YES

CKT #	ITEM SERVED	CIRCUIT BREAKER RATING - AMPERES POLE	TRIP	FRAME	COMMENTS	LOAD
1	EX ENGINE HEATER (1KW)	1	20	100		
2	EX UNIT HEATER, EUH-1 (10KW)	3	40	100		
3	EX MAINT. RECEPTACLE (LAUNCHER)	3	30	100		
4	EX HYDRAULIC UNIT	3	20	100		
5	EX MAINT. RECEPTACLE (LAUNCHER)	3	70	100		
6	EX MAINT. RECEPTACLE (LAUNCHER)	3	70	100		
7	EX SPARE	3	30	100		
8	EX PROVISIONAL SPACE	3	-	100		
9	EX PROVISIONAL SPACE	3	-	100		
10	EX PROVISIONAL SPACE	3	-	100		
11	EX PANEL 'LDB' (LAUNCHER)	3	175	225		
12	EX PANEL 'LDC' (SOFT SUPPORT)	3	125	225		
13	EX CABLE PRESSURIZATION UNIT	3	20	100		
14	EX AIR COMPRESSOR, CAC-1	3	20	100		
15	EX PANEL 'LLA' (SOFT SUPPORT)	3	100	100		
16	EX PROVISIONAL SPACE	3	-	100		
17	EX MAIN (NORMAL FEED TO ATS)	3	100	100		

EX PANEL 'LLA'

BUSING 100 AMPS VOLTAGE 208 /120V 3 -Ph 4-W
S.C.R. 10,000 AIC MOUNTING SURFACE MANUFAC: FEDERAL PACIFIC
CATALOG #: AF-863205
MAIN DEVICE MLO TYPE: NHB

NO	DESCRIPTION	CB/P	CB/P	DESCRIPTION	NO
1	EX LIGHTS	20/1	20/1	EX SUMP PUMP, SERVICE DRAINAGE	2
3	EX RECEPTACLES	20/1	20/1	EX THERMOSTAT HEAT CABLE	4
5	EX FUEL PUMP, P-101	20/1	20/1	EX SUMP PUMP, SP-103	6
7	EX SPARE	20/1	20/1	EX SPARE	8
9	EX SPARE	20/1	20/1	EX SPARE	10
11	EX SPARE	20/1	20/1	EX S.I.N. TELEPHONE	12
13	EX SPARE	20/1	20/1	EX CHARGER	14
15	EX OUTDOOR CAMERA RECEPT	20/1	20/1	EX SPARE	16
17	EX FLOODLIGHT AND CONTACTOR	20/1	20/1	EX SECURITY PANEL	18

SEVEN GENERATIONS
architecture +engineering

600 E. Michigan Ave., Suite B
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)

NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS
24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:

PMIS NUMBER:
257125

NPS DRAWING NUMBER:
–

SHEET TITLE

SHEET NO.

ESK1

THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED.
© SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

Page intentionally left blank

KEYNOTES

1. RETROFIT EXISTING PANEL WITHIN EXISTING ENCLOSURE. PROVIDE NEW BUSSING AND CIRCUIT BREAKERS TO MATCH EXISTING DISTRIBUTION. RECONNECT EXISTING FEEDER AND BRANCH CIRCUITING/CONDUIT (SIZES AND QUANTITIES OF CONDUCTOR AND CONDUIT TO MATCH EXISTING), REFER TO PANEL SCHEDULES FOR ADDITIONAL INFORMATION. EXISTING ENCLOSURES, EXTERIOR AND INTERIOR, SHALL BE CLEANED THOROUGHLY TO REMOVE DUST AND CORROSION. PHOTOGRAPHICALLY DOCUMENT SURVIVING PAINT FINISHES PRIOR TO PAINT REMOVAL ASSOCIATED WITH CORROSION MITIGATION AND REPAIR WORK.

