

Fort Matanzas National Monument

St. Augustine, Florida

Structural Condition Assessment Report



October 2016

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On the front cover: View of Fort Matanzas looking north during a live canon firing. Internet photo, undated. Source: www.augustine.com.

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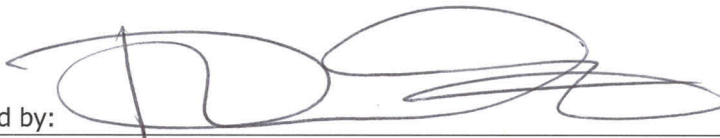
Fort Matanzas National Monument

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October 2016

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Superintendent, Fort Matanzas National Monument

10/31/2016
Date


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12/1/16
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Foreword

We are pleased to make available this Structural Condition Assessment Report, part of our ongoing effort to provide comprehensive documentation for the historic structures and cultural landscapes of National Park Service units in the Southeast Region. A number of individuals contributed to the successful completion of this work, but we would particularly like to thank the Project Team who authored the report. The authors would like to thank the staff at the Fort Matanzas National Monument who assisted greatly with the project, including Fort Matanzas Site Supervisor Andrew Rich, Chief of Interpretation & Education for Castillo de San Marcos & Fort Matanzas National Monument Steven Roberts, and the several Park staff who assisted with the analysis and inspection of Fort Matanzas, as well as Historical Architect Danita Brown, AIA of the Southeast Regional Office for her assistance. We hope that this study will prove valuable to park management in their ongoing efforts to preserve the building and to everyone in understanding and interpreting this unique resource.

Dan Scheidt, Chief
Cultural Resources, Partnerships and Science Division
Southeast Regional Office
2016

Executive Summary

In January 2016, the National Park Service (NPS) entered into a contract with GWWO, Inc./Architects from Baltimore, Maryland to provide a Structural Condition Assessment Report for Fort Matanzas National Monument. Assisting the lead firm, the documentation and evaluation team included Faisant Associates structural engineers of Baltimore and Existing Conditions, Inc. of Boston, Massachusetts to perform a three-dimensional (3D) laser point cloud scan of the existing structure.

Findings of this report are based on visual observations of current conditions as well as minimally-invasive testing with information having been gathered during site visits in February and May of 2016.



Figure 1: South and east elevations of Fort Matanzas viewed from ferry on Matanzas River (2016, Faisant Associates).

This report identifies areas of structural instability and makes recommendations for their remediation. These recommendations are intended to help guide the park both in addressing issues requiring repairs in the near term and in planning for preservation of the structure over the long term. While the evaluation team did not observe any critical structural deficiencies requiring immediate remediation, some recommended treatments will require shorter term attention to avoid further deterioration. In particular, selective stone repair and repointing, remediation of an over-capacity second floor support beam, and reduction of water intrusion into the Fort are among the high priorities. At the end of the report is a complete prioritized list of work recommended for the next eight years as well as for items requiring ongoing maintenance.

Measured drawings have also been prepared. Measurements were taken using 3D laser scanning. The drawings are included as Appendix A of this report and have been cross-referenced in the text. They have also been issued as a standalone drawing package for the park's future reference and use.

Previous documents note that some of the past rehabilitation work may not be historically accurate in appearance and/or method of construction. This report does not comprehensively document or make recommendations for addressing non-historic interventions, but the evaluation team developed the repair recommendations provided herein with an eye toward correcting past inaccuracies when doing so can be reasonably accomplished within the structural stabilization scope, and can be based on sound research or precedents.

Evaluation of the Fort's compliance with building codes, life safety codes, and universal accessibility standards lie beyond the scope of this report; however, to the extent the evaluation team observed any blatant concerns, they are noted in this report. Similarly, exhaustive evaluation of the wooden staircases leading from grade to the terreplein and from the terreplein to the second floor of the tower are outside the scope of this report as they are non-historic interventions installed for visitor convenience.

Since the Fort is listed on the National Register of Historic Places, all proposed work must be coordinated with and reviewed by the Florida Division of Historical Resources (DHR) (the State Historic Preservation Office (SHPO) of Florida) in order to comply with the National Historic Preservation Act of 1966.

Background

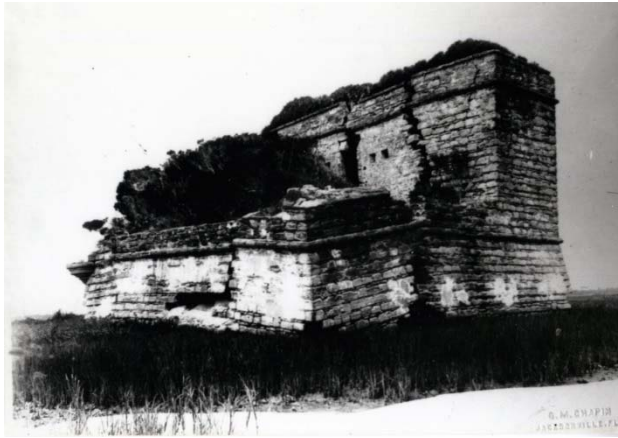


Figure 2: Circa early 1900s photo showing the Fort in very poor condition prior to start of rehabilitation efforts (NPS FOMA photo no. M54).

The Spanish built Fort Matanzas in 1740-42 to guard Matanzas Inlet at the southern mouth of the Matanzas River, which could be used as a rear entrance to the city of St. Augustine. Coquina stone masonry, a common shellstone building material in the area, comprises the vast majority of the structure. A foundation of pine pilings stabilizes the marshy terrain to accommodate a square building plan, approximately 49 feet in length on each side. Scarp walls 12 feet high rise to a terreplein, which covers two thirds of the base. A coquina sentry box projects from the terreplein's southwest corner and on its northern third a tower rises approximately 35 feet from the foundation with a roof-top observation platform. Four cannons line the southern and eastern edges of the terreplein – two reproduction six-pounders and two historic eight-pounders from the museum collection.

The Fort remained in continuous use from its construction through 1820, passing in that period from Spanish to British and then back to Spanish control. During the second Spanish period, availability of funding for upkeep of the structure became extremely limited, and over time it fell into severe disrepair to the point of becoming uninhabitable.

In 1821, the United States took control of Florida and thus Fort Matanzas. The US War Department became the custodian but deemed the Fort obsolete, abandoning it and allowing it to fall to ruin for nearly a century. The War Department began taking an interest in preservation of obsolete fortifications in the early 1900s and began a restoration and stabilization of Fort Matanzas in 1916. The following timeline outlines additional significant restoration efforts, with thoroughly detailed information available in the *Historic Structure Report (HSR) for Fort Matanzas National Monument*, dated November 1980

- 1916-17:** The second floor's vaulted ceiling was partially rebuilt, and steel rods equipped with turnbuckles were introduced (precise locations not indicated). The face of the south tower wall fronting the terreplein was partially reconstructed.
- 1924:** Additional and more extensive wall reconstructions were undertaken. Terreplein and tower roofs were resurfaced. The second floor framing and flooring were reconstructed, partially in wood timbers with concrete infill and partially with lumber.
- 1927:** Concrete curb stones were set around the southeast base of the Fort for erosion protection. North-south tie rods were installed above the crown of the vault.
- 1929:** The sentry box was dismantled and reconstructed.
- 1933:** Control of Fort Matanzas National Monument was turned over to the NPS by Executive Order.
- 1936:** A steel and concrete bulkhead with stone riprap was constructed around the south, east, and a part of the north side of the Fort to minimize erosion. Shoreline stabilization repairs and enhancements became an ongoing activity over the following decades.

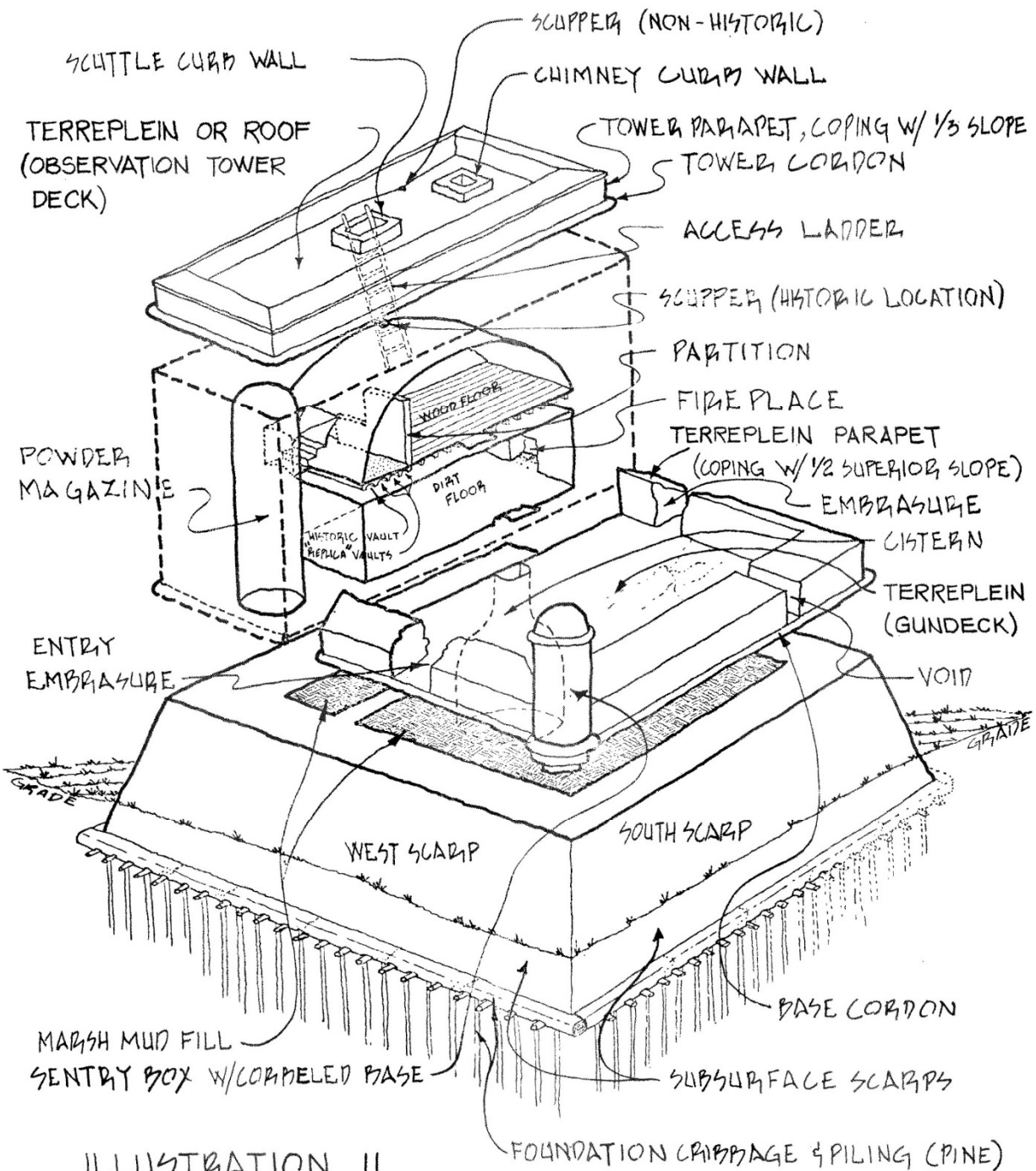


ILLUSTRATION II
EXISTING ARCHITECTURAL ELEMENTS, FORT MATANZAS

Figure 3: Exploded view of Fort Matanzas sketched as an illustration to the 1980 HSR (page 196).

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- 1938-39:* The second floor vault was completely reconstructed.
- 1947-52:* The southeast corner, the west wall, and the tower were extensively repointed. This was the most extensive rehabilitation work performed under NPS management to date. Care was taken to match mortar colors to historic material, but the mortar mixes used relied on Portland cement binders.
- 1979-80:* The Fort underwent a major rehabilitation project involving the complete rebuilding of the tower roof. Work included removal of the old north-south tie rods. Four of the five north-south rods were removed, but the central one could not be extracted and was left in place.
- 1980:* HSR was prepared. Although the report is now nearly four decades old, it remains one of the key resources for historical data regarding repairs made up to the date of its publication. Although many of the recommended treatments offered in that document were addressed through subsequent restoration efforts, some of the issues related to deterioration of the structure have been ongoing and remain relevant considerations for the long term preservation of the Fort today.
- 1993:* NPS engaged GWWO, Inc. to perform a limited investigation of cracks that were then visible in the vaulted ceiling of the second floor of the tower. The thought at the time was that corrosion of one of the old steel rods embedded in the stone was causing the cracking. The recommendation was to remove the rod and replace it.
- 1997:* The NPS Historic Preservation Training Center (HPTC) replaced two tie rods and end plates at the roof level and installed an EPDM roof membrane coated by a tabby (a type of concrete made by burning oyster shells to create lime, then mixing it with water, sand, ash and broken oyster shells) walking surface topping on the tower.
- 1996:* Enlisted Men's Quarters cypress wood shutters and door fabricated and installed.
- 1997:* East and west faces of stone removed to facilitate removal of two steel end plates connecting the corroding east-west tie rods (from 1916). One additional north-south tie rod (from 1916) was also replaced in this project. Roof tabby and underlayment were demolished and replaced during this project. New underlayment was replaced and the deck surface replaced using 1 part white Portland to 6 parts coquina. The Officer's vault, damaged by the corroding tie rod was also repaired during this project using a mix of 1 part white Portland to 4 parts coquina sand. Joints were tuckpointed at this location using 1 part gray Portland, 1 part lime and 7 parts sand to closely match existing mortar.
- 1997:* Officer's Quarters cypress wood shutter and door installed. Designs were copied from those in use at Castillo de San Marcos.
- 2012:* The University of South Florida (USF) Alliance for Integrated Spatial Technologies (AIST), undertook a survey utilizing 3D laser point cloud scanning and other forms of standard and advanced photo imagery. The information collected was synthesized into a Google Earth model and 3D fly-through videos and models for interpretive purposes and was also made available to the park as a baseline for continued monitoring of the Fort and surrounding site. See <http://aist.usf.edu/projects/fortMatanzas.aspx#> for more information.

Existing Conditions and Recommendations for Treatment

Fort Matanzas stands today in stable condition, but many materials and assemblies are exhibiting deterioration that could jeopardize the structure if not addressed in the near to medium term. Fortunately, observations leading to the preparation of this report did not discover any critical structural deficiencies or safety concerns requiring immediate attention. Still, the Fort faces risks to its long term preservation. These risks are heightened by the structure's construction with soft, porous coquina stone, its high potential for exposure to wind-driven rain, its siting in a marshy area, and its relatively high annual visitation, which continues to grow and topped 70,000 in 2015. The 1980 HSR offered the following broad recommendation, and it essentially remains worth revisiting in pursuing the recommendations of this report:

...many of the stabilization treatments proposed can be classified as an intensive maintenance effort with the implication that a concerted cyclic maintenance program must become an important aspect of park planning. The stabilization of this historic building must not be considered final treatment, but rather the initial step of an ongoing stabilization process. With this approach, problems will not be allowed to rise to critical levels.

The sections below list observations of existing conditions and specific recommendations for treatment of deficient items. Section headings define the primary components and spaces of the Fort exterior and interior. A discussion of prioritization of the repairs is presented at the end of this report.

A. Coquina Stone Masonry

1. Considerations: Stone Coatings

The exterior and interior walls were historically coated with lime plaster, as evidenced by some very small, isolated areas of plaster remaining. A plaster coating would protect the historic coquina from further rainwater erosion, soiling and erosion by air pollutants, and attack from biological growth. The park considered and rejected application of plaster at various points in the past, and most of the current considerations would be the same.

A major issue is how the plaster would be applied. Upon original construction, the Fort's stones would have been cleanly cut with smooth walls and details such as door and window surrounds crisply defined. As noted above, this is not the current condition, so a decision would need to be reached as to whether to allow the plastering to follow the irregularities of the eroded coquina or to attempt to restore the original smooth plaster detailing. Both options could face preservation compliance hurdles. Implementation of a major change to a historic structure requires evidence that the proposed restoration is historically justified. Irregular plastering is not supported by any known documentary evidence and thus could be viewed as a non-historic intervention. Smooth plastering is more likely to have existed historically, but known documentation does not provide enough detailed information to serve as a basis for reinstallation of the coating.

Another important consideration is that a plaster coating would significantly change the appearance of the Fort from the way visitors have experienced it for more than 150 years. The deterioration of the original plaster occurred concurrently with the overall decline of the Fort in its final years under Spanish control and subsequent abandonment under US War Department ownership. The current appearance of the Fort plays a role in interpretation of this part of its history. Because *The Secretary of the Interior's Standards for the Treatment of Historic Properties* call for "changes to a property

that have acquired historic significance in their own right” to be retained, it may, again, be difficult to achieve preservation compliance for a plaster coating.

Other considerations include the fact that a plaster coating would become a maintenance issue of its own, needing to be touched up and reapplied periodically. Any continued or future movement in the underlying stonework would eventually telegraph through as cracks or delamination. It would be difficult to install the plaster in a way that does not risk further damage to the stone when the material delaminates or in the event that the coating must be removed in the future.

