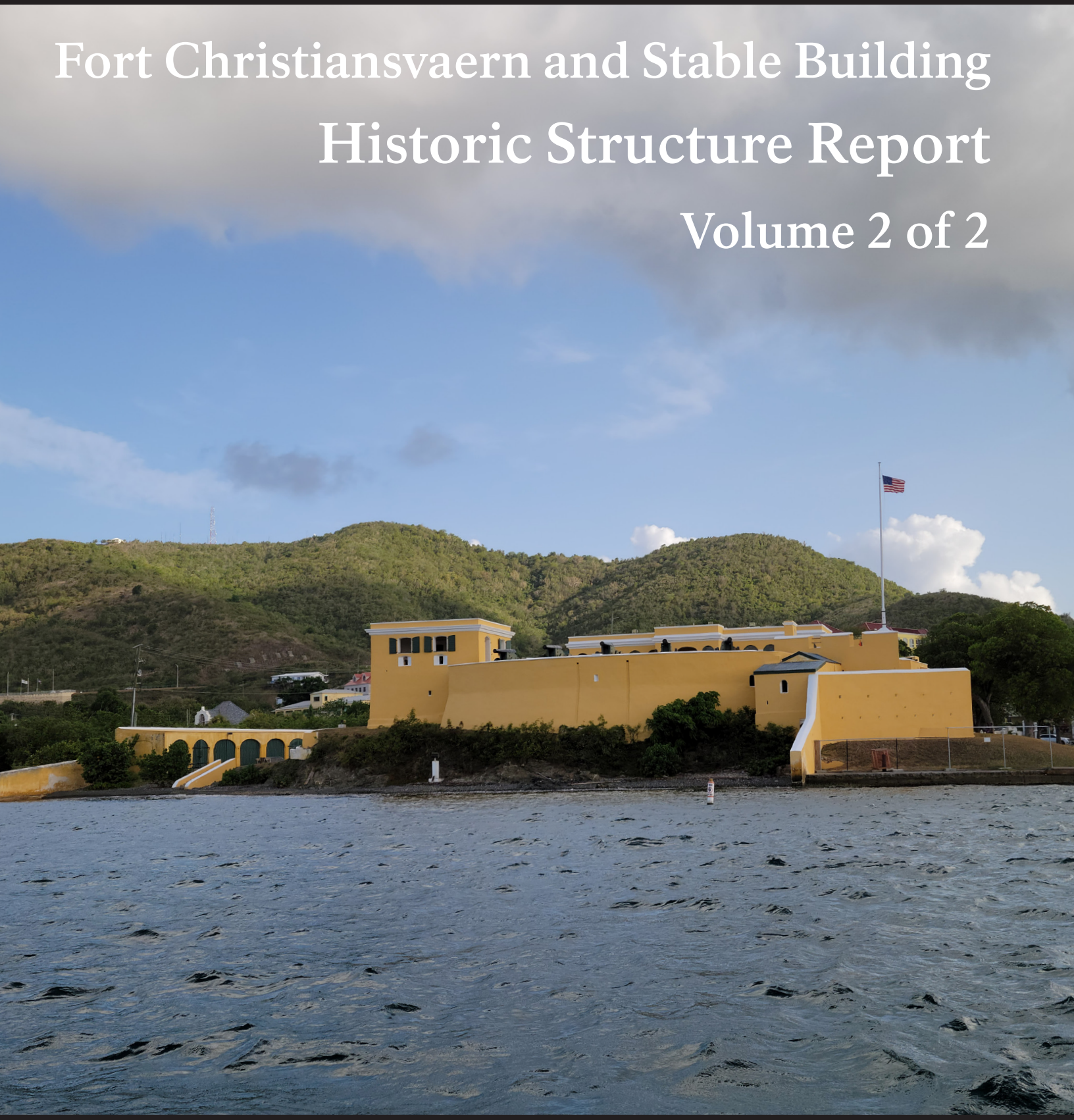
National Park Service
U.S. Department of the Interior

Christiansted National Historic Site
Christiansted, VI

Fort Christiansvaern and Stable Building Historic Structure Report

Volume 2 of 2



Cultural Resources Partnerships and Science Division

Interior Region 2

Fort Christiansvaern and Stable Building

Christiansted National Historic Site

Historic Structure Report

Volume 2 of 2

2023

for

Christiansted National Historic Site
Interior Region 2: South Atlantic-Gulf, National Park Service

by

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Interior Region 2: South Atlantic-Gulf
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The historic structure report presented here exists in two formats. A traditional, printed version is available for study at the park, at the Interior Region 2: South Atlantic-Gulf office of the National Park Service (NPS), and at a variety of other repositories. For more widespread access, the historic structure report also exists in digital format through the IRMA Portal, Integrated Resource Management Applications, including the NPS Data Store, accessed at <https://irma.nps.gov/App/Reference/Welcome>, a website of the National Park Service.