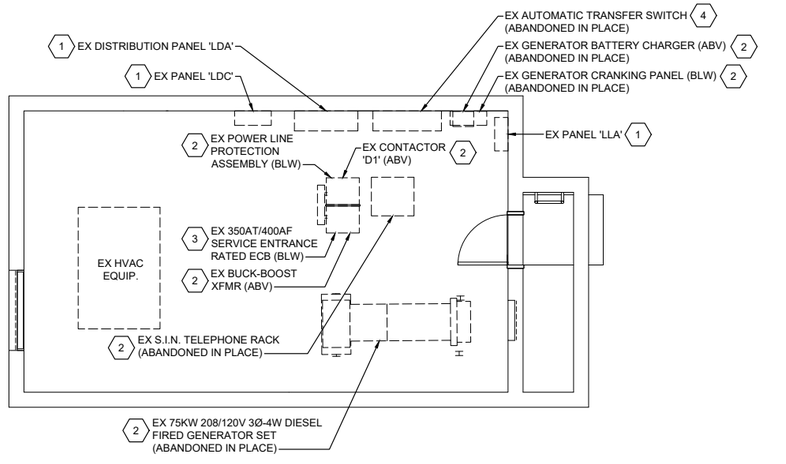
2. EXISTING ELECTRICAL EQUIPMENT ABANDONED IN PLACE. EQUIPMENT SHALL BE CLEANED THOROUGHLY TO REMOVE DUST AND CORROSION. PHOTOGRAPHICALLY DOCUMENT SURVIVING PAINT FINISHES PRIOR TO PAINT REMOVAL ASSOCIATED WITH CORROSION MITIGATION AND REPAIR WORK.

3. EXISTING SERVICE ENTRANCE RATED 350AT/400AF ENCLOSED CIRCUIT BREAKER TO BE REPLACED IN KIND. ENCLOSURE SHALL BE CLEANED THOROUGHLY TO REMOVE DUST AND CORROSION. PHOTOGRAPHICALLY DOCUMENT SURVIVING PAINT FINISHED PRIOR TO PAINT REMOVAL ASSOCIATED WITH CORROSION MITIGATION AND REPAIR WORK.

4. EXISTING AUTOMATIC TRANSFER SWITCH ABANDONED IN PLACE. ALL INTERNAL ELECTRICAL COMPONENTS SHALL BE CLEANED THOROUGHLY TO REMOVE DUST AND CORROSION, AND RETURNED TO A REFURBISHED AND WORKING CONDITION. PHOTOGRAPHICALLY DOCUMENT SURVIVING PAINT FINISHES PRIOR TO PAINT REMOVAL ASSOCIATED WITH CORROSION MITIGATION AND REPAIR WORK.

GENERAL NOTES

1. PROVIDE ALLOWANCE FOR CLEANING AND REMOVAL OF CORROSION TO APPROXIMATELY (25) EXISTING TO REMAIN 18" IN DIAMETER INDUSTRIAL LIGHTING PENDANTS. PHOTOGRAPHICALLY DOCUMENT SURVIVING PAINT FINISHES PRIOR TO PAINT TOUCH-UP ASSOCIATED WITH CORROSION MITIGATION AND REPAIR WORK.

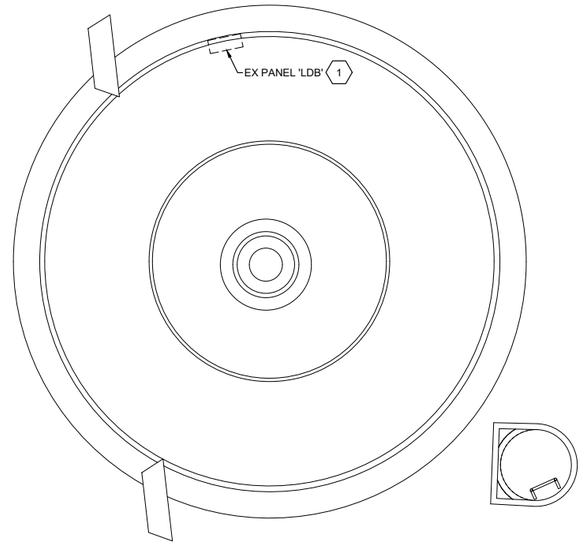


2 ENLARGED SOFT SUPPORT BUILDING - ELECTRICAL

Scale: 1/4" = 1'-0"

0 2' 4' 8'

N



3 ENLARGED LAUNCH FACILITY - ELECTRICAL

Scale: 1/4" = 1'-0"

0 2' 4' 8'

N

SEVEN GENERATIONS architecture +engineering

600 E. Michigan Ave., Suite B
Kalamazoo, MI 49007
P: 269.927.0144
www.7GenAE.com

HISTORIC STRUCTURE REPORT FOR DELTA-09 LAUNCH FACILITY (LF) SUPPLEMENTAL ANALYSIS FOR DELTA-01 LAUNCH CONTROL CENTER (LLC)

NATIONAL PARK SERVICE: MINUTEMAN MISSILE NHS

24545 COTTONWOOD RD. PHILLIP, SD 57567

ISSUE DATE:

PMIS NUMBER:
257125

NPS DRAWING NUMBER:
–

SHEET TITLE

SHEET NO.