A plaster coating could improve long term protection of the historic coquina and for this reason may be worth further evaluation despite the many risks and tradeoffs. Any further assessment of this approach should be approached carefully, in consultation with NPS historic preservation specialists and the Florida DHR.

Also contemplated by the park previously, but never applied, were penetrating or consolidating clear coatings for the coquina. These coatings are touted as having water-repellent capabilities that could arrest further water damage. They would not change the outward appearance of the structure. Unfortunately, once applied, they cannot be removed or reversed non-destructively. In a white paper entitled *Colorless Coatings for Brick Masonry*, the Brick Industry Association concluded that “penetrating water-repellent coatings seldom stop water penetration through cracks more than 0.02 in. wide, and their effectiveness under conditions of wind driven rain is limited. As a result, the use of water-repellent coatings to eliminate water penetration in a wall with existing defects can be futile.” These are the sorts of defects present at the Fort. Additionally, the coatings have not been commercially available long enough to evaluate or understand their potential effects over the very long time frame for which the Fort’s preservation must be planned. The evaluation team strongly recommends avoiding the use of clear coatings for this structure.

2. Observations: Coquina Stone Masonry

Exterior Elevations of Scarp and Tower Walls: Observations are referred to the cardinal compass directions though the Fort is oriented off axis.

General

- a. The masonry appears to be structurally intact but does exhibit cracking, voids, and extensive erosion of the coquina stones. The cracks are most likely due to movements of the timber foundation which may be a combination of long term settlement and cyclical fluctuations in groundwater levels.
- b. There is extensive evidence along all four building elevations and both sides of the tower and terreplein parapet walls of past repointing repairs using a Portland cement-based mortar. Due to the incompatibility of the hardness and expansion/contraction properties of this mortar compared to those of coquina, deterioration of the stones has accelerated adjacent to the re-pointed joints, creating cement “ledges” which allow for the accumulation of water, further hastening the erosion.
- c. The cornice and cordon courses along the entire Fort perimeter are severely eroded, most likely due to the outward projection of the coursing from the wall faces, resulting in greater exposure to weathering (*photos A-1 and A-2*).
- d. Voids at the bases of the scarp walls were noted along with evidence of mortar washing out from adjacent joints and from the fill soil within the body of the walls.



Photo A-1: Cordon course deterioration, at north tower wall (2016, Faisant Associates).



Photo A-2: Cornice erosion at southeast tower corner (2016, Faisant Associates).



Photo A-3: Crack at north scarp (2016, Faisant Associates).



Photo A-4: Void at base of north scarp (2016, Faisant Associates).

North Elevation

- e. A vertical crack was noted near the northeast corner and it extends from the cordon course down to grade. It follows the mortar joints and shows evidence of past repairs (*photo A-3*).
- f. Erosion of the coquina is most severe along the northeast corner and at the base of the scarp wall near the northwest corner (*photos A-4 and A-5*).

East Elevation

- g. A vertical crack was observed below the embrasure and it extends from the cordon course down to grade. It follows the mortar joints and shows evidence of past repairs (*photo A-6*).
- h. Small voids were observed at several locations where repointing mortar lost its bond and has fallen away.

West Elevation

- i. A vertical crack was observed in the scarp wall midway between the stair and southwest corner. The crack is telegraphing through a previous repointing repair (*photo A-7*).
- j. Erosion of the coquina is most severe at the base of the scarp wall near the northwest corner.

South Elevation

- k. A crack in the south tower wall, near the east corner, is currently being monitored.



Photo A-5: Coquina erosion at northwest scarp (2016, Faisant Associates).



Photo A-6: Crack at east wall embrasure (2016, Faisant Associates).



Photo A-7: Settlement crack at west scarp (2016, Faisant Associates).



Photo A-8: Coquina erosion at south tower wall (2016, Faisant Associates).

- l. Advance erosion of the coquina was observed on the south tower wall, adjacent to the downspout (*photo A-8*). This erosion may predate the installation of the downspout during the 1979-80 renovations. The currently installed downspout dates to 2008.
- m. A mortar joint crack was observed next to the keystone in the head of the second floor doorway. The crack extends through the wall thickness (*photo A-9*).
- n. Severe erosion of the coquina was noted at the southeast scarp corner (*photo A-10*).
- o. Cracks were observed in the tower wall east of the doorway. They are telegraphing through old repairs (*photo A-11*).

Tower Parapet

- p. A crack has reopened at a previous repair at the north wall (*photo A-12*).
- q. A large crack was observed on the north wall, at a point approximately midway between the roof hatch and chimney. The crack extends for the full height of the parapet and is confined to the mortar joints.

Terreplein Parapet

- r. Numerous cracks were observed in the parging on the top surface of the south parapet wall which is allowing the infiltration of water into the body of the wall (*photo A-13*).
- s. Extensive erosion of the coquina was observed along the tops of the east and west walls.

- t. Significant erosion of the stone adjacent to past repairs using portland cement-based mortar is apparent on the inside faces of all three walls.



Photo A-9: Second floor door head crack (2016, Faisant Associates).



Photo A-10: Coquina erosion at portland cement mortar repointing at south scarp (2016, Faisant Associates).



Photo A-11: South tower wall cracks (2016, Faisant Associates).



Photo A-12: Crack in north tower parapet wall (2016, Faisant Associates).



Photo A-13: Cracks in parging at top of south scarp (2016, Faisant Associates).

3. Recommended Treatments: Coquina Stone Masonry

- a. At historic repair locations where a Portland cement-based repointing mortar was used and the adjacent coquina has eroded enough to create ledges along the mortar joint, remove the old mortar and repoint the joints with a compatible mortar. (*Note: During discussions and meetings with maintenance personnel at the Fort, the compatible mortar mix currently in use has a record of satisfactory performance.*) A second option is to remove all Portland cement-based mortar repairs and repoint with compatible mortar. This was discussed with the park and they would prefer to leave the older repairs intact where local coquina deterioration has not occurred.
- b. Repoint all existing open mortar joints and cracks.
- c. At locations where older repaired cracks are telegraphing through the repair mortar, remove the existing mortar and repoint.
- d. Where not a preexisting, historic condition, install new stones where voids have occurred or stones are missing. At locations where cracks run through individual stones, remove and replace the stones.
- e. Remove old and cracked parging from the top of the terreplein parapet and repoint cracks and open joints.
- f. Develop a stockpile of high quality coquina. Although maintenance and repair of existing stones are always preferable to pursue prior to considering stone replacement, it is likely that selective stone replacements will be required over a 50 to 100-year maintenance period. The park indicated availability of coquina of comparable density and hardness to that present in the existing structure is limited. It may be beneficial to the park to maintain a moderate quantity of overhead stock in protected storage to facilitate ongoing and future repairs.
- g. Avoid applying plaster or penetrating coatings to coquina stone. The *Secretary of the Interior's Standards for Restoration* item number 7 states "replacement of missing features from the restoration period will be substantiated by documentary and physical evidence". The currently known documentary evidence does not appear to support restoration of the plaster. Further research and continued discussion with the Florida DHR may support a plastering effort at a later time. Penetrating coatings – as noted above – could be damaging to the stone and therefore are not recommended under any circumstance.

B. Terreplein

Visitors access the terreplein by way of a wood stair along the west elevation. A second wood stair located along the south tower wall and leads from the terreplein deck to the second floor room. Coquina masonry parapet walls surround the terreplein on the east, west and south sides. The terreplein deck consists of a tabby concrete slab that slopes to drain through a scupper located in the south parapet. A wood gun deck, supporting four cannons, partially covers the tabby slab and extends to the north and west from the southeast corner. A circular coquina sentry box projects from the southwest corner (*photos B-1 through B-4*).

Refer to drawing sheet A1.1 for a floor plan view, see Appendix A.

1. Observations: Terreplein, Sentry Box, Stairs, and Cistern

Terreplein Deck

- a. The terreplein deck consists of a tabby concrete slab which is partially overlain by a pressure-treated pine timber deck supporting four cannons. The slab was installed as part of the 1979-80 restoration and those drawings indicate a 4-inch thick slab underlain by a vapor barrier and coquina gravel fill. The surface, which slopes to drain through a scupper located in the south parapet, is very irregular, cracked, and eroded. The slope of

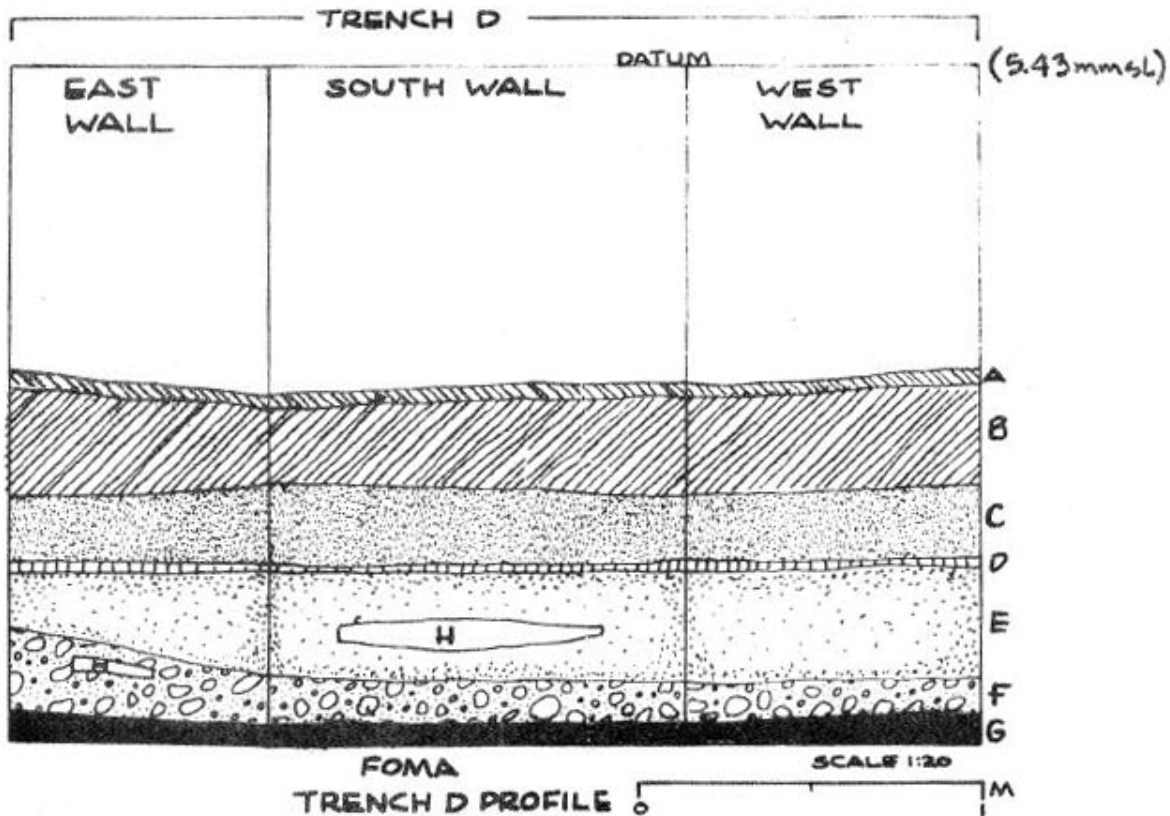


Illustration G-9a

KEY	
A-	Floor 1; Grey concrete
B-	Floor 2: Concrete with coquina aggregate
C-	Floor 3: Coquina Block
D-	Layer 1: Crushed orange coquina
E-	Layer 2: Loose beach sand and coquina shell
F-	Layer 3: Mortar and tabby rubble
G-	Grey-green, clayey mud
H-	Mortar and shell rubble (loose lenses)

Figure 4: Section view through a trench dug in the terreplein surface during archeological investigations in 1978. The archeologist concluded that coquina block represented by key item "C" is likely the terreplein floor level established during the 1924 restoration and that the rubble shown by key item "F" is likely the approximate Colonial-era floor level (See 1980 HSR pages 429-433 for graphic and full description).

Note that the 1980 HSR recommended removal of approximately 1'-8" of terreplein material – which roughly corresponds to the materials represented by key items "A" and "B" above – and its replacement with 3" of tabby. It is unclear whether the work was carried out exactly as detailed, but the terreplein floor has seen subsequent work and resurfacing.



Photo B-1: Terreplein, looking southwest (2016, Faisant Associates).



Photo B-2: Terreplein, looking southwest (2016, Faisant Associates).



Photo B-3: Terreplein, looking south (2016, Faisant Associates).

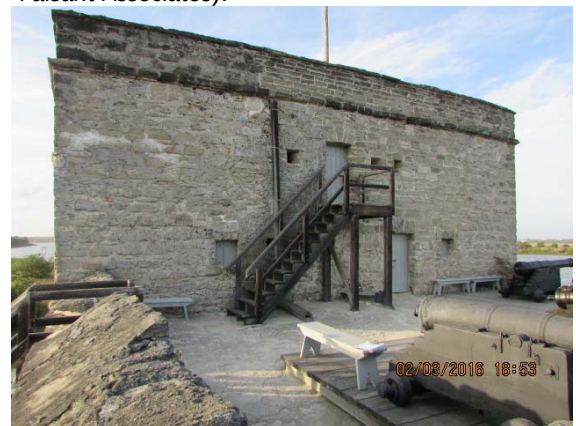


Photo B-4: Stair and south tower wall (2016, Faisant Associates).



Photo B-5: Wood deck framing (2016, Faisant Associates).



Photo B-6: Sentry box (2016, Faisant Associates).

the deck is uneven and dramatic at locations near the south tower wall. Archeological investigations in 1978 (See Figure 4 and HSR Appendix G) revealed additional layers of coquina block and tabby surfacing beneath the finished terreplein level, with only the base layer of tabby believed to date to the Colonial period.

- b. The timber deck is composed of 3" x 12" decking supported by 6" x 6" joists spaced at 24 inches on center. The joists are supported by a grid of 6x6 posts that bear directly on the tabby concrete slab. The deck extends inward from the east and south parapets

approximately 9'-7" and 11'-6" respectively. The decking shows signs of wear but is in generally good condition. Limited observations of the framing did not uncover any deterioration due to weather or insect attack (*photo B-5*).

Sentry Box

- c. The sentry box underwent two reconstructions in 1926 and 1929, and its corbelled base was repaired during the 1979-80 restorations (*photo B-6*). Though in relatively good condition, the masonry exhibits erosion adjacent to the mortar joints due to the use of a Portland cement based mortar during the 1929 reconstruction.

Stairs

- d. The stairs leading from grade to the terreplein elevation (constructed in 2001), and from the terreplein to the second floor (constructed in 1998) are of wood construction. Though no signs of rotting or insect damage were noted, advanced weathering and biological growth were observed (*photos B-7 and B-8*).
- e. Carriage bolts were used at the connections between the rail posts and the stair framing. The Park has indicated that the bolts were added after the stair reconstruction to reinforce the connections. The National Design Specification for Wood Construction (NDS) does not publish values for this type of bolt nor does it specifically recognize their use; however, past experience with the analysis of similar rail post connections indicates that it is unlikely that these connections would be sufficient to resist current code requirements for guardrail loading. Additionally, this type of post anchorage causes



Photo B-7: Stair at Fort entrance (2016, Faisant Associates).



Photo B-8: Biological growth on stair framing (2016, Faisant Associates).



Photo B-9: Stair rail post connection (2016, Faisant Associates).



Photo B-10: Stair posts at terreplein deck support (2016, Faisant Associates).



Photo B-11: Stair post base connection to terreplein, 1998 stair reconstruction (1998, FOMA).



Photo B-12: Wall crack at beam seat connection (2016, Faisant Associates).



Photo B-13: Wall crack at beam seat connection, 1998 stair reconstruction (1998, FOMA).

cross-gain bending in the stair stringer, a condition that should be avoided per recommendations in the NDS (*photo B-9*).

- f. The supporting posts for the stair leading from the terreplein deck to the second floor do not appear to have been anchored to the terreplein deck per the 1979-80 drawing details (*photo B-10*). The park has indicated that the posts are fastened to the deck by way of an embedded “pintle-type” connection. A photo supplied by the park, taken during the stair reconstruction, shows this connection (*photo B-11*).
- g. A wall crack was observed below the anchor bolts that fasten a steel angle beam seat to the wall at the second floor landing elevation (*photo B-12*). The park has supplied a photo that indicates that the crack predates the 2001 stair reconstruction (*photo B-13*).

Cistern

- h. The cistern was inaccessible at the time of the site visit and requires a confined entry permit for manual inspection. The park provided video of the cistern interior taken April, 2016 for the evaluation team's review. From the video, the cistern interior is coquina with its lower portion parged with mortar and its upper portion – the chamber's “throat” – unparged. There is graffiti carved into the mortar parging, which may date to the 1920s rehabilitation efforts. Overall, the cistern interior appears to be in good condition, with minimal observable deterioration.