September 2023
Historic Structure Report
Fort Christiansvaern and Stable Building
Christiansted National Historic Site
(CHRI)

CRIS Number:
Fort: 00188
Stable: 091554

Cover Photo: JKOA, July 2021

Christiansted National Historic Site

Historic Structures Report

Fort Christiansvaern and Stable Building and Associated Stableyard, Gate and Walls

Christiansted, St. Croix, U. S. Virgin Islands

Approved:

ANGELITA ALVINO Digitally signed by ANGELITA ALVINO Date: 2023.10.12 09:54:36 -04'00'

Superintendent, Christiansted National Historic Site **Date**

Recommended:

JULIE ERNSTEIN Digitally signed by JULIE ERNSTEIN Date: 2024.03.28 08:21:36 -04'00'

Chief, Cultural Resources, Partnerships, and Science **Date**
Interior Region 2, South Atlantic Gulf

Recommended:

KAREN CUCURULLO Digitally signed by KAREN CUCURULLO Date: 2024.09.17 13:54:48 -04'00'

Deputy Regional Director **Date**
Interior Region 2, South Atlantic Gulf

Approved:

MARK FOUST Digitally signed by MARK FOUST Date: 2024.09.19 08:23:56 -04'00'

Regional Director, Interior Region 2, South Atlantic Gulf **Date**

Regional Director, Interior Region 2, National Park Service Date

Foreword

We are pleased to make available this Historic Structures Report for Fort Christiansvaern and its associated Stable Building at Christiansted National Historic Site, part of the ongoing effort to provide comprehensive documentation for the historic structures of the National Park Service. The success of this project is due in large part to the staff of the Christiansted National Historic Site. The park has long sought to protect and interpret this important resource. Evan Gwilliam, the Park's Supervisory Resource Management Specialist, as well as staff from the park and the region have assisted in providing support for this project.

We would like to thank Project Lead Joseph K. Oppermann, FAIA, Preservation Architect Robert J. Hotes, Architectural Historian Langdon E. Oppermann, Architectural Staff Christopher Woolard and Jeffrey P. Anderson, of Joseph K. Oppermann - Architect, P.A., Structural Engineer John Matteo of MCC 1200 Architectural Engineers, PLLC, and Architectural Conservator Dorothy Krotzer of Building Conservation Associates for their thorough research, rigorous existing conditions documentation, and carefully considered recommendations. The Park would also like to thank Interior Region 2 for their careful reviews and contributions on this project.

Angelita Alvino
Superintendent

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Volume 2

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Materials Analyses Report by BCA

Project Team

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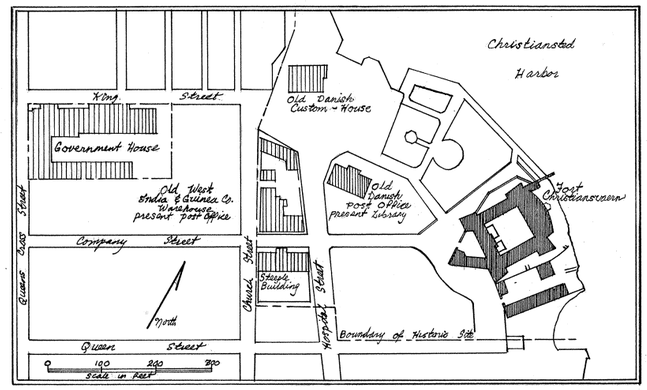
National Park Service – Christiansted National Historic Site

Angelita Alvino, Park Superintendent
Evan Gwilliam, Supervisory Resource Management Specialist