ESK1

THE REPRODUCTION, COPYING OR OTHER USE OF THIS DRAWING WITHOUT WRITTEN AUTHORIZATION IS PROHIBITED.
© SEVEN GENERATIONS ARCHITECTURE & ENGINEERING, LLC

Page intentionally left blank

Appendix G. Cost Estimate

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BASIS OF ESTIMATE

PROJECT INFORMATION

Project:	Delta 09 Soft Support Building & Delta 09 Launch Facility
Park:	Minuteman Missile National Historic Site
Park Apha:	
PMIS:	257125
Estimate Date:	7/18/2024
Prepared By:	Donald Parker
Company:	Kirk Associates, Inc.
Address:	3007 N. 156th Dr.
City, State Zip:	Goodyear, AZ
Phone:	313-701-2084

BACKGROUND SUPPORTING MATERIAL (Scope of Work):

Three options for best, good and alternate renovations to the Soft Support Building and two options for best and good renovations to the Launch Facility. A list of items of work and quantities were provided by the A-E for all 5 options.

SOURCE OF COST DATA:

RS Means, 2024 edition

ESTIMATE ASSUMPTIONS:

None. All items of work and quantities provided by A-E.
This is a Class C estimate requested to be made using the Class A format.

MAJOR CHANGES FROM PREVIOUS ESTIMATE:

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BASIS OF ESTIMATE

PROJECT INFORMATION

Project:	Delta 09 Soft Support Building & Delta 09 Launch Facility
Park:	Minuteman Missile National Historic Site
Park Apha:	
PMIS:	257125
Estimate Date:	7/18/2024

DESCRIPTION OF MARK-UP & ADD-ONS:

Design Contingency:	20.00%	Normal for concept stage
Standard. General Conditions:	10.00%	NPS change
Government General Conditions:	5.00%	NPS change
Contractor Overhead:	10.00%	NPS change
Contractor Profit:	10.00%	NPS change
Historic Preservation Factor	10.00%	NPS change
Contracting Method Adjustment:	10.00%	Standard with no contract method adjustment.
Annual Inflation Escalation Factor:	6.00%	Projected annual inflation rate.
Time Until Project Midpoint (Months)	12	Number of months from estimate (or data) date until the projects midpoint of construction.

OTHER COMMENTS:

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

PROJECT COST SUMMARY

Project: Delta 09 Soft Support Building & Delta 09 Launch Facility
Park: Minuteman Missile National Historic Site
Park Alpha:
PMIS Number: 257125