2. Recommended Treatments: Terreplein, Sentry Box, Stairs, and Cistern

- a. Engage a qualified geotechnical engineer to inspect the in situ stone and soil layers of the terreplein deck (see Figure 4) for their adequacy to support a slab-on-grade. Remove the existing tabby concrete deck slab, replace unsuitable subbase materials, and regrade the stone layer to drain evenly toward the existing scupper in the south scarp parapet wall. To prevent the infiltration of water into the soil layers below, install a new barrier membrane on top of a sand bed with a passive drainage system above it, consisting of a grid work of perforated PVC piping, sloped to an outlet located either at the existing scupper or an additional location. Install a new tabby concrete slab containing fiber reinforcement, and saw cut control joints to mitigate shrinkage cracking (*see drawing 3/A6.1*). Alternatively, due to the poor performance of tabby, consider paving materials such as textured, colored concrete, exposed aggregate concrete, rustic-finished terrazzo, or bonded resin aggregate, all of which could give a similar appearance to the tabby with increased durability for foot traffic and weathering. A sheet of heavy plastic sheeting should be used to isolate new work from existing, to aid in future removal and reversibility of non-historic material. With any paving material, the new surface should be nominally leveled out, with only minimal slopes (maximum 2%) for drainage. Doing so might remove some or even most of the 1924 reconstruction material, but that may be worth doing for improvement of visitor safety.
- b. Dismantle and reconstruct the wood gun deck as required to accomplish terreplein slab work indicated above. Replace any deteriorated wood planks or support members. Alternatively, because the wood gun deck was not consistently present at the Fort during the historic period (see HSR pages 71-72, 271), consider removing it and placing the guns directly on the rehabilitated terreplein slab.
- c. Verify the capacity of and reinforce as necessary the connections between the vertical rail posts and stair stringers to eliminate cross-grain bending and meet the loading requirements stipulated in the International Building Code (IBC) and National Design Specification (NDS). Repoint the wall crack below the beam seat angle. Periodic inspections of the stairs for deterioration are recommended including the retightening of fasteners. Consider complete replacement of the stairs in 6-8 years, when they will have completed 25 years of service life.
- d. Repoint the upper portion of the cistern chamber (the throat). Inspect the cistern periodically by lowering a still or video camera into the chamber. Attempt to keep the chamber de-watered to the extent possible. Although the cistern is abandoned, it is important to maintain the chamber interior as degradation could compromise the tower walls and/or terreplein deck.
- e. Refer to Section "A," Paragraph 3, Item "a" for recommended treatment of coquina masonry.

C. First Floor Room

A doorway located in the south tower wall serves as the sole entry point to the first floor room. The unpartitioned space has exposed coquina masonry walls, a loose dirt floor, and plaster vaulted ceiling with exposed timber beams supporting the second floor. Windows are unglazed with solid wood plank shutters and include a single opening in the north wall and two in the south wall. Three loopholes penetrate the south wall near the room's west end. A fireplace sits centered on the east end wall, with its coquina opening supported by a timber lintel (*photos C-1 and C-2*).

Refer to drawing sheet A1.1 for a floor plan view, see Appendix A.

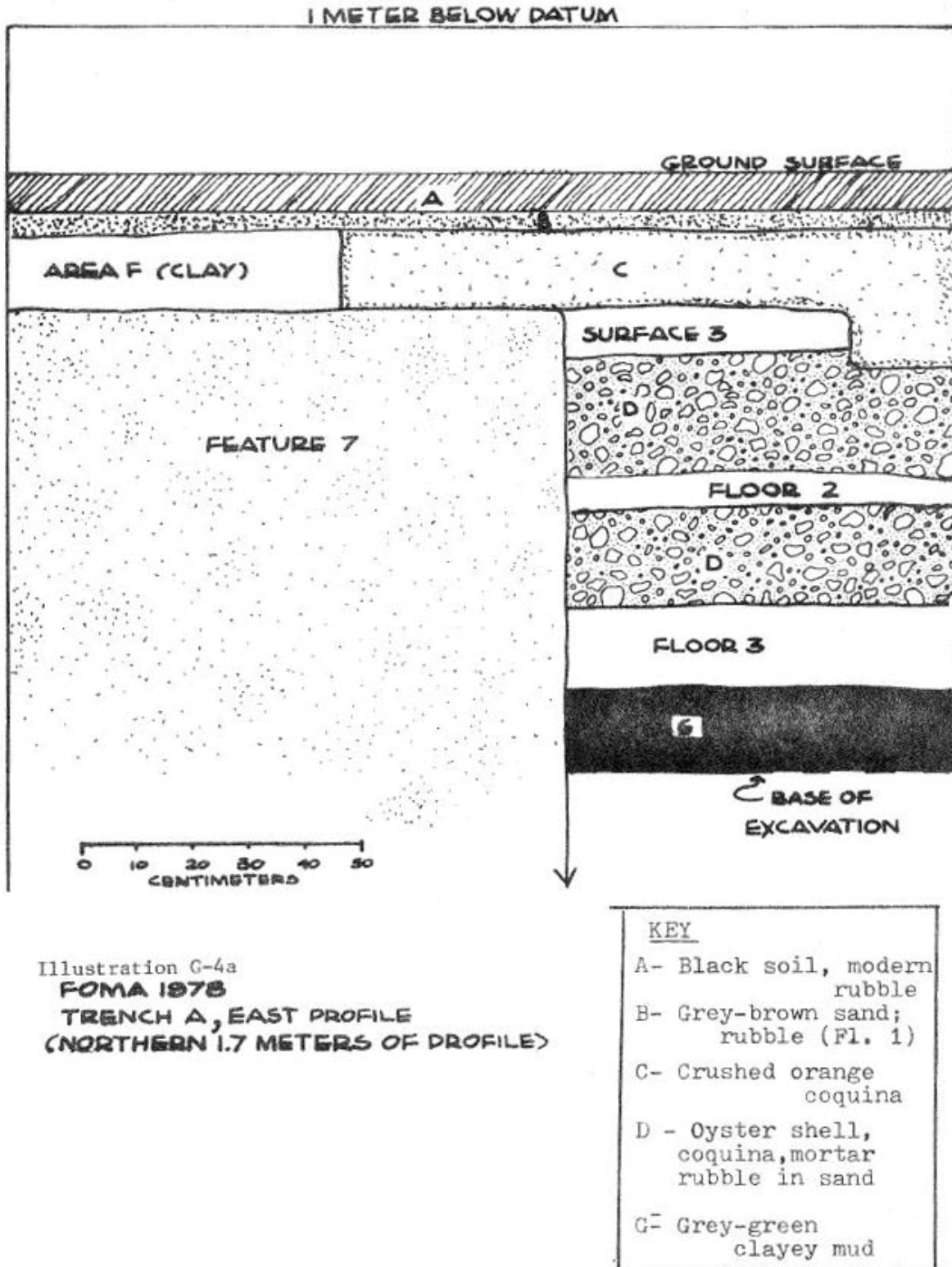


Figure 5: Section view through a trench dug along the west wall of the first floor room during archeological investigations in 1978. The archeologist concluded "Floor 3" was probably the earliest Colonial tabby floor. "Feature 7" is a coquina ledge or bench along the north wall (See 1980 HSR pages 415-426 for graphic and full description).

1. Observations: First Floor Room

General

- a. A through-wall crack was observed in the northeast corner.
- b. Past repointing repair work of the walls was in evidence at various locations and most extensively around the hearth.
- c. A large crack was observed in the wall on the west side of the door extending diagonally downward from the opening head to the floor. The crack runs through both the mortar joints and individual stones (*photo C-3*).
- d. The masonry above the doorway is a modern reconstruction that was not formed into an arch configuration with a keystone. A crack was observed in the joint between the two center stones. Since arching action of the masonry is questionable, the load above may be partially supported by the door frame. The load from the floor joist may be causing the stones to deflect and rotate inward relative to each other enough to overcome the mortar's bond strength (*photo C-4*).
- e. The west wall felt wet to the touch near the southwest corner of the room. Biological growth was observed at locations on all of the walls. The source of dampness was not apparent (*photo C-5*).
- f. The hearth shows evidence of recent reconstruction; however, the chimney flue is in poor condition, exhibiting deteriorated stones, open mortar joints, and moderate soot buildup (*photo C-6*). A wood lintel supports the fireplace opening, which is not in compliance with IBC 2015 section 2111.8 stating that "masonry over a fireplace opening shall be supported by a lintel of noncombustible material."
- g. A void and crack were observed in the wall below the north window.
- h. Loose dirt placed over a thin concrete slab comprises the present finished flooring. Per the HSR (see page 367), the floor originally had a tabby finish approximately 30 inches lower than its current level, as confirmed by archeological investigations performed in 1978 (see Figure 5 and HSR Appendix G). The original floor was overlaid one or two times during the Colonial period with crushed shell, rubble, and said topped with additional tabby. Each resurfacing raised the floor a number of inches. Restoration work of the early twentieth century resulted in additional layers, raising the floor to its current level and configuration at that time. Encased beneath the floor fill is a stone platform along the north wall, potentially serving as a bench when the floor was at its original level.



Photo C-1: First floor room, looking west (2016, Faisant Associates).



Photo C-2: First floor room, looking east (2016, Faisant Associates).



Photo C-3: Wall crack, west side of doorway (2016, Faisant Associates).



Photo C-4: Crack at door head (2016, Faisant Associates).



Photo C-5: Biological growth on north wall (2016, Faisant Associates).



Photo C-6: Chimney flue (2016, Faisant Associates).

2. Recommended Treatments: First Floor Room

- a. Fill wall voids and repoint cracks.
- b. Evaluate reapplying plaster finish to interior walls. Considerations for interior plaster are similar to those for exterior plaster noted above in section A3, paragraph g.
- c. Remove the coquina masonry above the doorway and reconstruct it in an arch configuration.
- d. Clean biological growth from interior walls. Use gentle removal methods, starting with plain water at low pressure and working up to soft brushes, mild detergents, and pH neutral, biodegradable cleaning products designed for limestone cleaning as necessary. Reference NPS Preservation Brief number 1 for additional information on stone cleaning. Establish a biannual cleaning regimen to keep growth from reoccurring.
- e. Investigate sources of water infiltration. The porous nature of coquina makes it impossible to waterproof the Fort, but any cracks or voids in the exterior walls and roof exacerbate water ingress.
- f. Check the downspout on the south exterior wall of the tower for leaks as its position is very near the damp area in the southwest corner of the first floor room.
- g. Inspect and clean the chimney and firebox. Repoint the interior of the firebox. Consider discontinuing use of the fireplace or using it sparingly and in a highly-supervised manner.
- h. Remove the dirt floor and subsequent non-historic fill layers at least to the level of the latest presumed Colonial floor level. Should the historic floor materials be intact, leave them in place and cover with a bond breaker sheet and 2-3 inches of gravel fill finished with a new tabby concrete slab containing fiber reinforcement, and sawcut control joints to mitigate

shrinkage cracking. Alternatively, due to the poor performance of tabby, consider paving materials such as textured, colored concrete, exposed aggregate concrete, rustic-finished terrazzo, or bonded resin aggregate, all of which could give a similar appearance to the tabby with increased durability for foot traffic. A sheet of heavy plastic sheeting should be used to isolate new work from existing, to aid in future removal and reversibility of non-historic material.

D. First Floor Ceiling and Second Floor Structure

The second floor structure consists of inverted “T” -shaped timber joists supporting a lightweight concrete slab and tabby concrete topping (*Figure 6*). The joists span in the north/south direction and bear on the coquina masonry walls. There are fourteen vaults and joists with approximately equal spacing. The underside of the slab (first floor ceiling) is vaulted between the joists and most vaults have a plaster finish. The majority of the joists are embedded in the vaulted slab with only their bottom surfaces and flanges visible. The first vault directly adjacent to the west wall and the third floor joist east of the west wall are both historic. The second, third, and fourth vaults date from the 1916 restorations and do not have a plaster coating. The second floor structure east of the fourth vault was completely reconstructed during the 1979-80 restorations to resemble the historic configuration. The first, second, and fourth joists east of the west wall were also replaced during the 1979-80 repairs.

Refer to drawing sheets A4.1 and A4.2 for section views of the floor structure, see Appendix A.

1. Observations: First Floor Ceiling and Second Floor Structure

General

- a. A crack was observed in the vaults that span between the second floor joists. The crack runs east/west, appears in each vault, and is located 3'-0" to 3'-6" north of the south wall (*photo D-1*).
- b. A small area of the tabby concrete has delaminated at the fourth vault east of the west wall at a location near the south wall (*photo D-3*).
- c. The first, second, and fourth joists east of the west wall, replaced during the 1979-80 restorations, and the historic joist, are 6 inches wide across the bottom surface and have a flange thickness that varies between 1¼ to 2½ inches. The remainder of the joists measure 7 inches across at the bottom and have a consistent 2½-inch thick flange. No decay or deterioration of the wood was noticed, however, most of the joist depth is

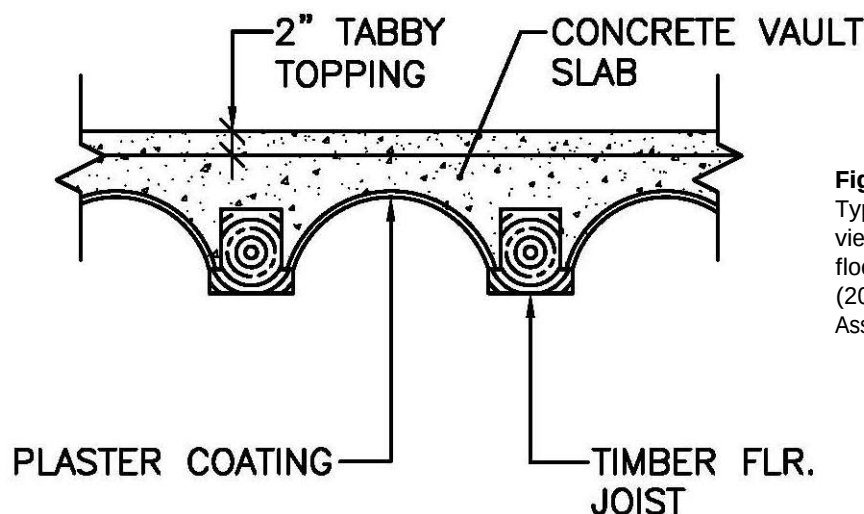


Figure 6, left:
Typical sectional view of the second floor construction (2016, Faisant Associates).

concealed by the concrete vaults. The joist ends are embedded in the coquina masonry walls and could not be observed. The historic joist exhibits some splitting and a reduction in its width (most likely dating from its fabrication) at its bearing on the south wall (*photo D-4*). The historic joist also shows signs of deterioration or wood softness at its north and south bearings.

- d. A noticeable vertical deflection was observed in the second and fourth joists east of the west wall (*photos D-2 and D-3*). A coquina partition wall is located above this area on the second floor and the weight of the wall may be contributing to the deflection by way of load sharing through the arched floor slab (*photo E-6*)., though the main factors affecting the deflection are: the thickness of the slab in this area, replaced in 1916, appears from the 1979-80 drawings to be greater than the adjacent, newer slab; the concrete used in 1916 was most likely higher density normal weight versus the light weight concrete used for the 1979-80 slab; and these joists have a smaller cross section than the other joists replaced in 1979-80 (i.e. the bottom flange thickness and width are less than those of the joists at the newer floor area). It is notable that the historic joist, located between these two newer joists, is not deflecting as much. This may be due to the possibility that the species of wood used for the historic joist has a greater elastic modulus (stiffness) than the wood used for the newer joists. The second joist east of the west wall appears in a photograph from the park archives taken in 1983 which shows that the deflection at that time was less than observed today (*photo D-5*). This may be due to the tendency of timber members to continue to deflect or creep over time under sustained dead loads, as they continue to season and age in place.



Photo D-1: Crack in ceiling vault (2016, Faisant Associates).



Photo D-2: Deflecting floor joist (2016, Faisant Associates).



Photo D-3: Deflecting floor joist and delaminated tabby ceiling vault (2016, Faisant Associates).



Photo D-4: Historic joist, bearing at south wall (2016, Faisant Associates).

2. Structural Investigation and Analysis of Second Floor Framing

Investigation

DATE: 5/13/2016

SITE TEMPERATURE: 79°F

SITE HUMIDITY: 64%

JOIST NO.	NORTH BEARING	SOUTH BEARING	MIDSPAN
1	24.0-27.1	15.0-17.5	12.2-15.5
2	15.5-17.4	18.0-21.0	13.6-15.5
3	16.5-20.7	17.5-22.0	12.6-15.5
4	14.0	16.5-16.8	11.7-15.5
5	17.5-23.7	13.2-16.5	13.5-16.5
6	17.5-21.8	16.0-18.5	13.2-16.5
7	18.5-21.8	16.5	14.4-16.5
8	18.5-20.5	13.2-16.5	12.8-18.5
9	19.5-20.0	17.0-17.5	14.5-23.0
10	20.5-25.1	17.1-21	15.7-18.5
11	19.5-22.2	18.4-24	13.3-18.5
12 ⁽³⁾	20.5-26.6	24.0	30.0-31.5
13	16.5-19.4	15.6-18.5	14.0-16.5
14	17.5-19.0	15.0-19.5	13.0-16.5



Photo D-5, above: First Floor Room looking west (1983, FOMA, M1890).