Appendix A:
1959 HABS Documentation Drawings

FORT CHRISTIANSVAERN

CHRISTIANSTED NATIONAL HISTORIC SITE – CHRISTIANSTED, ST. CROIX, U. S. VIRGIN ISLANDS

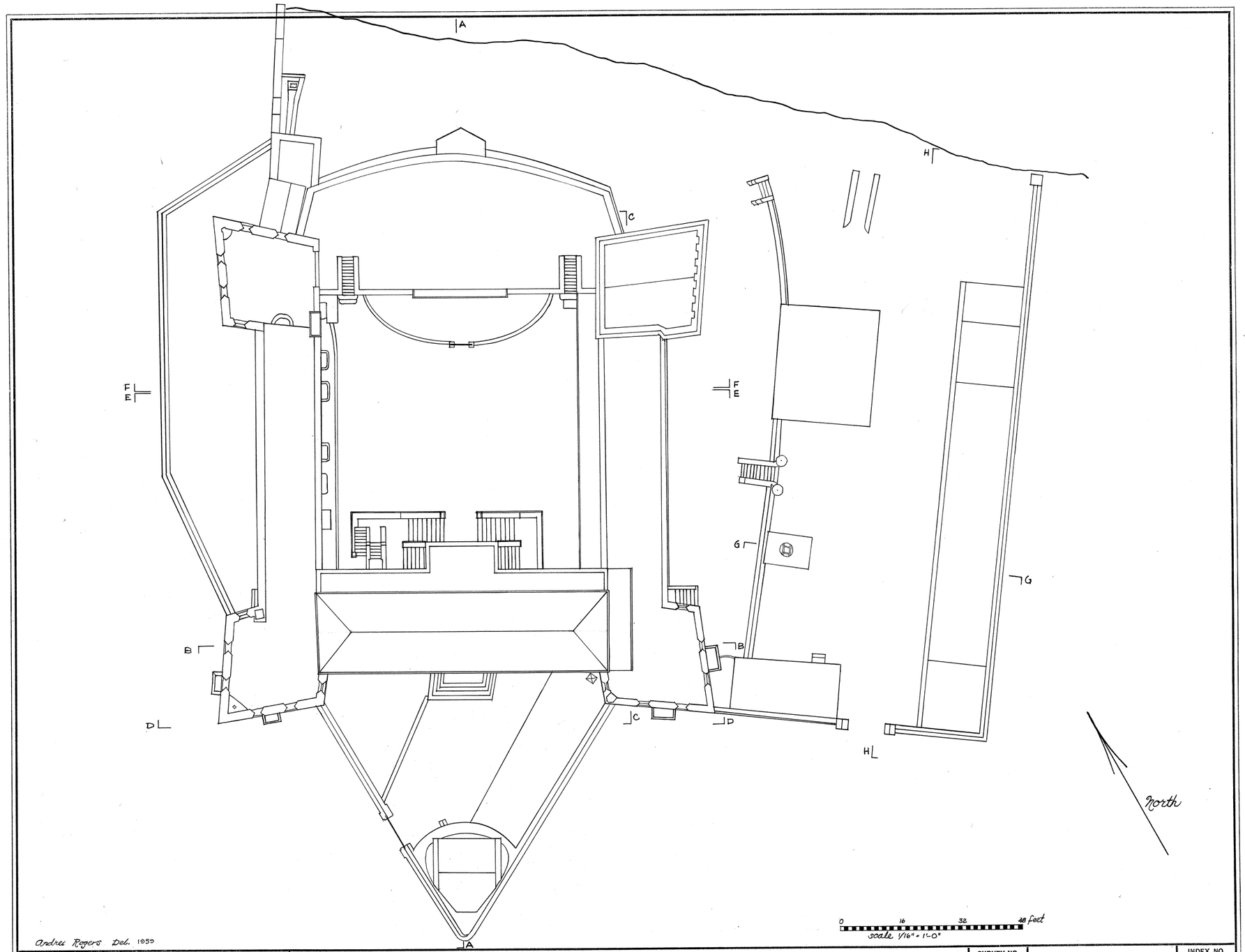


A SMALL SEVENTEENTH CENTURY SQUARE CITADEL, WITH FOUR BASTIONS AT THE SALIENT ANGLES, A RAVELIN, A SALLYPORT, A DUNGEON AND CELLS, AND A HORSE YARD WITH STABLES. THE FORT MEASURES 210 BY 220 FEET. BEGUN IN 1738 ON AN OLDER FORT SITE, IT IS A BRICK MASONRY STRUCTURE. THE BASTIONS AND NORTH WING ARE VAULTED SUPPORTING GUNDECKS. THE REMAINING MASONRY ROOFS ARE BRICK CARRIED ON TIMBER. DECORATIONS ARE FORMED IN BRICK AND STUCCOED.

THIS PROJECT WAS FINANCED FROM FUNDS OF THE "MISSION 66" PROGRAM OF THE NATIONAL PARK SERVICE. MEASURED AND DRAWN UNDER THE DIRECTION OF CHARLES E. PETERSON, SUPERVISING ARCHITECT, HISTORIC STRUCTURES AND FREDERIK GJESSING, ARCHITECT. JUNE – SEPTEMBER, 1957 BY STUDENT ARCHITECTS F. HANSON (SYRACUSE) AND NEIL PENRY (UNIV. OF CALIF.). JUNE – SEPTEMBER, 1959 BY ARCHITECT J. M. EVERETT, STUDENT ARCHITECTS A. ROGERS (UNIV. OF CALIF.) AND F. MACOIGE (UNIV. OF PENN.).