Estimate By: Donald Parker
Date: 07/18/24
Reviewed By: Kirk
Date: 07/18/24

Option No.	Option Description	Total Material Cost	Total Labor Cost	Total Equipment Cost	Total Direct Construction Costs	Design Contingency 20.00%	General Conditions & Govt GC 15.00%	General Contractor Overhead 10.00%	General Contractor Profit 10.00%	Contracting Method Adjustment & Historic Preservation Factor 20.00%	Inflation Escalation APR 6.00%	Inflation Escalation Months 12	Item Total
1-SSB	Soft Support Building											TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):	$ -
	Priority: Serious (best option)	$ 37,280.30	$ 43,336.00	$ 4,333.75	$ 84,950.05								
Soft Support Building Option 1		$ 37,280.30	$ 43,336.00	$ 4,333.75	$ 84,950.05	$ 16,990.01	$ 15,291.01	$ 11,723.11	$ 11,723.11	$ 28,135.46	$ 10,128.76		$ 178,941.50
2-SSB	Soft Support Building											TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):	$ -
	Priority: Serious (good option)	$ 1,025.00	$ 3,225.00	$ 1,200.00	$ 5,450.00								
Soft Support Building Option 2		$ 1,025.00	$ 3,225.00	$ 1,200.00	$ 5,450.00	$ 1,090.00	$ 981.00	$ 752.10	$ 752.10	$ 1,805.04	$ 649.81		$ 11,480.05
3-SSB	Soft Support Building											TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):	$ -
	Priority: Serious (alternative coating option)	$ 1,625.00	$ 6,500.00	$ 1,300.00	$ 9,425.00								
Soft Support Building Option 3		$ 1,625.00	$ 6,500.00	$ 1,300.00	$ 9,425.00	$ 1,885.00	$ 1,696.50	$ 1,300.65	$ 1,300.65	$ 3,121.56	$ 1,123.76		$ 19,853.12
1-LF	Launch Facility											TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):	$ -
	Priority: Serious (best option)	$ 39,807.50	$ 70,170.00	$ 5,460.00	$ 115,437.50								
Launch Facility Option 1		$ 39,807.50	$ 70,170.00	$ 5,460.00	$ 115,437.50	$ 23,087.50	$ 20,778.75	$ 15,930.38	$ 15,930.38	$ 38,232.90	$ 13,763.84		$ 243,161.24
2-LF	Launch Facility											TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):	$ -
	Priority: Serious (alternative coating option)	$ 2,400.00	$ 9,840.00	$ 1,200.00	$ 13,440.00								
Launch Facility Option 2		$ 2,400.00	$ 9,840.00	$ 1,200.00	$ 13,440.00	$ 2,688.00	$ 2,419.20	$ 1,854.72	$ 1,854.72	$ 4,451.33	$ 1,602.48		$ 28,310.45

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BID ITEM COST SUMMARY

Project: Delta 09 Soft Support Building & Delta 09 Launch Facility
Park: Minuteman Missile National Historic Site
Park Alpha:
PMIS Number: 257125

Estimate By: Donald Parker
Date: 07/18/24
Reviewed By: Kirk
Date: 07/18/24

Option 1 - SSB (Soft Support Building)