Notes:

1. The instruments used to measure moisture contents were the mini-LIGNO E/D, manufactured by the Lignomat Co., and a FLIR MR77.
2. All joists were measured by each instrument and the results have been presented in the table as a range of moisture readings.
3. Joist No. 12 is the historic member dating to the Fort's original construction.
4. Referring to Figure 8, joists 1 through 10 are Type 1 and joists 11, 13, and 14 are Type 2.
5. Refer to section 1 on drawing A4.2 for joist locations.

Figure 7, above: Floor joist moisture content in percent (%) (2016, Faisant Associates).

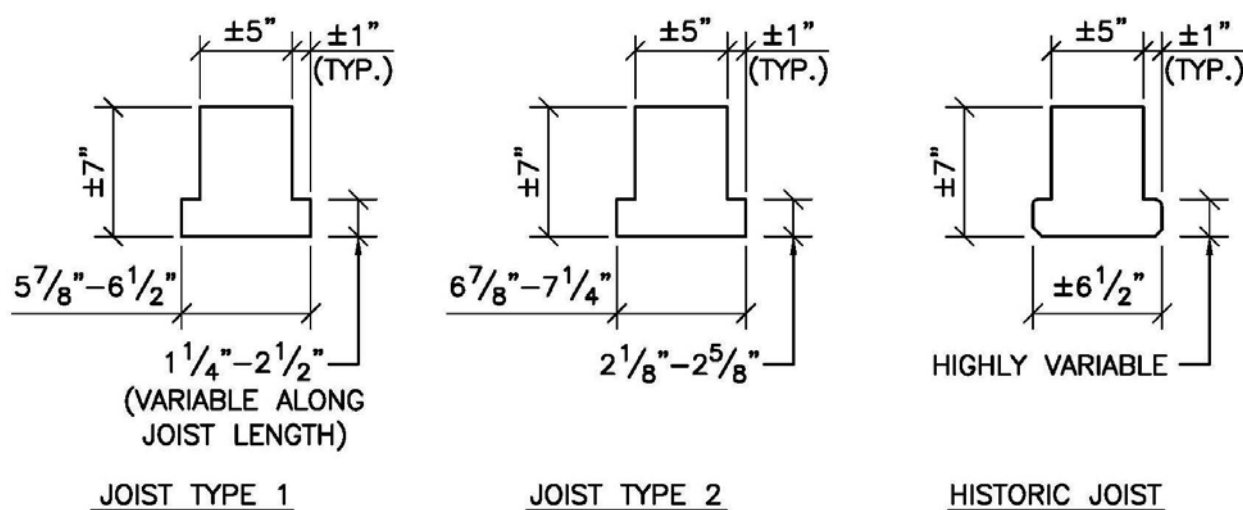
The investigation of the existing floor joists comprised probing to measure moisture content, sampling for laboratory testing to determine wood species, and visual grading using the methods described in *A Grading Protocol for Structural Lumber and Timber in Historic Structures / 2009-01*, published by the National Center for Preservation Technology and Training (NCPTT). The moisture contents of the joists were measured using electrical capacitance-type moisture meters and the results are tabulated in Figure 7.

Referring to figure 7, with the exception of the historic joist, moisture readings were found to be higher near the north and south joist bearings than at their mid-spans. This may be indicative of water penetration through the porous coquina masonry, gaps in mortar joints, and cracks. Embedment of the joist bearings in the walls also inhibits air circulation and the ability of the wood to dry out leading to higher retained moisture. The joists installed during the 1979-80 restoration were varnished or stained which could be acting to inhibit the absorption of moisture from the air, resulting in lower readings near the mid-span. The historic joist is uncoated and split at several locations along its length allowing for humid air to penetrate the member, resulting in higher moisture content.

Though the moisture readings are not considered to be excessively high (with the exception of the historic joist), it is recommended that one side of the joist bearing at two locations along the north wall be exposed to observe their conditions. This exploratory work is pending. The Recommended treatments section assumes that the embedded ends of the joists are in good condition.

Laboratory testing conducted by Timber Products Inspection of Conyers, Georgia, has determined that the wood species for the joists installed during the 1979-80 restoration is Bald Cypress (see Appendix B). Visual grading of the exposed faces of the members determined that they meet the requirements for a grade of Select Structural. The species of the historic joist is unknown; however, considering the timber most likely and readily available at the time of the fort's construction, it could be Southern Yellow Pine with the grade estimated to be no better than No. 1.

Figure 8 illustrates the cross sectional dimensions of the floor joists. Though the dimensions vary from joist to joist, it was determined that, generally, joists with two different cross sections were installed during the 1979-80 restorations. Referring to the building drawings and section view 1/S4.2, joists 11, 13, and 14 are Type 1, and replaced existing joists supporting the vaulted floor slab reconstructed in 1916, and the historic floor vault adjacent to the west wall. The historic joist is number 12. As part of the 1979-80 restoration, the 1916 and historic vaults were to be left intact, along with the historic joist. The replacement joists needed to be custom fabricated and closely match the slots left in the floor slab after the existing members were removed. Evidence for this can be observed in the variability in the thicknesses of the joist flanges as they follow the edges of the vaulted slabs. The floor area supported by joists 1 through 11 was completely reconstructed using the Type 2 joist cross section. Though the Type 2 dimensions vary between joists, the flange thicknesses are mostly consistent along the lengths of individual joists, unlike Type 1.



Note: Due to the embedment of the joists within the concrete floor vaults, only the dimension across their bottoms and the thickness of their flanges could be field measured. The remaining dimensions were obtained from the 1979-80 restoration drawings, and for analysis purposes are assumed to be the same for the historic joist.

Figure 8: Floor joist cross sectional dimensions (2016, Faisant Associates).

Structural Analysis

Joists 1 to 11, 13 and 14 were analyzed using allowable stress and modulus of elasticity values obtained from the Supplement to the National Design Specification for Wood Construction. The analysis determined the total load carrying capacity of the joists from which dead loads (comprising the weight of the joist, floor slab and plaster ceiling) were subtracted to determine the residual or live load capacity. The cross sectional properties used for the analysis were based on a 5-inch x 7-inch rectangular shape. The results are tabulated in Figure 9.

JOIST NUMBER	LIVE LOAD CAPACITY (P.S.F.)
1 to 10	52.5
11	33.0 ⁽¹⁾
13 & 14	12.5 ⁽¹⁾

(1) This lower live load capacity as compared to joists 1 to 10 reflects the assumed use of heavier normal weight concrete for the 1916 floor reconstruction, and the thicker vaulted slab in this area, resulting in a higher dead load.

Figure 9: Floor joist live load capacities (2016, Faisant Associates).

Current building codes do not directly correlate live load requirements for particular occupancy categories to numbers of occupants; however, it is possible to arrive at a reasonable estimate of the maximum second floor occupant load. In the 2015 International Building Code (IBC) Section 1004 - Occupant Load, Table 1004.1.2 lists 5 square feet as the maximum floor area allowance per standing occupant in an assembly setting. With 5 square feet of floor area allowed per individual, the approximate total number of occupants in the areas supported by joists 1 to 11 and, 13 and 14 would be 42 and 10, respectively. Using a conservative average adult weight of 200 pounds, this occupancy corresponds to a floor live load of 40 p.s.f. Though this load exceeds the calculated capacity for joists 13 and 14, access to this area of the room to visitors will be prevented by the partition wall; however, the lower live load capacity would still allow for maintenance access for park personnel (approximately four 200 lb. individuals). The live load capacity calculated for joist 11 is also less than 40 p.s.f.; however, the joist will reach this threshold if the increased section properties provided by the bottom flanges are considered in the analysis.

The analysis of the historic joist established the bending and shear stresses in the member due to current dead loads (including the coquina partition wall) and a live load of 40 p.s.f. applied to the floor on the visitor accessible east side of the coquina partition wall. A comparison was made of the calculated stresses to those listed in the NDS Supplement for Southern Yellow Pine. The wood grade of the joist would have to be No. 1 Dense or Select Structural in order to comply with the calculated bending stress. Visual grading of the historic joist does not justify either of these grades and the calculated bending stress would then exceed that allowed for a lower grade of wood.

In summary, the analysis indicates that the second floor joists 1 to 11 will support the anticipated occupancy live load. The floor area above joists 13 and 14 will support a live load that will allow for limited access for maintenance and upkeep purposes. Remedial action is recommended for the historic joist, see Section 3, Recommended Treatments.

3. Recommended Treatments: First Floor Ceiling and Second Floor Structure

- a. Historic Floor Joist Options:
 - i. Reduce bending stress in the joist by removing the existing coquina partition wall at the second floor and replacing it with one of wood construction (see section E.3 below for recommendations for its replacement). Reconstructed as part of the 1916 restorations, this wall is not historic; however, there is evidence that a wall at this location did exist at the time of the Fort's construction. The original wall's configuration and material are unknown. A lighter weight partition wall will reduce the bending stress to a level that will allow for the occupancy described in the analysis in Section 3. Additionally, reinforce the joist bearings with a concealed steel cross section, or if feasible a timber cross section using a "Dutchman" repair technique.
 - ii. Leave the existing coquina partition in place, remove the historic joist and replace it with a steel member concealed by wood that mimics the shape of the exposed joists. The use of a steel member will eliminate the effects of long term dead load deflection. Exhibit the historic joist.
- b. Insert borate rods into the joist bearings (beyond the interior wall faces) in holes drilled at an upward angle from the bottoms of the joists. The presence of the borate rods will act to prevent or arrest fungal and insect attack. A wood plug can be installed to fill the holes and stained to match the existing joist finish.
- c. To address the deterioration of the historic joist bearings, several options are available:
 - i. Replace the joist.
 - ii. Locally reinforce the joist bearings with a concealed steel cross section, or if feasible a timber cross section using a "Dutchman" repair technique.
- d. Repair the delaminated ceiling vault.
- e. Install monitors at two locations on the ceiling vault cracks to determine if they are currently active. A repair strategy can be developed if the cracks are dormant. (See also

Recommended Treatments: Second Floor Ceiling and Roof Structure under Section F of this report). Two crack monitors were installed during a site visit on May 13, 2016.

E. Second Floor Room

A doorway located in the south tower wall serves as the entry point to the second floor room from the exterior wood stair. A partial height coquina masonry partition separates a small area adjacent to the magazine near the west wall. The exterior walls are exposed coquina masonry and the floor finish is a tabby concrete topping slab. Wall openings include one unglazed window with solid wood plank shutters on the north wall and three loopholes on the south wall. A coquina masonry vault forms the ceiling and supports the roof above. An opening centered in the vaulted ceiling provides access to the roof level via a wood ladder (*photos E-1, E-2, and E-6*).

Refer to drawing sheet A1.2 for a floor plan view, see Appendix A.

1. Observations: Second Floor Room

General

- a. Large voids were observed in the coquina walls at two locations along the north wall near the floor (*photo E-5*). These were likely pockets for framing where wood interior partitions historically existed. There were two partitions – one separating the officer's quarters and the other defining an outer chamber for the magazine.
- b. Two parallel, diagonally oriented cracks were observed at the north wall near the northeast corner (*photo E-4*).
- c. Installed during the 1979-80 restorations, the tabby floor topping is in poor condition. The surface is extensively eroded and irregular. At several locations, the structural concrete slab and welded wire reinforcing below has been exposed (*photo E-3*). A crack was observed in the topping approximately 1'-6" to 1'-10" east of the coquina partition wall, running in the north/south direction. It is believed that this crack is related to the presence of a construction joint in the slab below, between the 1916 and 1979-80 restorations. It is suspected that the crack extends through the structural slab and is the result of negative bending in the slab occurring above the fourth joist in from the exterior west wall (*photo E-7*). Due to the closeness of the joist spacing and arching action of the vaults, it is felt that the slab is not dependent on continuity (i.e. negative bending) over the joists to support the floor loads; therefore, the crack is considered to be cosmetic.
- d. Biological growth was observed at several locations on the walls.



Photo E-1: Second floor room, looking west (2016, Faisant Associates).



Photo E-2: Second floor room, looking east (2016, Faisant Associates).

- e. The powder magazine was inaccessible at the time of the site visit and requires a confined entry permit for manual inspection. The park provided video of the magazine interior taken April 2016 for the evaluation team's review. From the video, the magazine interior is coquina stone with a wooden platform several feet down creating a false bottom. The park indicated they installed the platform to reduce the magazine's depth for safety. Conditions beneath the platform could not be seen on the video. The portions of the magazine interior visible on the video appear to be in good condition, with no observable deterioration.



Photo E-3: Deteriorated second floor tabby topping (2016, Faisant Associates).



Photo E-4: Wall cracks, northeast corner (2016, Faisant Associates).



Photo E-5: Void in north wall and biological growth (2016, Faisant Associates).



Photo E-6: Coquina partition wall (2016, Faisant Associates).



Photo E-7: Crack in tabby floor topping (2016, Faisant Associates).

2. Recommended Treatments: Second Floor Room

- a. Remove the existing tabby topping and membrane below. Care must be taken to avoid disturbing or damaging the PVC sleeve encased steel tie rods located below the topping and partially embedded in the floor slab. Inspect the floor slab for cracks or other deterioration and provide repairs as necessary. Consideration should be given to installing carbon fiber reinforced sheets on the structural slab above the construction joint to prevent future cracking in the topping slab. Install new floor topping. Alternatively, due to the poor performance of tabby, consider paving materials such as textured, colored concrete, exposed aggregate concrete, rustic-finished terrazzo, or bonded resin aggregate, all of which could give a similar appearance to the tabby with increased durability for foot traffic.
- b. Repoint wall cracks.
- c. Evaluate reapplying plaster finish to interior walls. Considerations for interior plaster are similar to those for exterior plaster noted above in section A.3.g.
- d. Clean biological growth from interior walls. Use gentle removal methods, starting with plain water at low pressure and working up to soft brushes, mild detergents, and pH neutral, biodegradable cleaning products designed for limestone cleaning as necessary. Reference NPS Preservation Brief number 1 for additional information on stone cleaning. Establish a biannual cleaning regimen to keep growth from reoccurring.
- e. Consider reconstructing wood partitions. The partitions could be fully reconstructed but the work would be largely conjectural as there is no known information about their exact configuration. A better alternative may be to partially reconstruct the partitions in a minimal way that gives the impression of what may have existed. Depending on how this were achieved, it could have the added benefit of keeping the second floor space unified as a single open room, which facilitates visitor access. Any reconstruction in wood would impart less floor loading than the current coquina partition. In light of the structural analysis summarized in section D.3, construct a partial height wood partition wall adjacent to the powder magazine, located as far east as the doorway will allow to prevent visitor access to this area.
- f. Inspect the powder magazine periodically by lowering a still or video camera into the chamber. Although the powder magazine is abandoned, it is important to maintain the chamber interior as degradation could compromise the tower walls and/or roof deck.

F. Second Floor Ceiling and Roof Structure

The second floor ceiling and roof structure consists of a stone vault arching in the east/west direction. The vault was completely reconstructed in 1938-39 due to settlement problems along the east wall. As part of the 1979-80 restorations, five existing transverse steel tie rods, embedded in the north and south walls, were slated to be replaced; however, the center rod could not be extracted and was left in place. A new 3-inch thick tabby topping slab and vapor barrier were installed on the roof at this time. The 1980 HSR on page 392 describes the then-current condition of the roof scuttle. At the time, a "badly deteriorated" coquina curb surrounded the opening, with no hatch cover at all. It is likely that repairs were made to this curb as part of the 1979-80 work.

A report prepared in 1993 by GWWO, Inc., recommended the removal and replacement of the remaining center tie rod, due to the deterioration of stonework at the underside of the vault caused by the continuing exfoliation of the rod. No written record of the completion of this work has been found; however, in *the Historic Structures Record of Treatment* for repair work undertaken in 1997, mention is made of all five transverse tie rods having been previously replaced, and a further reference is made to the replacement of a tie rod in the early 1990s.

The restoration work completed in 1997 included the replacement of two longitudinal steel tie rods embedded in the east and west walls and the installation of a new roof system. The new roof consists of

a 3-inch thick tabby concrete slab installed over a drainage layer of geotextile and a 2-inch thick layer of pea gravel placed over a roof membrane that rests on a 2-inch thick bed of sand. Additionally, stonework along the underside of the vault, damaged by the exfoliation of the old tie rods, was repaired by infilling with a Portland cement/coquina sand mixture that was then hand tooled to resemble individual stones and mortar joints. Although the 1997 work report does not specifically mention repairs to the scuttle, photos from that project indicate some minor repointing may have been performed on the curb.

From 1980 until some point beyond 1997, a hatch was not installed on the roof scuttle opening. The current hatch is of wood construction and is in very good condition, having been installed in 2014. Its construction and style are in-keeping with other wood doors and shutters present on the Fort. Presumably, its design is conjectural as the 1980 HSR indicates that while various hatches and even an entire hatch-house were present in the past, the exact details of their construction and appearance cannot be substantiated.

Refer to drawing sheets A4.1 and A4.2 for section views of the floor structure, see Appendix A.