J. M. Everett Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 1 OF 26 SHEETS	INDEX NO.



Andrei Rogers Del. 1959

U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
BRANCH OF PLANS AND DESIGN

NAME OF STRUCTURE
Fort Christiansvaern
Christiansted, St. Croix, U. S. V. I.

SURVEY NO.
VI-5

HISTORIC AMERICAN BUILDINGS SURVEY
SHEET 2 OF 26 SHEETS

INDEX NO.

Neil Perry & J.M. Everett Del. 1959

feet 1 0 8 16 24 feet

Scale: 1/8" = 10'

First Floor

Guard House

Wood floor

Brick paved

Concrete walk

Planted Area

Mango

Key to Sheet 3

Key to Sheets 1 & 6

Key to Sheet 1 & 6

Wood floor

Wood floors

Cistern

Brick paved

Wood floors

Wood floor

Wood floor

Brick & Stone block paved

Trap door to Dungeon

Concrete floor

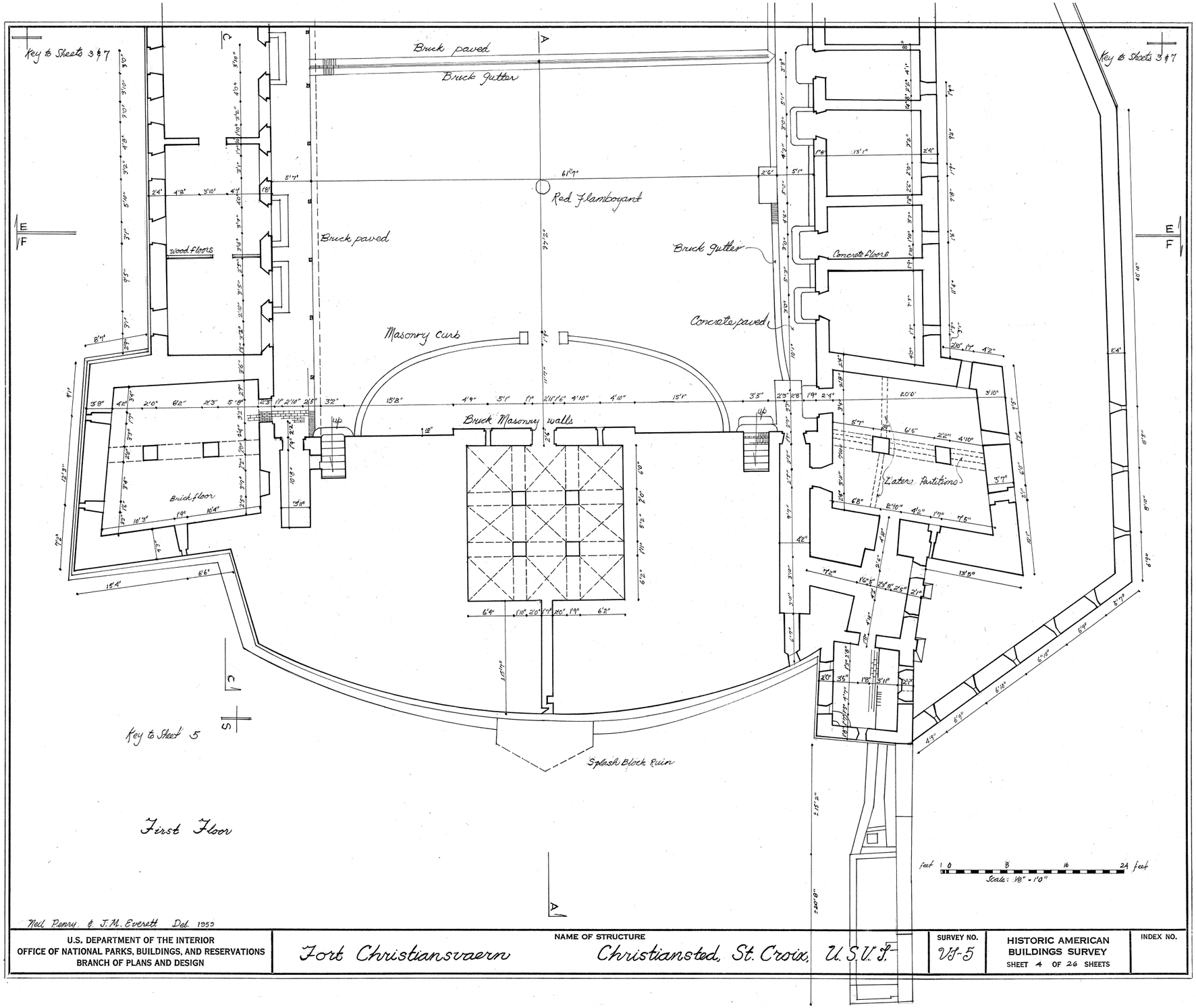
Kitchen

Cistern 8'6"x30" ops.