Item No.	WBS	Description	Quantity	Measure	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
		STRUCTURAL										
		Prepare & paint interior concrete walls & ceiling	1200	SF	$ 2.00	$ 2,400.00	$ 7.00	$ 8,400.00	$ 1.00	$ 1,200.00	$ 10.00	$ 12,000.00
		Remove slab	275	SF	$ -	$ -	$ 5.00	$ 1,375.00	$ 1.00	$ 275.00	$ 6.00	$ 1,650.00
		New 2.5" topping slab	275	SF	$ 5.00	$ 1,375.00	$ 10.00	$ 2,750.00	$ 1.00	$ 275.00	$ 16.00	$ 4,400.00
		Remove split slab waterproofing system	275	SF	$ -	$ -	$ 3.00	$ 825.00	$ 1.00	$ 275.00	$ 4.00	$ 1,100.00
		New split slab waterproofing	275	SF	$ 2.00	$ 550.00	$ 7.50	$ 2,062.50	$ 0.25	$ 68.75	$ 9.75	$ 2,681.25
		Inject cracks in structural slab w/polyurethane grout	25	LF	$ 0.50	$ 12.50	$ 2.00	$ 50.00	$ 9.60	$ 240.00	$ 12.10	$ 302.50
		New Polyurethane waterproofing on conc. Topping	325	SF	$ 1.00	$ 325.00	$ 5.00	$ 1,625.00		$ -	$ 6.00	$ 1,950.00
		MECHANICAL										
		Remove centrifugal fan & condensing unit section from brine chiller	1	EA			$ 2,000.00	$ 2,000.00		$ -	$ 2,000.00	$ 2,000.00
		Clean 22"x18"x18' duct	120	SF	$ 0.50	$ 60.00	$ 10.00	$ 1,200.00		$ -	$ 10.50	$ 1,260.00
		New 7.5 ton blower coil unit	1	EA	$ 3,400.00	$ 3,400.00	$ 500.00	$ 500.00		$ -	$ 3,900.00	$ 3,900.00
		DDC control panel for damper controls	1	LS	$ 800.00	$ 800.00	$ 750.00	$ 750.00		$ -	$ 1,550.00	$ 1,550.00
		Replace pnuematic damper operators	5	EA	$ 750.00	$ 3,750.00	$ 500.00	$ 2,500.00		$ -	$ 1,250.00	$ 6,250.00
		Replace damper linkages	4	EA	$ 100.00	$ 400.00	$ 200.00	$ 800.00		$ -	$ 300.00	$ 1,200.00
		New sump pump with controls	1	LS	$ 6,000.00	$ 6,000.00	$ 1,000.00	$ 1,000.00		$ -	$ 7,000.00	$ 7,000.00
		Clean & pressure test brine lines	200	LF	$ 0.25	$ 50.00	$ 2.00	$ 400.00		$ -	$ 2.25	$ 450.00
		New 5 hp circulating pump	1	EA	$ 3,450.00	$ 3,450.00	$ 1,200.00	$ 1,200.00	$ 2,000.00	$ 2,000.00	$ 6,650.00	$ 6,650.00
		Glycol fill station	1	EA	$ 2,625.00	$ 2,625.00	$ 450.00	$ 450.00		$ -	$ 3,075.00	$ 3,075.00
		5 kw electric heater	1	EA	$ 275.00	$ 275.00	$ 300.00	$ 300.00		$ -	$ 575.00	$ 575.00
		ELECTRICAL										
		Demo bussing & overcurrent protection devices	3	EA		$ -	$ 150.00	$ 450.00		$ -	$ 150.00	$ 450.00
		Demo 350a enclosed breaker	1	EA		$ -	$ 200.00	$ 200.00		$ -	$ 200.00	$ 200.00
		New 400a, 208/120v panel, 22,000 AIC	1	EA	$ 2,850.00	$ 2,850.00	$ 1,675.00	$ 1,675.00		$ -	$ 4,525.00	$ 4,525.00
		CB -20a	4	EA	$ 30.00	$ 120.00	$ 65.00	$ 260.00		$ -	$ 95.00	$ 380.00
		CB -30a	2	EA	$ 30.00	$ 60.00	$ 65.00	$ 130.00		$ -	$ 95.00	$ 190.00
		CB -40a	1	EA	$ 30.00	$ 30.00	$ 65.00	$ 65.00		$ -	$ 95.00	$ 95.00
		CB -70a	2	EA	$ 50.00	$ 100.00	$ 80.00	$ 160.00		$ -	$ 130.00	$ 260.00
		CB -100a	2	EA	$ 325.00	$ 650.00	$ 175.00	$ 350.00		$ -	$ 500.00	$ 1,000.00
		CB -125a	1	EA	$ 325.00	$ 325.00	$ 175.00	$ 175.00		$ -	$ 500.00	$ 500.00
		CB -175a	1	EA	$ 425.00	$ 425.00	$ 350.00	$ 350.00		$ -	$ 775.00	$ 775.00
		New 100a, 208/120v panel, 22.000 AIC	1	EA	$ 1,400.00	$ 1,400.00	$ 750.00	$ 750.00		$ -	$ 2,150.00	$ 2,150.00
		CB -20a	2	EA	$ 30.00	$ 60.00	$ 65.00	$ 130.00		$ -	$ 95.00	$ 190.00
		CB -30a	1	EA	$ 30.00	$ 30.00	$ 65.00	$ 65.00		$ -	$ 95.00	$ 95.00
		New 100a, 208/120v panel, 22.000 AIC	1	EA	$ 1,400.00	$ 1,400.00	$ 750.00	$ 750.00		$ -	$ 2,150.00	$ 2,150.00
		CB -20a	18	EA	$ 30.00	$ 540.00	$ 65.00	$ 1,170.00		$ -	$ 95.00	$ 1,710.00
		350AT/400AF enclosed CB, 65,000 AIC	1	EA	$ 2,500.00	$ 2,500.00	$ 275.00	$ 275.00		$ -	$ 2,775.00	$ 2,775.00
		Clean panel corrosion and dust	3	EA	$ 10.00	$ 50.00	$ 750.00	$ 2,250.00		$ -	$ 760.00	$ 2,280.00
		Clean automatic transfer switch corrosion and dust	1	EA	$ 10.00	$ 50.00	$ 500.00	$ 500.00		$ -	$ 510.00	$ 510.00
		Clean dust & corrosion from 75kw generator set	1	EA	$ 10.00	$ 50.00	$ 1,000.00	$ 1,000.00		$ -	$ 1,010.00	$ 1,010.00
		Clean corrosion from 18" dia pendant light fixtures	5	EA	$ 5.00	$ 75.00	$ 250.00	$ 1,250.00		$ -	$ 255.00	$ 1,275.00
		Clean telephone rack, transformer enclosure, etd.	6	EA	$ 5.00	$ 50.00	$ 250.00	$ 1,500.00		$ -	$ 255.00	$ 1,530.00
		Reconnect 5 hp pump	1	EA	$ 15.00	$ 50.00	$ 50.00	$ 50.00		$ -	$ 65.00	$ 65.00