1. Observations: Second Floor Ceiling and Roof Structure

General

- a. A crack in the stone vault was observed running in a rough arc between the southwest and southeast corners of the room. The crack curves to a point located approximately 1'-6" south of the roof hatch opening. The crack runs through both mortar joints and individual stones. The vault also exhibits stone erosion adjacent to mortar joints at many locations which may be due to the use of a portland cement mortar for the vault reconstruction in 1938-39. More recent repairs using a compatible mortar were observed north of the roof scuttle and do not exhibit the same deterioration. These repairs are most likely the ones completed in 1997 and possibly earlier in the 1990s. It is not clear what has caused the arc-shaped vault crack, but the observation of cracks in the first floor ceiling vaults which, like the roof vault crack, are located near the south tower wall, indicate that they may be related.
- b. Two cracks were observed running through the tabby topping slab on the roof. Both are oriented in the north/south direction and extend across the width of the roof. One crack is aligned with the scupper opening in the north wall and the other is aligned with the west edge of the roof hatch opening (*photos F-1 and F-2*).
- c. Other than the cracks noted above, the tabby topping is in the best condition of any of the tabby walking surfaces on the site.
- d. Park representatives report that the current hatch has failed to stop water intrusion into the structure and that efforts to add supplemental coverings to the hatch have either failed or been too cumbersome for staff to utilize effectively. A major problem with the current setup is that the ladder rails extend above the hatch approximately 18 inches, making it difficult to achieve a weather-tight seal (*photo F-3*). Due to the semi-open nature of the Fort, wind uplift of the hatch is a problem as well. Rainwater entering through the roof hatch collects on the floor below and there is no formal means (such as a drain) of evacuating water from the second floor room. This leads to water being absorbed into the tabby and concrete floor deck and also into the surrounding coquina walls. This contributes to deterioration of the floor, walls, and display items and possibly to some of the biological growth seen on the interior walls. The inherent porosity of coquina will make it impossible to fully weatherproof the Fort, but tightening up the roof hatch could be helpful in reducing a significant amount of water ingress.
- e. Minor cracks and voids are present in the mortar of the coquina curb at the roof scuttle.



Photo F-1: Roof tabby crack at scupper (2016, Faisant Associates).



Photo F-2: Roof tabby crack at hatch opening (2016, Faisant Associates).



Photo F-3: Roof scuttle (2016, Faisant Associates).

2. Recommended Treatments: Second Floor Ceiling and Roof Structure

- a. Monitoring of the roof vault and first floor ceiling vault cracks (See also Recommended Treatments: First Floor Ceiling and Second Floor Structure under Section D of this report) would be conducted at the same time to determine if they are currently active. Given the history of the roof repair work and previous replacement of the tie rods, it is suspected that the cracks are most likely due to foundation movements. A repair strategy can be developed if the cracks are dormant. Two crack monitors were installed during a site visit on May 13, 2016.
- b. Repair cracks in roof tabby concrete slab.
 - i. Consider replacement of the tabby roof topping with paving materials such as textured, colored concrete, exposed aggregate concrete, rustic-finished terrazzo, or bonded resin aggregate, all of which could give a similar appearance to the tabby with increased durability for foot traffic and weathering. Although replacement of the roof topping is not urgent as of the writing of this report, tabby's poor longevity combined with the age of the underlying membrane (installed in 1997 with an approximate 20-25 year expected service life), it should be an item on the park's maintenance list on that time horizon.
- c. Roof Ladder:
 - i. To retain rail extensions above curb: If the ladder extensions are to be retained, "sleeves" made of waterproof awning canvas could be sewn and sealed to the

- existing holes in the hatch cover. The sleeves would slide over the rail extensions as the hatch closed, providing a more water-resistant seal.
- ii. To cut off rail extensions above curb: Alternatively, the rail extensions could be cut off flush with the curb and a supplemental railing system installed outside of the hatch that would not interfere with its operation.
 - d. Roof Curb: The unevenness of the top of the curb prevents a weather-resistant seal. A wood, concrete, or dimension stone level curb installed on top of the coquina would provide an even surface against which the bottom of the hatch could seal. Repoint curb coquina as necessary.
 - e. Roof Hatch: There are two options for improving the watertightness of the roof hatch and which one is selected will require additional deliberation by the park and consultation with the Florida DHR.
 - i. Improve the existing hatch. If the curb were leveled as described in paragraph “e” above, a gasket could be added around the hatch’s perimeter. A skirt board of approximately 2-3 inches in depth around the perimeter of the hatch door would further guard against water intrusion by creating an overlap at the top of the curb. Depending on the approach selected for the ladder, the holes in the hatch could either have sleeves added as described in paragraph “d.i” above or be filled in entirely. A gas strut or other counterweight system could be added to the hatch door to make operation easier/safer. With a level curb, locking hardware could be improved to prevent wind uplift.
 - ii. Alternatively, the existing hatch could be removed and replaced with a factory-fabricated commercial or marine-grade hatch assembly. These can be specified with gas struts, balanced hinges, and integrated gasketing. Some may allow exterior wood cladding, but it is likely the finished product would be more modern in appearance than the current installation. The upside of this solution is that it is likely to offer the best weatherproofing.

Prioritization of Recommended Treatments

As noted above, the evaluation team did not observe any critical structural deficiencies requiring immediate remediation. Still, some treatments recommended in this report require shorter term attention while others could be addressed over longer timeframes. Recommendations are categorized in the following priority levels:

1. Priority 1: Items requiring attention within 1 to 2 years.
 - a. Terreplein parapet repairs (Ref. Section A3, Para. e).
 - b. Stockpiling of new coquina for maintenance (Ref. Section A3, Para. f).
 - c. Terreplein deck repairs (ref. Section B2, Paras. a & b and Drawing A6.1)
 - d. Door lintel repair at First Floor Room (Ref. Section C2, Para. c).
 - e. Coquina partition removal in Second Floor Room (Ref. Section D3, Para. a and Section E2, Para. e).
 - f. Downspout repairs (Ref. Section C2, Para. f).
 - g. Apply borate treatment at wood joist ends (Ref. Section D3, Para. b).
 - h. Historic joist repair or replacement (Ref. Section D3, Para. c).
 - i. Delaminated ceiling vault repairs (Ref. Section D3, Para. d).
 - j. Second floor topping replacement (Ref. Section E2, Para. a).
 - k. Repair roof tabby topping cracks (Ref. Section F2, Para. b).
 - l. Masonry repairs in First and Second Floor Rooms (Ref. Section C2, Paras. a, b, d, and e, and Section E2, Paras. b, c, and d).
 - m. Improvements to roof hatch (Ref. Section F2, Paras. d, e, and f and Drawing A6.1).
 - n. Stair repairs (Ref. Section B2, Para. c).
2. Priority 2: Items requiring attention in 3-5 years.
 - a. Plastering of exterior coquina, if pursued (Ref. Section A3, Para. g).
 - b. Repoint cistern interior throat (Ref. Section B2, Para. d).
 - c. Chimney and firebox repairs (Ref. Section C2, Para. g).
 - d. Install hard floor at first floor room (Ref. Section C2, Para. h).
3. Priority 3: Items requiring attention in 6-8 years.
 - a. Plastering of interior coquina, if pursued (Ref. Section C2, Para. b and Section E3, Para c).
 - b. Replace wood stairs (Ref. Section B2, Para. c).
 - c. Reconstruct wood interior partitions at second floor (Ref. Section E3, Para. d).
 - d. Replace roof tabby topping (Ref. Section F2, Para. c).
4. Ongoing Priority: Items requiring routine, periodic maintenance.
 - a. Repairs to exterior coquina masonry (Ref. Section A3, Paras. a to d).
 - b. Inspect cistern interior (Ref. Section B2, Para. d).
 - c. Inspect powder magazine interior (Ref. Section E2, Para. f).
 - d. Collect and log crack monitor data (Ref. Section D3, Para. e and Section F2, Para a).
 - e. Clean biological growth from coquina.

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Appendix A: Wood Grading Results

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Wood Grading Results

Species Name: Southern Yellow Pine

Grade	Nominal Thickness	Nominal Width	Classification	Edge Knot Wide Face	Center Knot Wide Face	Knot On Narrow Face	Maximum Slope Of Grain
Select Structural	5" and larger	6	Timbers	1.625	1.625	1.625	1:14
No. 1	5" and larger	6	Timbers	2.125	2.125	2.125	1:11
No. 2	5" and larger	6	Timbers	3	3	3	1:6

Grading is one aspect of a structural assessment. This program provides grade limitations based solely on species, knot size, and slope of grain. It does not account for checks, splits, insect damage, decay, or other factors that may affect the performance of structural timber.

Appendix B: Wood Species Determination

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Report Date: June 24, 2016

LABORATORY RESULTS

Client & Address: Mr. Edmund G. Foy P.E.
Faisant Associates, Inc.
810 Light Street, Suite 100
Baltimore, MA 21230

Test: Determination of Specie Identification in Wood Samples

Sample ID	Specie Identification
Joist #2	Bald Cypress (<i>Taxodium distichum</i>)
Joist #10	Bald Cypress (<i>Taxodium distichum</i>)

Note: These samples were submitted by the client. These results should not be construed as acceptance or rejection of any lot or lots which may be in question. Timber Products Inspection, Inc. waives all **responsibility for any damages resulting from the usage and/or implementation of the products or data** described in the report.

Report Authorized By:

Chris Barber
Manager, TP Chemical Laboratory

Appendix C: Existing Conditions Drawings

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TOP OF
XXXX
EL. 0.00'

ELEVATION REFERENCE
POINT

X
XX.XX

DETAIL REFERENCE

X
XX.XX

BUILDING ELEVATION
REFERENCE

X
XX.XX

BUILDING SECTION
REFERENCE

KEY TO SYMBOLS

SOIL FILL

CONCRETE

COQUINA STONE - SECTION
OR
TABBY - SECTION

COQUINA STONE - ELEVATION

KEY TO MATERIALS

The map shows the Matanzas River flowing between Anastasia Island and Rattlesnake Island. Fort Matanzas is located on Rattlesnake Island. Key features include the Visitor Center, Nature Trail, Picnic area, Beach Ramp (car access), and Summer Haven. The map also shows the Intracoastal Waterway, Matanzas Inlet, and the Atlantic Ocean. A scale bar indicates distances in kilometers and miles. A legend identifies areas open to the public, closed to the public, boardwalks, and parking lots. A note indicates that the area is closed to vehicles above a certain point and open to 4-wheel-drive vehicles only below that point.

FORT MATANZAS PARK MAP

SHEET NO.	SHEET TITLE
A1.0	COVER SHEET
A1.1	FLOOR PLANS
A1.2	FLOOR PLANS
A3.1	ELEVATIONS
A3.2	ELEVATIONS
A3.3	ELEVATIONS
A3.4	ELEVATIONS
A4.1	SECTIONS
A4.2	SECTIONS
A6.1	PROPOSED DETAILS

SHEET INDEX

COQUINA:	LOCALLY AVAILABLE SHELL STONE.
CORDON:	THE ORNAMENTAL PROJECTING COURSE OF STONE BELOW THE PARAPET.
EMBRASURE:	AN OPENING IN THE PARAPET THROUGH WHICH CANNONS MAY BE FIRED.
LOOPHOLE:	A VERTICAL APERTURE IN A FORTIFICATION THROUGH WHICH A GUN CAN BE FIRED.
REVTMENT:	A RETAINING WALL.
SCARP:	THE BATTERED MAIN WALLS OF THE FORT.
TABBY:	AN UNREINFORCED CONCRETE USING SHELL AS AGGREGATE.
TERREPLEIN:	THE HORIZONTAL SURFACE IN REAR OF A PARAPET ON WHICH CANNON MAY BE PLACED.
NOTE: DEFINITIONS ARE EXCERPTED FROM THE DRAWING PACKAGE INCLUDED IN THE 1980 HSR (NPS DRAWING NUMBER 347-28000).	

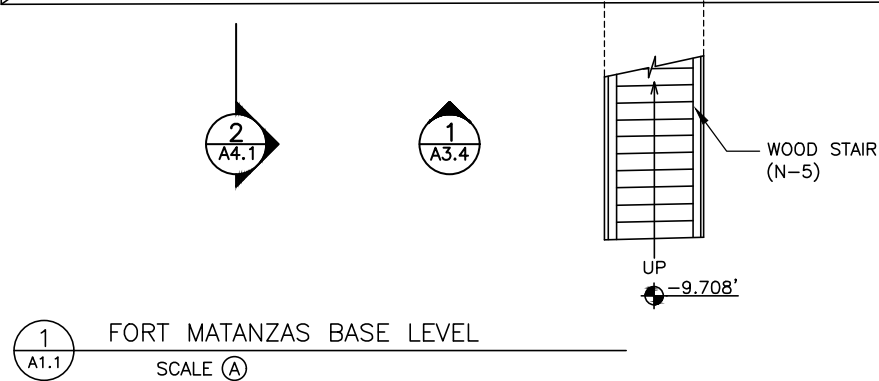
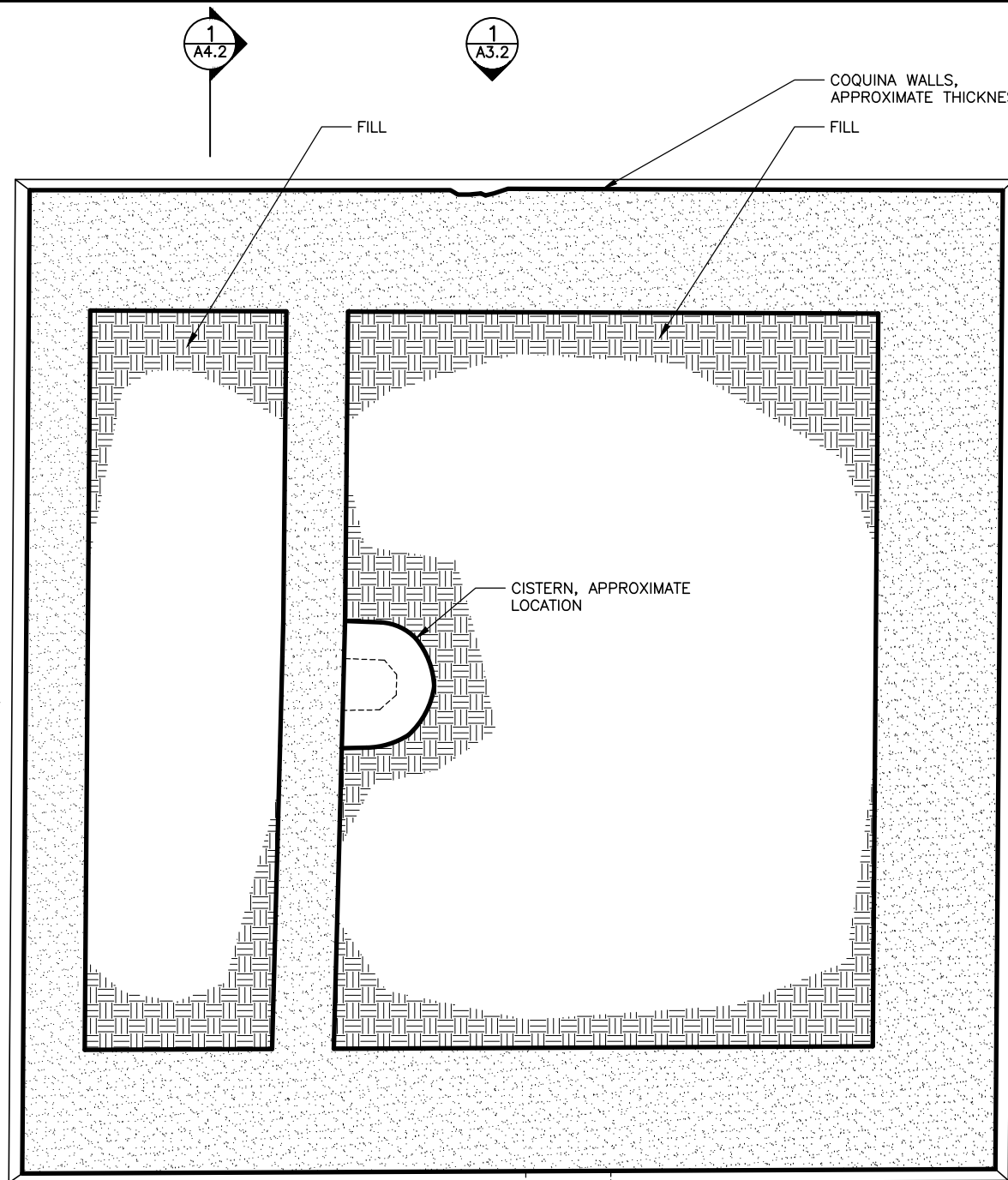
DEFINITIONS

A photograph of Fort Matanzas, a large stone fortification. A cannon is firing from the right side of the fort, with a large plume of smoke and fire visible. A person is standing on the stairs leading up to the fort. The fort is situated on a grassy area with water in the background.