Concrete floor

Dungeon

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 3 OF 26 SHEETS	INDEX NO.



Neil Penny & J.M. Everett Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 4 OF 26 SHEETS	INDEX NO.

Key to Sheets 4 & 7

Planted Area

Key to Sheets 3 & 6

Wood floors

Wood frame

Recent Wood Frame Garage

Wood Horse Stalls

Brick Gutter

Brick Arches & Piers

Sheet Metal Roof

Brick Roof

Brick Paved

Brick Masonry Walls

Horse Yard

Modern Latrine not shown

Scale 1/8" = 1'0"

Neil Perry & J.M. Everett Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 5 OF 26 SHEETS	INDEX NO.

Fred Hansen, Neil. Perry & J.M. Everett Del. 1959

feet 1 0 8 16 24 feet

Scale: 1/8" = 10"

Second Floor

Splash Block

Corrugated Metal Roof

Brick & Masonry Walls

Iron Spikes

Key to Sheet 5

Corrugated Metal Roof

Brick Steps

Wood Tray Ceiling

Wood Floors

Concrete Floor

Brick Paved Deck

Brick Steps

Down

Brick Paved Deck

Corrugated Metal Roof

Down

Brick Steps

Down

9"x9" Tile

5'9"x9" Stone Tile Floor

Iron Spikes

Key to Sheets 3 & 7

Key to Sheets 3 & 7

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 6 OF 26 SHEETS	INDEX NO.

Key to Sheets 4 & 6

Key to Sheets 4 & 6

Brick Paved Deck

Corrugated Metal Roof

Iron Grill Above Gate

Concrete Floor

Brick Paved Deck

Brick Paved Deck

Corrugated Metal Roof

Key to Sheet 5

Ruins of Former Cabins With Roof Caved in.

Second Floor

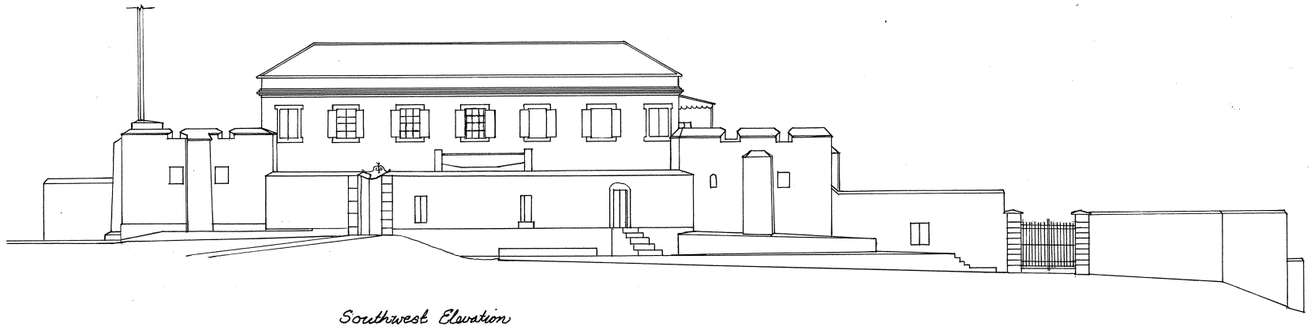
feet 1.0 8 16 24 feet

Scale: 1/8" = 1'0"