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BID ITEM COST SUMMARY

		3 #12 awg & 1 #12 AWG	80	LF	$ 2.00	$ 160.00	$ 3.00	$ 240.00		$ -	$ 5.00	$ 400.00
		3/4" conduit	20	LF	$ 3.75	$ 75.00	$ 8.00	$ 160.00		$ -	$ 11.75	$ 235.00
		Connection to 5 kw electric heater	1	EA	$ 20.00	$ 20.00	$ 50.00	$ 50.00		$ -	$ 70.00	$ 70.00
		3 #12 awg & 1 #12 AWG	80	LF	$ 2.00	$ 160.00	$ 3.00	$ 240.00		$ -	$ 5.00	$ 400.00
		3/4" conduit	20	LF	$ 3.75	$ 75.00	$ 8.00	$ 160.00		$ -	$ 11.75	$ 235.00
		Connection to DDC panel	1	EA	$ 25.00	$ 25.00	$ 50.00	$ 50.00		$ -	$ 75.00	$ 75.00
		2 #12 awg & 1 #12 AWG	30	LF	$ 2.00	$ 60.00	$ 3.00	$ 90.00		$ -	$ 5.00	$ 150.00
		3/4" conduit	10	LF	$ 3.28	$ 32.80	$ 6.35	$ 63.50		$ -	$ 9.63	$ 96.30
		Connection to 7.5 ton blower	1	EA	$ 25.00	$ 25.00	$ 50.00	$ 50.00		$ -	$ 75.00	$ 75.00
		3 #4 awg & 1 #8 awg	80	LF	$ 2.00	$ 160.00	$ 3.00	$ 240.00		$ -	$ 5.00	$ 400.00
		1-1/2" conduit	20	LF	$ 10.00	$ 200.00	$ 15.00	$ 300.00		$ -	$ 25.00	$ 500.00
		Subtotal Direct Construction Costs			**$ 27,020.03**	**$ 37,280**	**$ 14,920.85**	**$ 43,336.00**	**$ 2,013.85**	**$ 4,333.75**	**$ 43,955**	**$84,745**

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BID ITEM COST SUMMARY

Project: Delta 09 Soft Support Building & Delta 09 Launch Facility
Park: Minuteman Missile National Historic Site
Park Alpha:
PMIS Number: 257125

Estimate By: Donald Parker
Date: 07/18/24
Reviewed By: Kirk
Date: 07/18/24

Option 2 - SSB (Soft Support Building)

Item No.	WBS	Description	Quantity	Measure	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
		STRUCTURAL										
		Horizontal concrete patching on 2.5" topping slab	20	SF	$ 29.00	$ 580.00	$ 50.00	$ 1,000.00	$ -	$ -	$ 79.00	$ 1,580.00
		Route & seal cracks	120	LF	$ 1.00	$ 120.00	$ 5.00	$ 600.00	$ 10.00	$ 1,200.00	$ 16.00	$ 1,920.00
		New Polyurethane waterproofing on conc. Topping	325	SF	$ 1.00	$ 325.00	$ 5.00	$ 1,625.00	$ -	$ -	$ 6.00	$ 1,950.00
		Subtotal Direct Construction Costs			$ 31.00	$ 1,025	$ 60.00	$ 3,225.00	$ 10.00	$ 1,200.00	$ 101	$5,450

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BID ITEM COST SUMMARY

Project: Delta 09 Soft Support Building & Delta 09 Launch Facility
Park: Minuteman Missile National Historic Site
Park Alpha:
PMIS Number: 257125

Estimate By: Donald Parker
Date: 07/18/24
Reviewed By: Kirk
Date: 07/18/24

Option 3 - SSB (Soft Support Building)