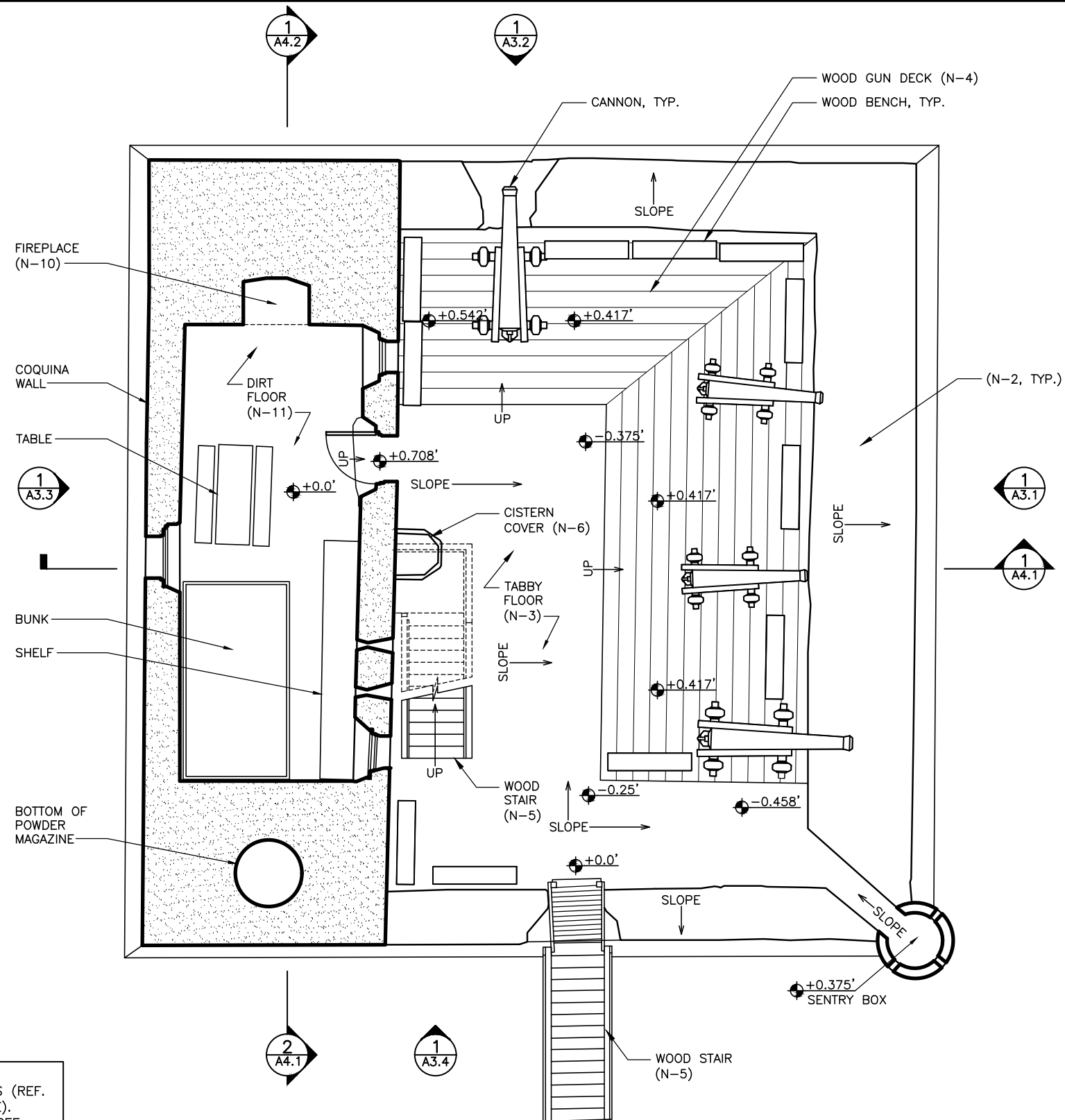
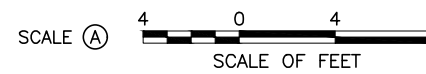
FORT MATANZAS - VIEW FROM SOUTH CORNER LOOKING SOUTH

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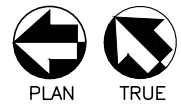
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 - N-3: TERREPLEIN DECK REPAIRS (REF. REPORT SECTION B2, PARA. A).
 - N-4: DISMANTLE AND RECONSTRUCT WOOD GUN DECK (REF. REPORT SECTION B2, PARA. B).
 - N-5: REPLACE WOOD STAIR.
 - N-6: CISTERN REPAIRS (REF. REPORT SECTION B2, PARA. D).
 - N-10: CHIMNEY AND FIREBOX REPAIRS (REF. REPORT SECTION C2, PARA. G).
 - N-11: FLOOR RESTORATION (REF. REPORT SECTION C2, PARA. H).



2 A1.1

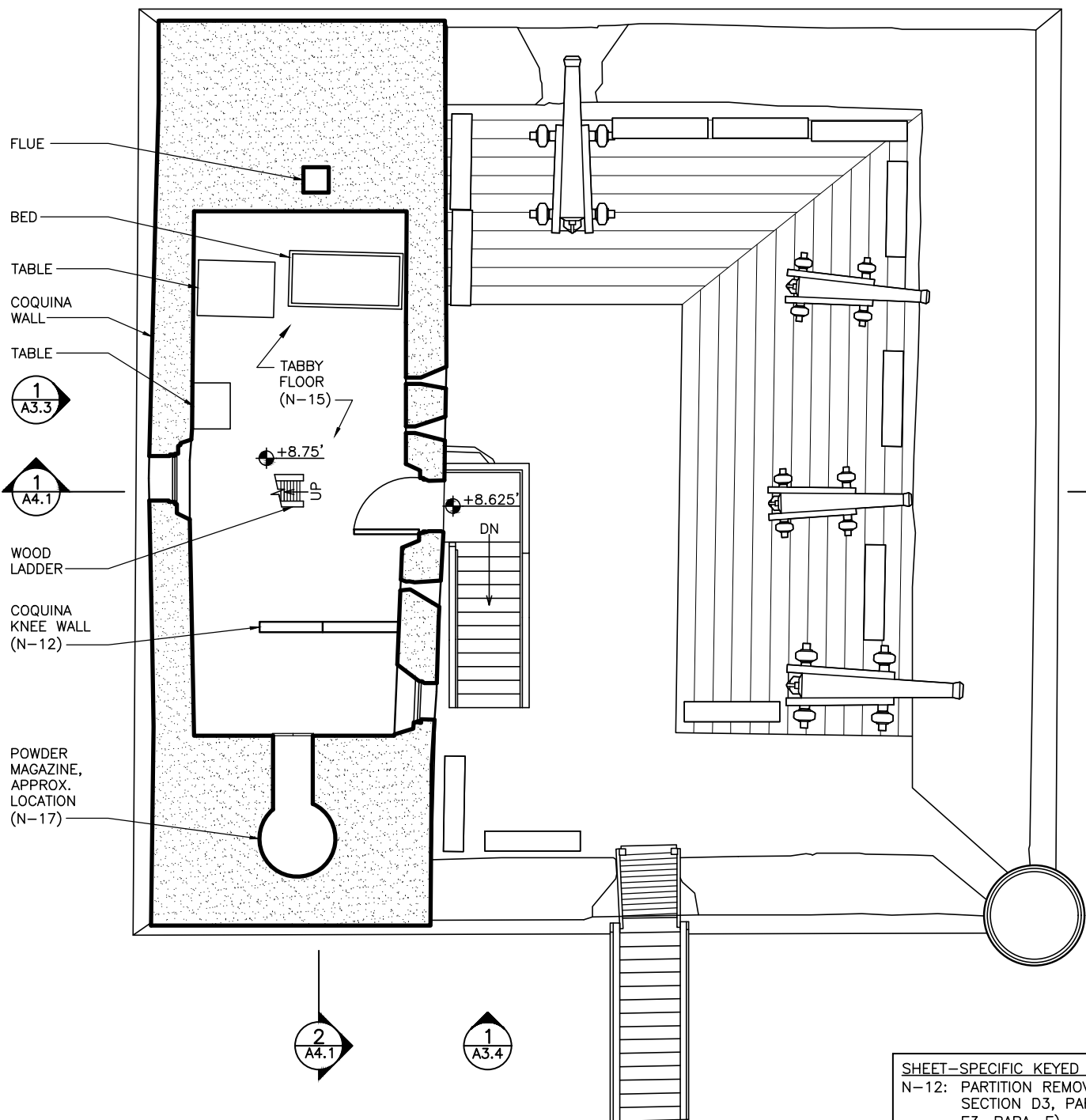
FORT MATANZAS TERREPLEIN LEVEL

SCALE (A)



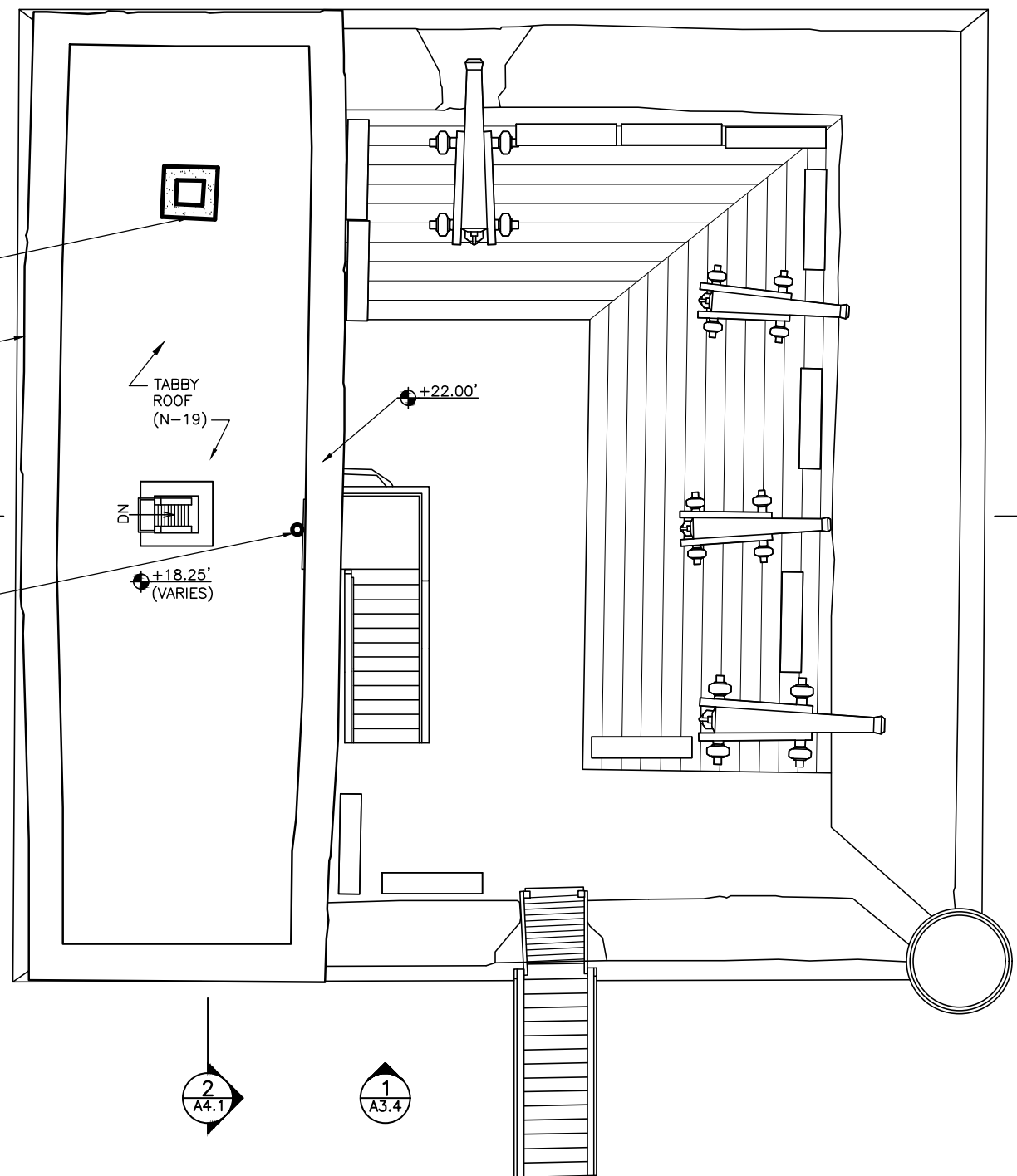
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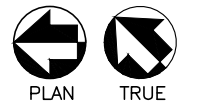


1 A1.2 FORT MATANZAS SECOND FLOOR
SCALE (A)

SHEET-SPECIFIC KEYED NOTES:
N-12: PARTITION REMOVAL (REF. REPORT SECTION D3, PARA. A, AND SECTION E3, PARA. E).
N-15: SECOND FLOOR TOPPING REPLACEMENT (REF. REPORT SECTION E2, PARA. A).
N-17: POWDER MAGAZINE REPAIRS (REF. REPORT SECTION E2, PARA. F).
N-19: REPAIR TABBY TOPPING CRACKS (REF. REPORT SECTION F2, PARA. B).

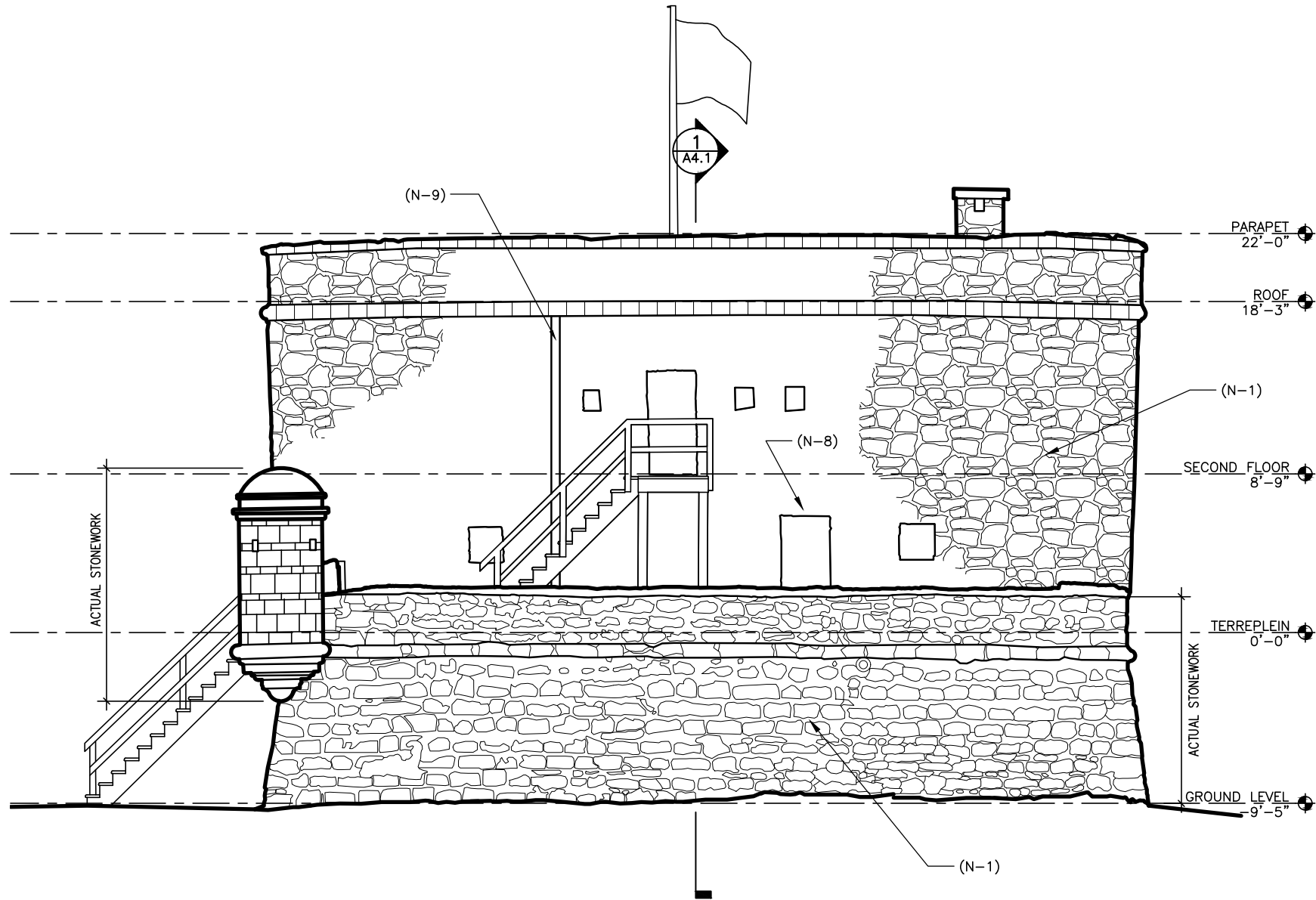


2 A1.2 FORT MATANZAS ROOF
SCALE (A)



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	DATE: 10/21/16			
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1 FORT MATANZAS SOUTH ELEVATION
A3.1 SCALE (A)

SHEET-SPECIFIC KEYED NOTES:
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N-8: DOOR LINTEL REPAIR (REF. REPORT SECTION C2, PARA. C).
N-9: DOWNSPOUT REPAIR (REF. REPORT SECTION C2, PARA. F).