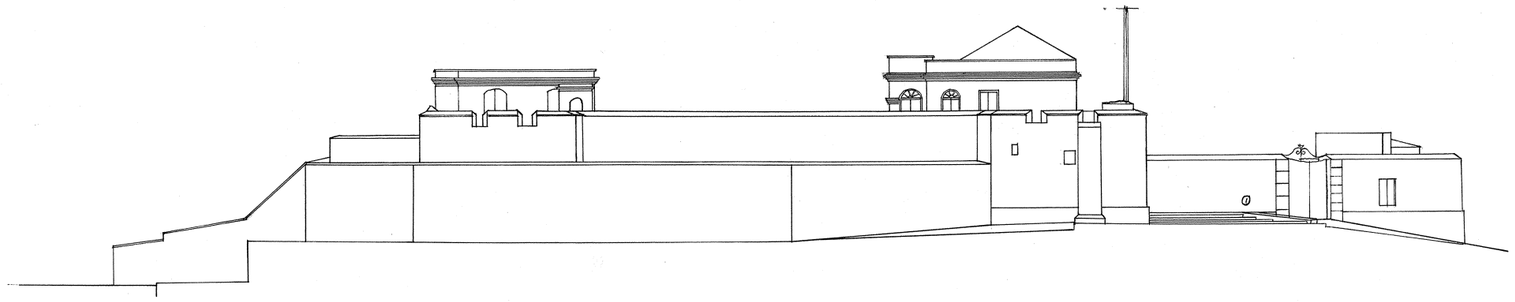
Neil Parry Del. 1957

Recent Construction

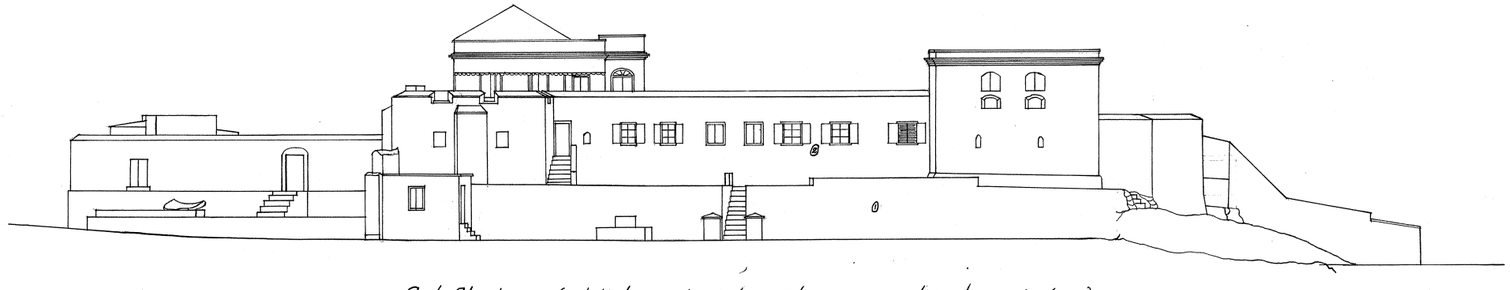
U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 7 OF 26 SHEETS	INDEX NO.



Southwest Elevation



West Elevation (@ modern balustrade and honor roll not shown)



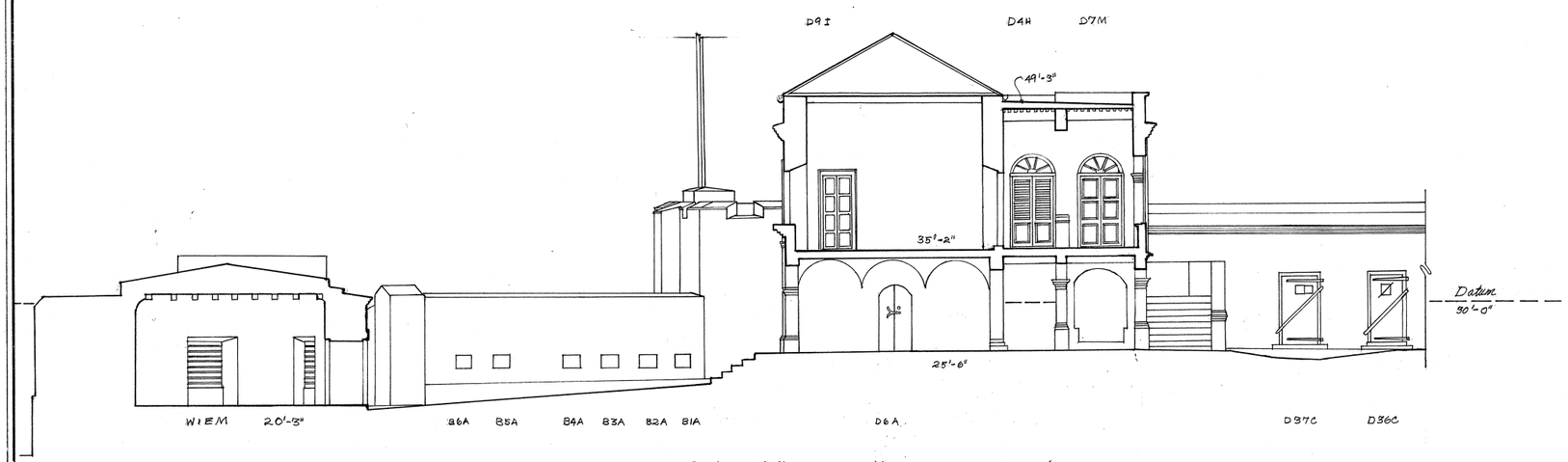
East Elevation (@ shed in horse yard not shown. @ bars on casement windows not shown)