Item No.	WBS	Description	Quantity	Measure	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
		STRUCTURAL										
		Prepare slab topping for sealer	325	SF	$ 2.00	$ 650.00	$ 5.00	$ 1,625.00	$ 2.00	$ 650.00	$ 9.00	$ 2,925.00
		Water repellant penetrating 100% silane sealer	325	SF	$ 3.00	$ 975.00	$ 15.00	$ 4,875.00	$ 2.00	$ 650.00	$ 20.00	$ 6,500.00
		Subtotal Direct Construction Costs			$ 5.00	$ 1,625	$ 20.00	$ 6,500.00	$ 4.00	$ 1,300.00	$ 29	$9,425

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BID ITEM COST SUMMARY

Project: Delta 09 Soft Support Building & Delta 09 Launch Facility
Park: Minuteman Missile National Historic Site
Park Alpha:
PMIS Number: 257125

Estimate By: Donald Parker
Date: 07/18/24
Reviewed By: Kirk
Date: 07/18/24

Option 1 - LF (Launch Facility)

Item No.	WBS	Description	Quantity	Measure	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
		STRUCTURAL										
		Prepare & paint closer door, tracks,interior launch shaft sheet walls, platforms, ladders & railings.	3000	SF	$ 2.00	$ 6,000.00	$ 7.00	$ 21,000.00	$ 1.00	$ 3,000.00	$ 10.00	$ 30,000.00
		Water repellant penetrating 100% silane sealer	90	SF	$ 5.00	$ 450.00	$ 15.00	$ 1,350.00	$ 1.50	$ 135.00	$ 21.50	$ 1,935.00
		Horz concrete patching on closer door & tracks	15	SF	$ 29.00	$ 435.00	$ 50.00	$ 750.00		$ -	$ 79.00	$ 1,185.00
		Inject crack in conc retaining wall w/epoxy resin	50	LF	$ 2.00	$ 100.00	$ 5.00	$ 250.00	$ 9.50	$ 475.00	$ 16.50	$ 825.00
		Horz concrete patching on conc. Roof	50	SF	$ 29.00	$ 1,450.00	$ 50.00	$ 2,500.00		$ -	$ 79.00	$ 3,950.00
		Rout & seal cracks in conc. Roof	250	LF	$ 5.00	$ 1,250.00	$ 15.00	$ 3,750.00	$ 5.00	$ 1,250.00	$ 25.00	$ 6,250.00
		Rout & seal cracks in conc. Door closer	50	LF	$ 1.00	$ 50.00	$ 5.00	$ 250.00	$ 5.00	$ 250.00	$ 11.00	$ 550.00
		New Polyurethane waterproofing on conc. Topping	360	SF	$ 5.00	$ 1,800.00	$ 15.00	$ 5,400.00		$ -	$ 20.00	$ 7,200.00
		Horz concrete patching on jack & tie down conc slab	40	SF	$ 29.00	$ 1,160.00	$ 50.00	$ 2,000.00		$ -	$ 79	$ 3,160.00
		Rout & seal cracks on above slab on grade	20	LF	$ 2.00	$ 40.00	$ 15.00	$ 300.00	$ 5.00	$ 100.00	$ 22	$ 440.00
		Remove joint sealant in launch roof structure	50	LF	$ 2.00	$ 100.00	$ 15.00	$ 750.00		$ -	$ 17	$ 850.00
		New Polyurethane waterproofing on conc. Roof	440	SF	$ 5.00	$ 2,200.00	$ 15.00	$ 6,600.00		$ -	$ 20	$ 8,800.00
		Repair drain operation in floor & neutralizer pit	2	EA	$ 75.00	$ 150.00	$ 75.00	$ 150.00		$ -	$ 150	$ 300.00
		Reopen weep holes on launch tube steel plate liner	10	EA	$ 10.00	$ 100.00	$ 50.00	$ 500.00		$ -	$ 60	$ 600.00
		Replace glazing & framing of the clerestory & viewing structure	225	SF	$ 20.00	$ 4,500.00	$ 30.00	$ 6,750.00		$ -	$ 50	$ 11,250.00
		Rout & seal cracks on concrete door closer	50	LF	$ 1.00	$ 50.00	$ 5.00	$ 250.00	$ 5.00	$ 250.00	$ 11.00	$ 550.00