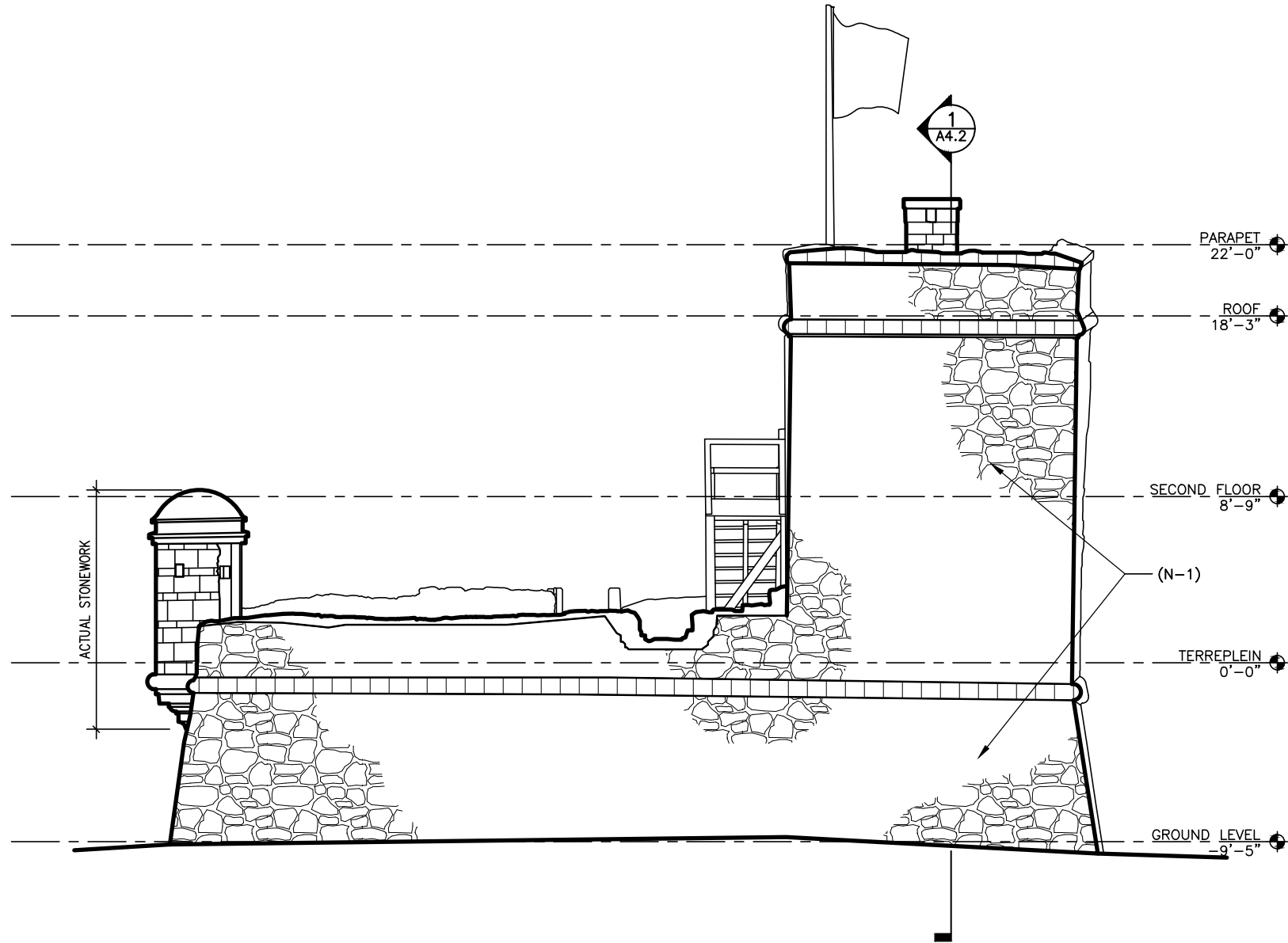
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- A. FLOOR LEVELS SHOWN ON THIS DRAWING ARE NOMINAL AS ACTUAL ELEVATIONS VARY CONSIDERABLY, PARTICULARLY ON THE TERREPLEIN AND ROOF LEVELS.
- B. EXCEPT WHERE OTHERWISE INDICATED, STONEWORK SHOWN IN ELEVATION IS A GENERIC PATTERN MEANT TO REPRESENT THE GENERAL APPEARANCE OF THE COQUINA BLOCK WALLS

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SCALE OF FEET

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1 FORT MATANZAS EAST ELEVATION
A3.2 SCALE (A)

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REPORT SECTION A3, PARAS. A TO D).

GENERAL NOTES:

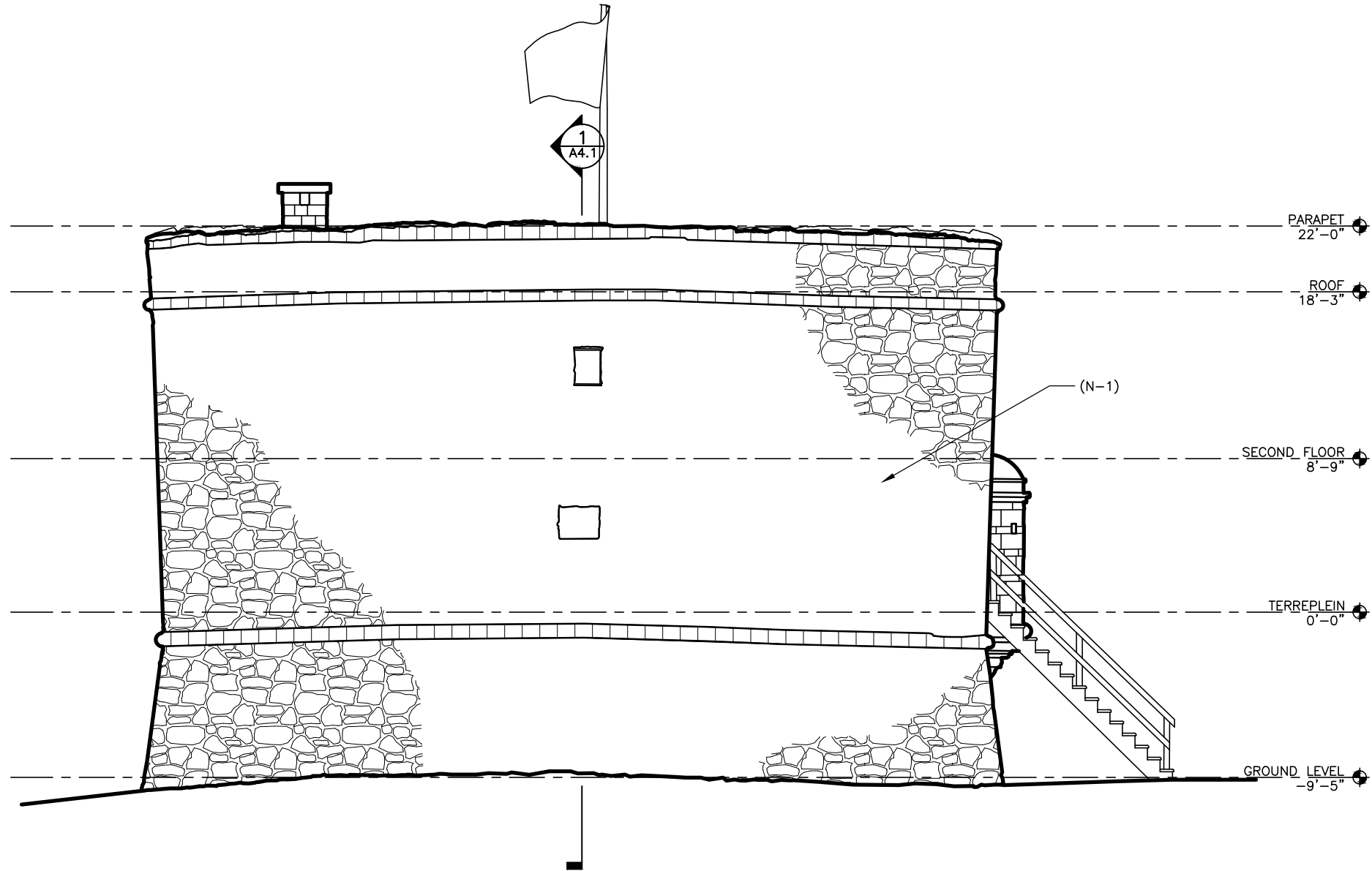
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ELEVATIONS VARY CONSIDERABLY,
PARTICULARLY ON THE TERREPLEIN
AND ROOF LEVELS.

B. EXCEPT WHERE OTHERWISE INDICATED,
STONEWORK SHOWN IN ELEVATION IS
A GENERIC PATTERN MEANT TO
REPRESENT THE GENERAL
APPEARANCE OF THE COQUINA BLOCK
WALLS

SCALE (A) 4 0 4 8
SCALE OF FEET

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1 FORT MATANZAS NORTH ELEVATION
A3.3 SCALE (A)

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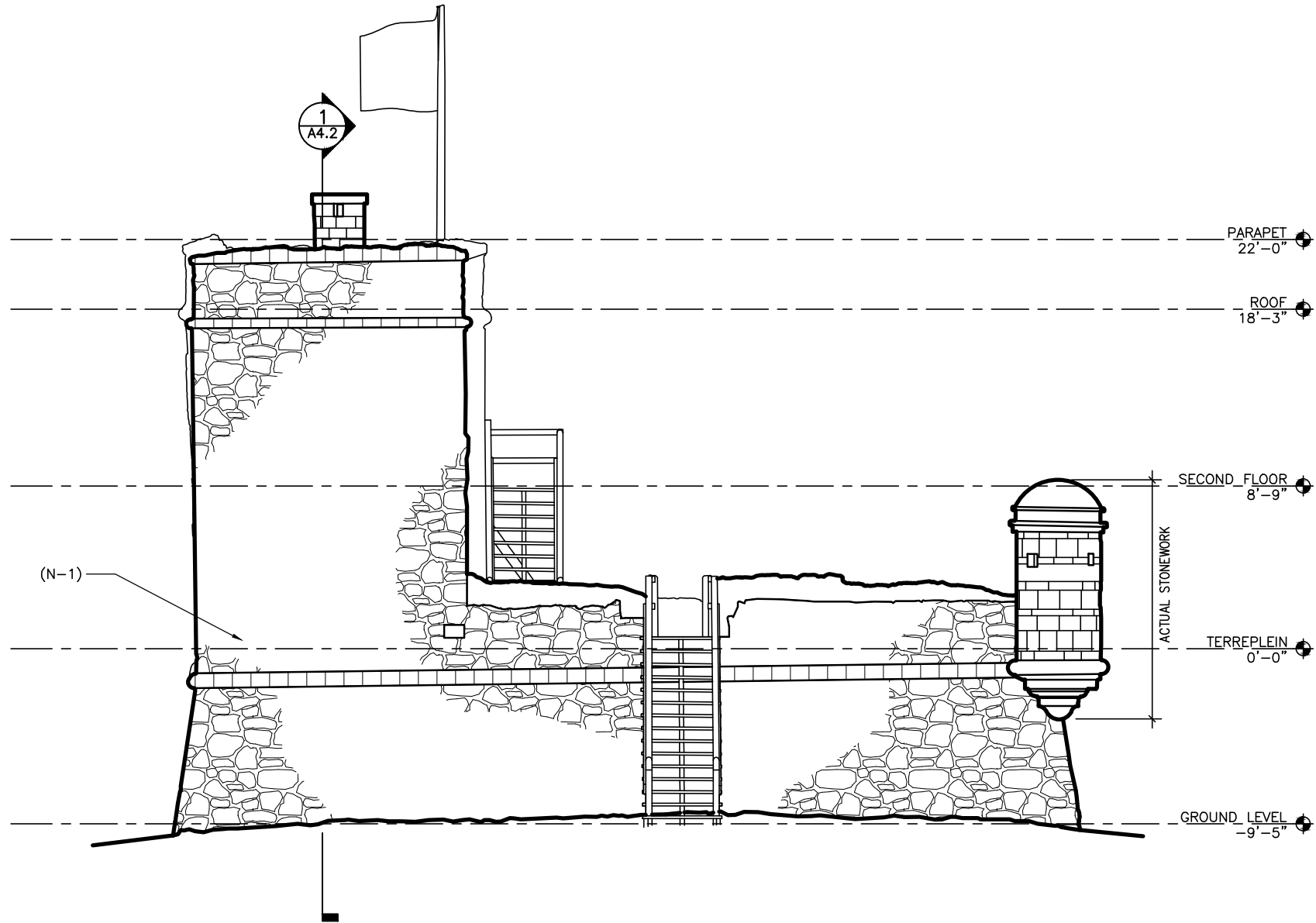
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AND ROOF LEVELS.

B. EXCEPT WHERE OTHERWISE INDICATED,
STONEWORK SHOWN IN ELEVATION IS
A GENERIC PATTERN MEANT TO
REPRESENT THE GENERAL
APPEARANCE OF THE COQUINA BLOCK
WALLS

SCALE (A) 4 0 4 8
SCALE OF FEET

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A3.4 FORT MATANZAS WEST ELEVATION
SCALE (A)

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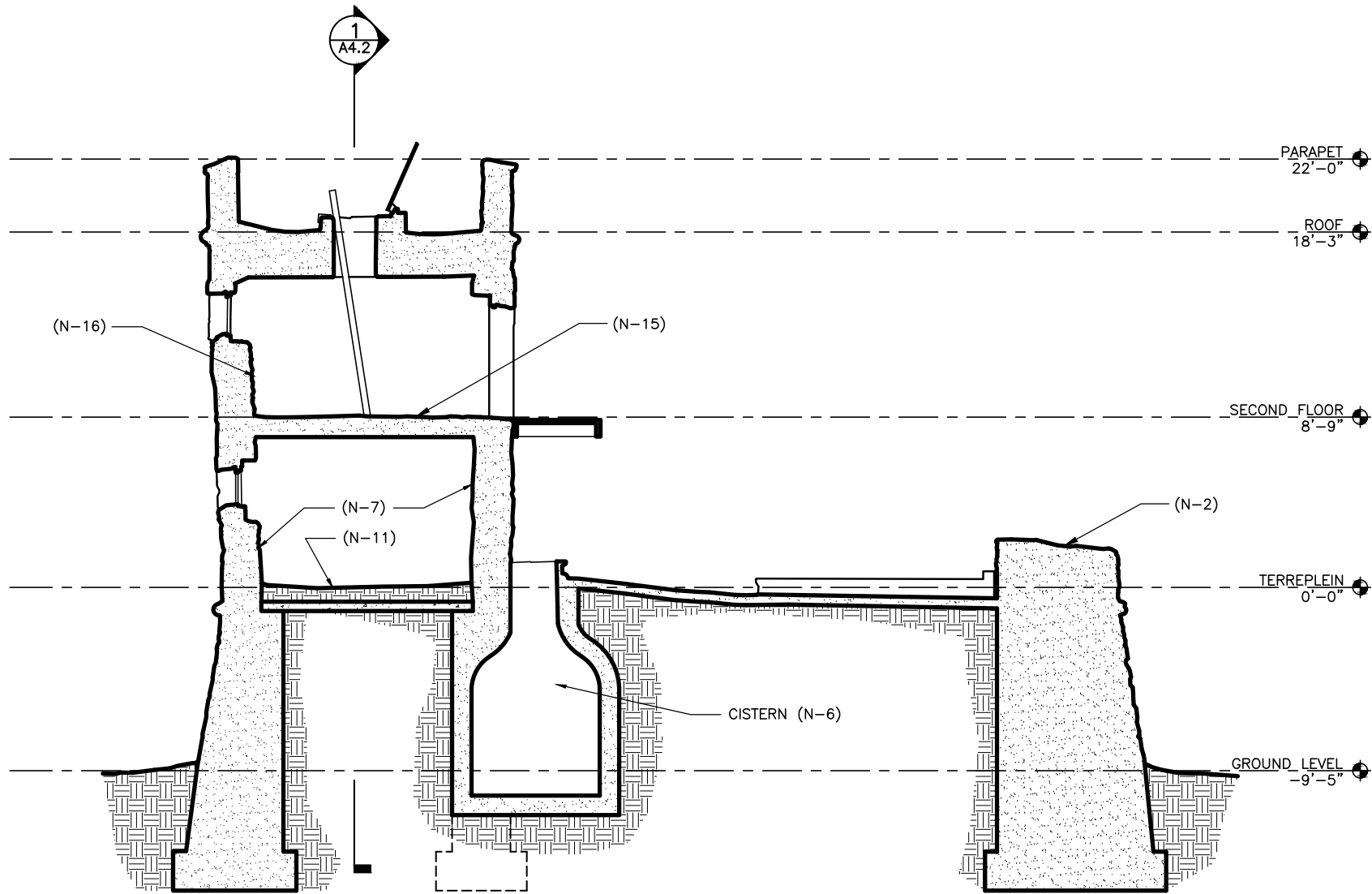
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- B. EXCEPT WHERE OTHERWISE INDICATED, STONEWORK SHOWN IN ELEVATION IS A GENERIC PATTERN MEANT TO REPRESENT THE GENERAL APPEARANCE OF THE COQUINA BLOCK WALLS

SCALE (A) 4 0 4 8
SCALE OF FEET

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1 FORT MATANZAS SECTION
A4.1 SCALE (A)

- SHEET-SPECIFIC KEYED NOTES:**
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 - N-6: CISTERN REPAIRS (REF. REPORT SECTION B2, PARA. D).
 - N-7: FIRST FLOOR ROOM MASONRY REPAIRS AND RESTORATION (REF. REPORT SECTION C2, PARAS. A, B, D, AND E).
 - N-11: FLOOR RESTORATION (REF. REPORT SECTION C2, PARA. H).
 - N-15: SECOND FLOOR TOPPING REPLACEMENT (REF. REPORT SECTION E2, PARA. A).
 - N-16: SECOND FLOOR ROOM MASONRY REPAIRS AND RESTORATION (REF. REPORT SECTION E2, PARAS. B, C, AND D).