0 8 16 32 48 feet

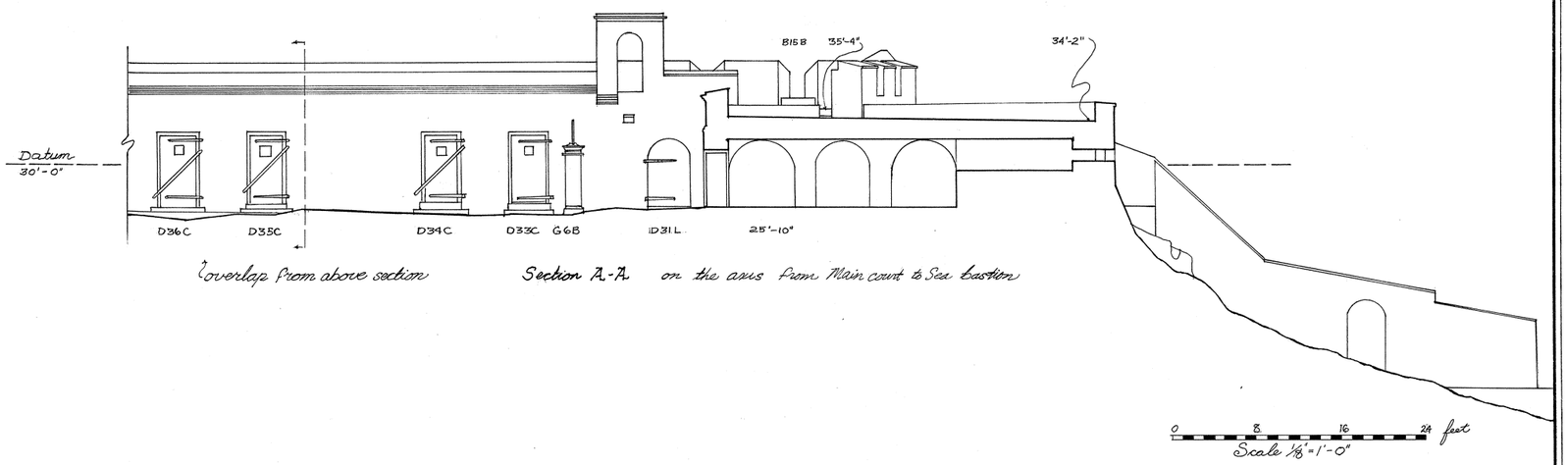
scale 1/16" = 1'-0"

Andrei Rogers & J. M. Everett Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 8 OF 26 SHEETS	INDEX NO.