		MECHANICAL										
		Remove and replace sump pump w/electronic controls & remote monitoring	1	EA	$ 6,000.00	$ 6,000.00	$ 3,000.00	$ 3,000.00			$ 9,000	$ 9,000.00
		6 ton water source heat pump	1	EA	$ 5,000.00	$ 5,000.00	$ 2,000.00	$ 2,000.00			$ 7,000	$ 7,000.00
		Temperature/humidity sensors	8	EA	$ 300.00	$ 2,400.00	$ 350.00	$ 2,800.00		$ -	$ 650	$ 5,200.00
		DDC local control panel	1	LS	$ 2,600.00	$ 2,600.00	$ 3,000.00	$ 3,000.00		$ -	$ 5,600	$ 5,600.00
		CAT6 control wiring	200	LF	$ 3.00	$ 600.00	$ 5.00	$ 1,000.00		$ -	$ 8	$ 1,600.00
		ELECTRICAL										
		Demo bussing & overcurrent protection devices	1	EA		$ -	$ 150.00	$ 150.00		$ -	$ 150	$ 150.00
		New 100a, 208/120v panel, 22.000 AIC	1	EA	$ 1,275.00	$ 1,275.00	$ 575.00	$ 575.00		$ -	$ 1,850	$ 1,850.00
		CB -20a	19	EA	$ 30.00	$ 570.00	$ 65.00	$ 1,235.00		$ -	$ 95	$ 1,805.00
		CB -30a	1	EA	$ 30.00	$ 30.00	$ 65.00	$ 65.00		$ -	$ 95	$ 95.00
		CB -50a	1	EA	$ 30.00	$ 30.00	$ 65.00	$ 65.00		$ -	$ 95	$ 95.00
		Clean corrosion from 18" dia pendant light fixtures	20	EA	$ 5.00	$ 100.00	$ 50.00	$ 1,000.00		$ -	$ 55	$ 1,100.00
		Connection to DDC panel	1	EA		$ -	$ 1,150.00	$ 1,150.00		$ -	$ 1,150	$ 1,150.00
		2 #12 awg & 1 #12 AWG	30	LF	$ 2.00	$ 60.00	$ 2.00	$ 60.00		$ -	$ 4	$ 120.00
		3/4" conduit	10	LF	$ 3.75	$ 37.50	$ 8.00	$ 80.00		$ -	$ 12	$ 117.50
		Connection to 6 ton heat pump	1	EA	$ 800.00	$ 800.00	$ 800.00	$ 800.00		$ -	$ 1,600	$ 1,600.00
		3 #10 awg & 1 #10 awg	160	LF	$ 2.00	$ 320.00	$ 2.00	$ 320.00		$ -	$ 4	$ 640.00
		3/4" conduit	40	LF	$ 3.75	$ 150.00	$ 8.00	$ 320.00		$ -	$ 12	$ 470.00
		Subtotal Direct Construction Costs			**$ 16,306.50**	**$ 39,808**	**$ 11,712.00**	**$ 70,170.00**	**$ 32.00**	**$ 5,460.00**	**$ 28,050.50**	**$115,438**

United States Department of the Interior
National Park Service
Class A Construction Cost Estimate

BID ITEM COST SUMMARY

Project: Delta 09 Soft Support Building & Delta 09 Launch Facility
Park: Minuteman Missile National Historic Site
Park Alpha:
PMIS Number: 257125

Estimate By: Donald Parker
Date: 07/18/24
Reviewed By: Kirk
Date: 07/18/24

Option 2 - LF (Launch Facility)

Item No.	WBS	Description	Quantity	Measure	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
		STRUCTURAL										
		Water repellant penetrating 100% silane sealer	360	SF	$ 3.00	$ 1,080.00	$ 9.00	$ 3,240.00	$ 1.50	$ 540.00	$ 13.50	$ 4,860.00
		Water repellant penetrating 100% silane sealer on concrete launch structure roof	440	SF	$ 3.00	$ 1,320.00	$ 15.00	$ 6,600.00	$ 1.50	$ 660.00	$ 19.50	$ 8,580.00
		Subtotal Direct Construction Costs			$ 6.00	$ 2,400	$ 24.00	$ 9,840.00	$ 3.00	$ 1,200.00	$ 33.00	$13,440

National Park Service
U.S. Department of the Interior

Minuteman Missile National Historic Site
Phillip, South Dakota