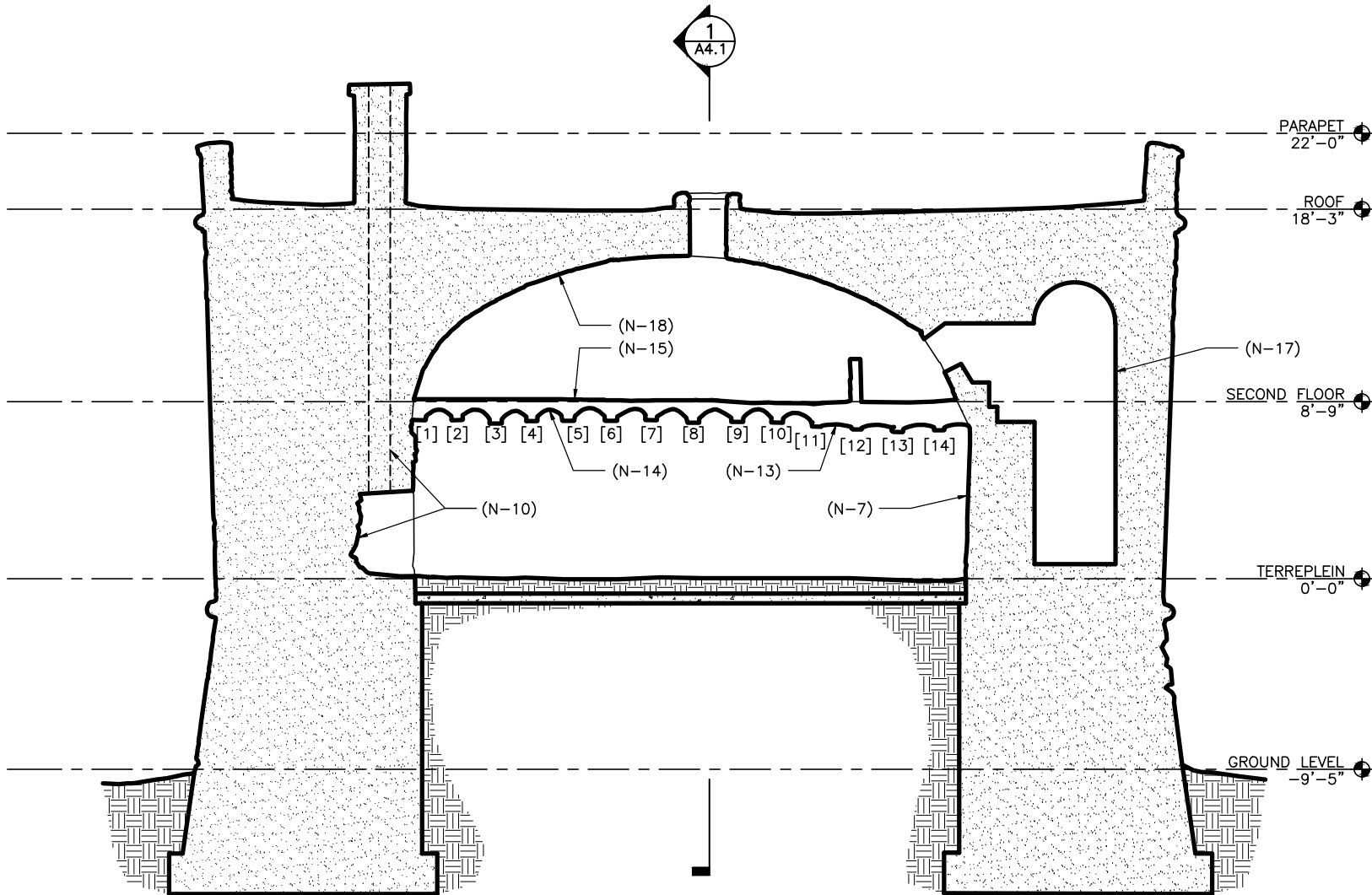
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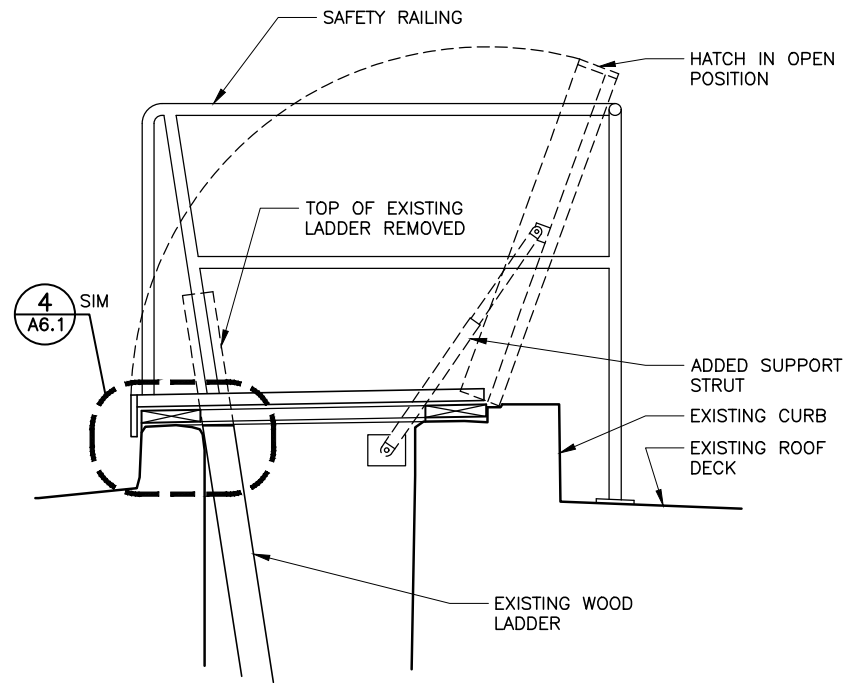
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A4.2 FORT MATANZAS SECTION
SCALE (A)

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N-10: CHIMNEY AND FIREBOX REPAIRS (REF. REPORT SECTION C2, PARA. G).
N-13: REPAIR CEILING VAULT TABBY DELAMINATION.
N-14: INSTALL CEILING CRACK MONITORS (REF. REPORT SECTION D3, PARA. E).
N-15: SECOND FLOOR TOPPING REPLACEMENT (REF. REPORT SECTION E2, PARA. A).
N-17: POWDER MAGAZINE REPAIRS (REF. REPORT SECTION E2, PARA. F).
N-18: INSTALL CRACK MONITORS (REF. REPORT SECTION F2, PARA. A).
[XX]: JOIST NUMBER

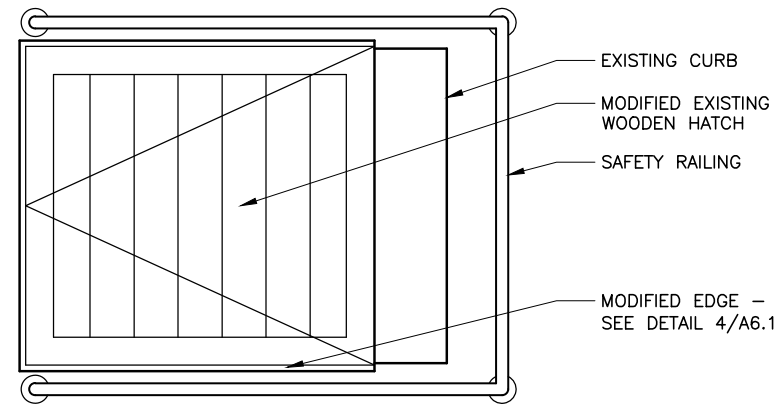
SCALE (A) 4 0 4 8
SCALE OF FEET

A/E FIRM PRIME: GWVO INC. BALTIMORE, MD STRUCTURAL: FAISANT ASSOC. BALTIMORE, MD	DESIGNED: BPF	SUB SHEET NO A4.2	TITLE OF SHEET EXISTING BUILDING SECTIONS EXISTING CONDITIONS FORT MATANZAS NATIONAL MONUMENT	DRAWING NO. XXX XXXXXX
	DATE: 10/21/16			PMIS/PKG NO. 00000000
	TECH. REVIEW: JRG			SHEET
				09 OF 10

10/21/2016 AUTOCAD 2016 P:\FOMA\000000\DRAWINGS\ARCH\A6.1 - FOMA DETAILS.dwg

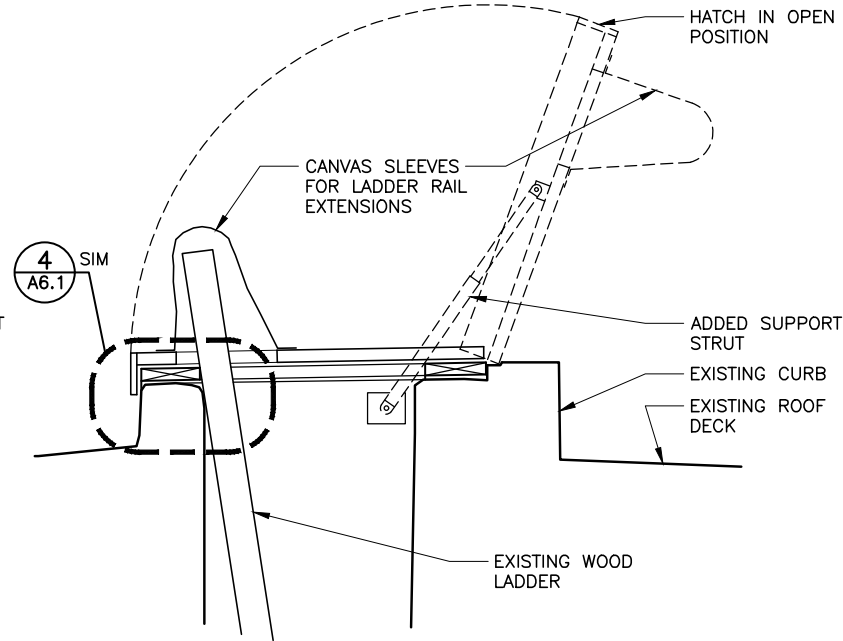


SECTION VIEW - MODIFIED LADDER

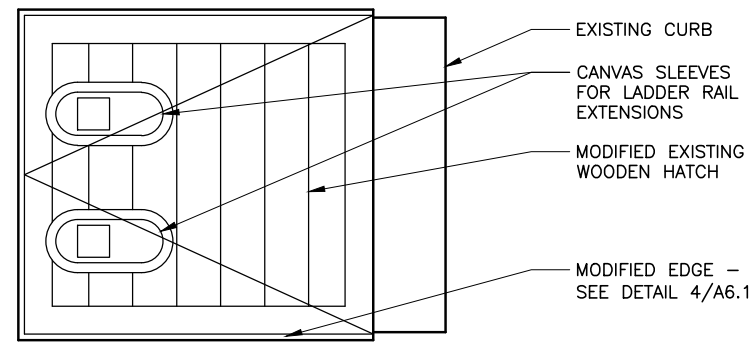


PLAN VIEW - MODIFIED LADDER

1
A6.1
PROPOSED DETAIL - ROOF HATCH OPTION
SCALE (A)

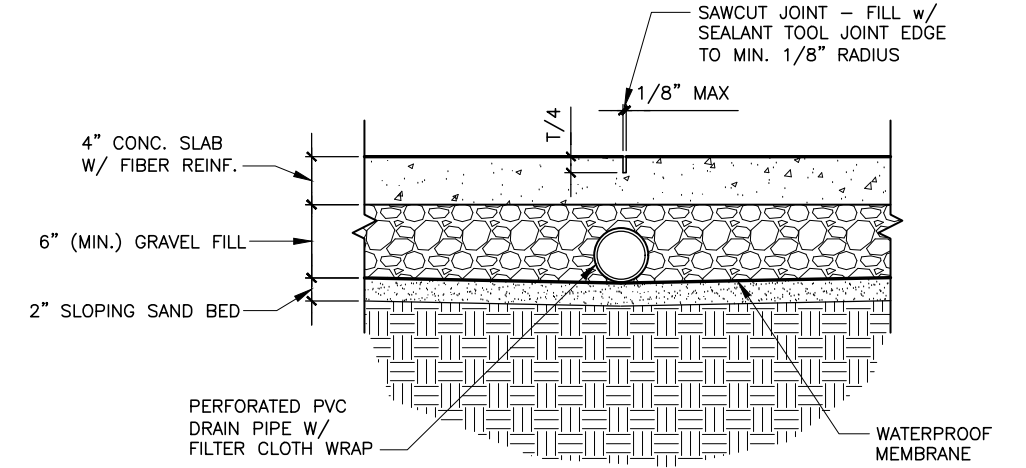


SECTION VIEW - LADDER SLEEVES

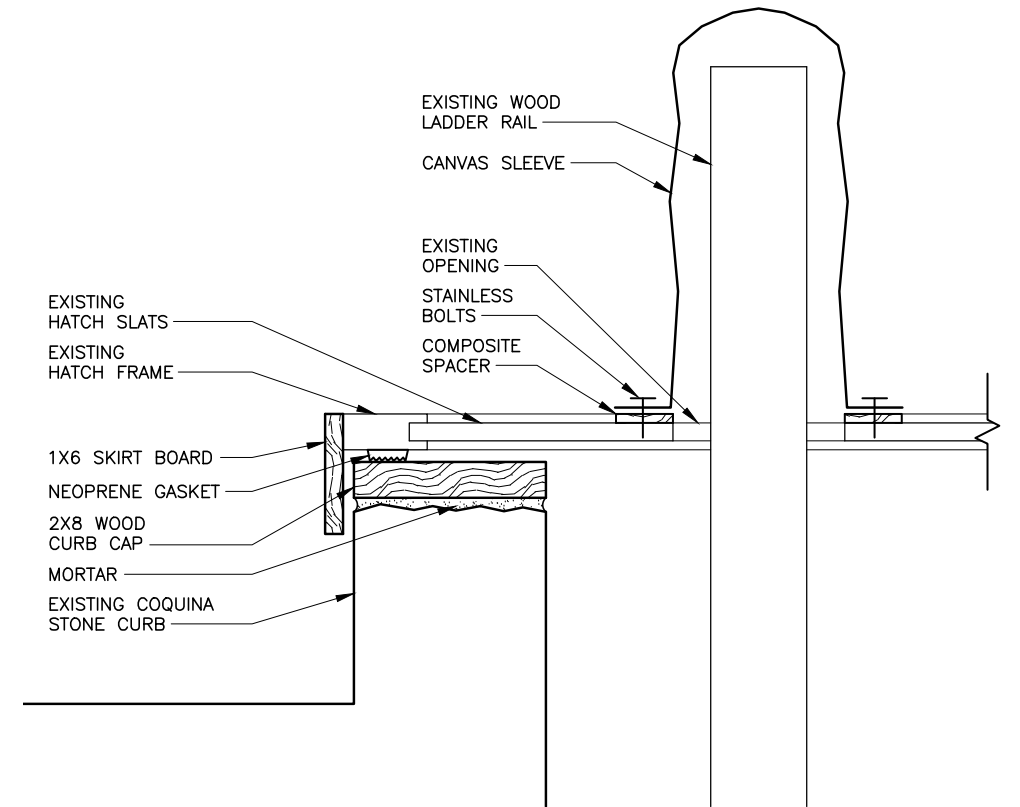


PLAN VIEW - LADDER SLEEVES

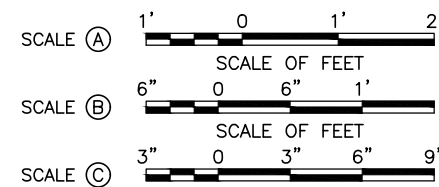
2
A6.1
PROPOSED DETAIL - ROOF HATCH OPTION
SCALE (A)



3
A6.1
PROPOSED DETAIL - TERREPLEIN DECK
SCALE (B)



4
A6.1
PROPOSED DETAIL - ROOF HATCH EDGE
SCALE (C)



A/E FIRM PRIME: GWVO INC. BALTIMORE, MD STRUCTURAL: FAISANT ASSOC. BALTIMORE, MD	DESIGNED: BPF GABD BPF TECH. REVIEW: JRG DATE: 10/21/16	SUB SHEET NO A6.1	TITLE OF SHEET PROPOSED DETAILS EXISTING CONDITIONS FORT MATANZAS NATIONAL MONUMENT	DRAWING NO. XXX XXXXXX PMIS/PKG NO. 00000000 SHEET 10 of 10
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