Section A-A on the axis from Guardhouse to Main court

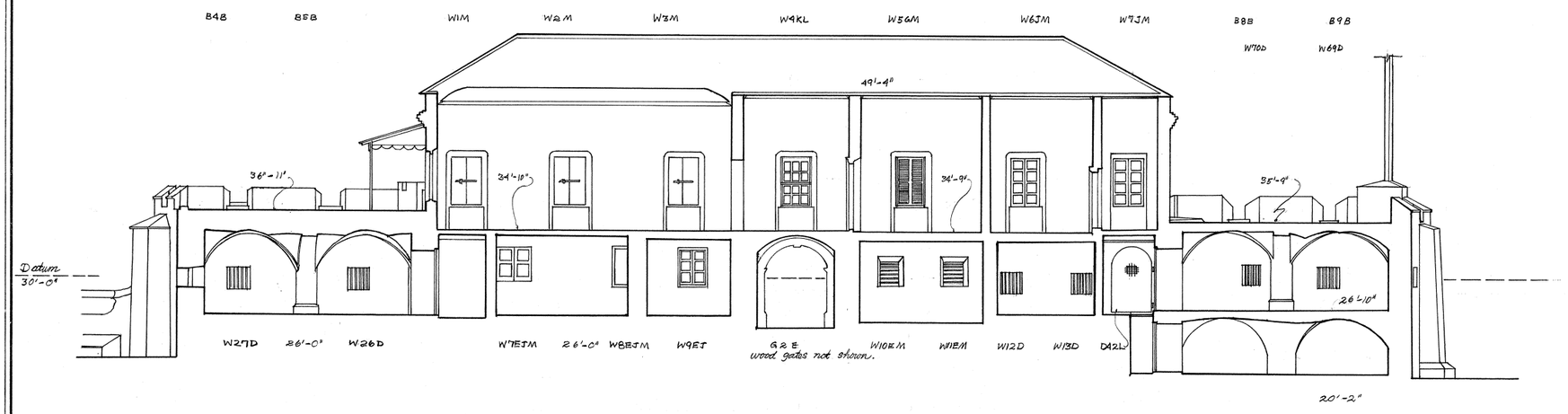


Overlap from above section

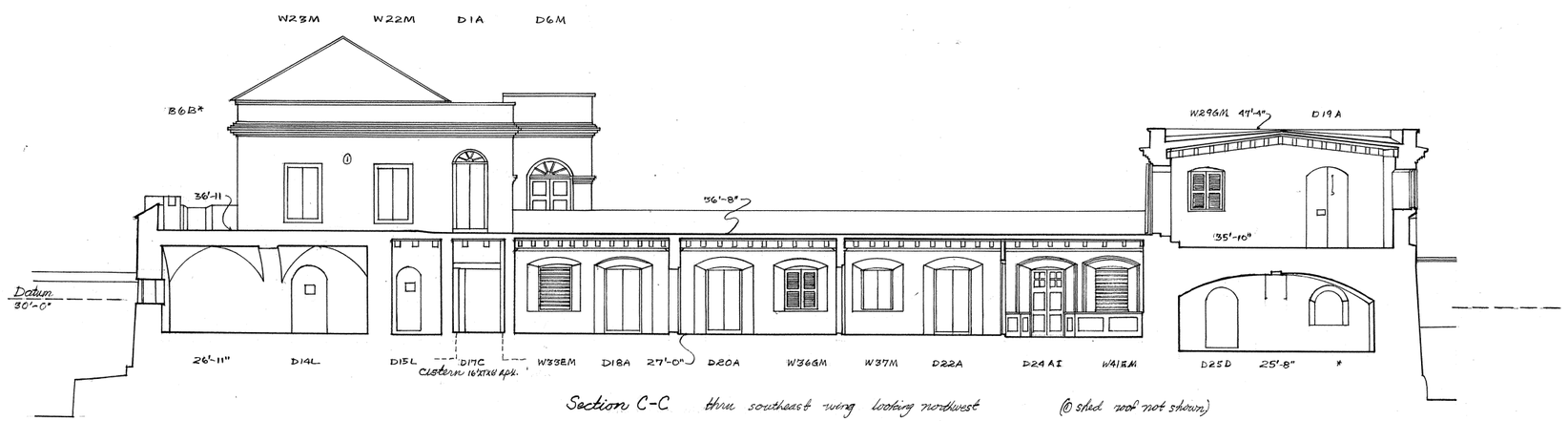
Section A-A on the axis from Main court to Sea bastion

Andrei Rogers Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 9 OF 26 SHEETS	INDEX NO.



Section B-B thru southwest wing looking southwest

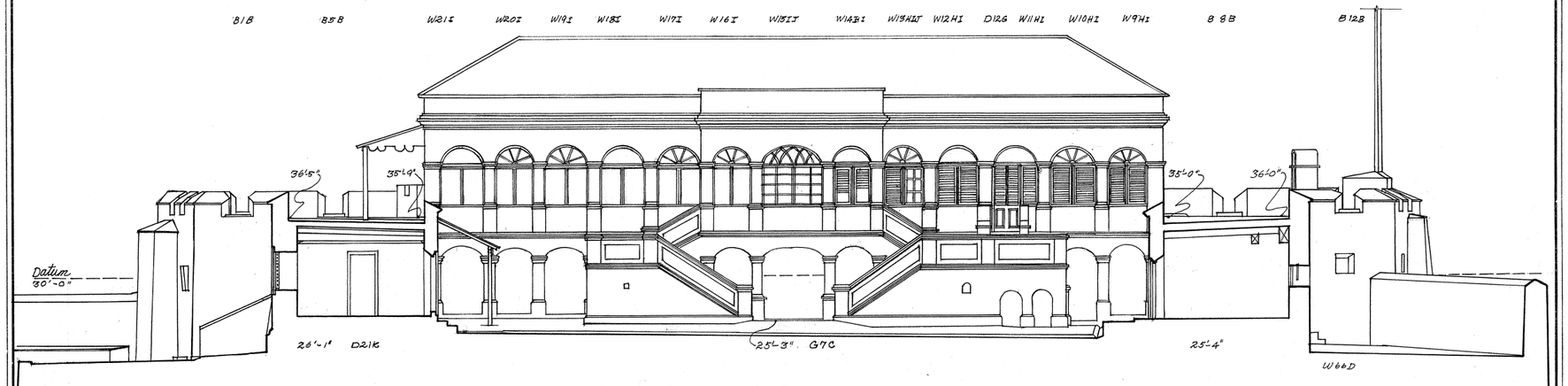


Section C-C thru southeast wing looking northwest (* shed roof not shown)

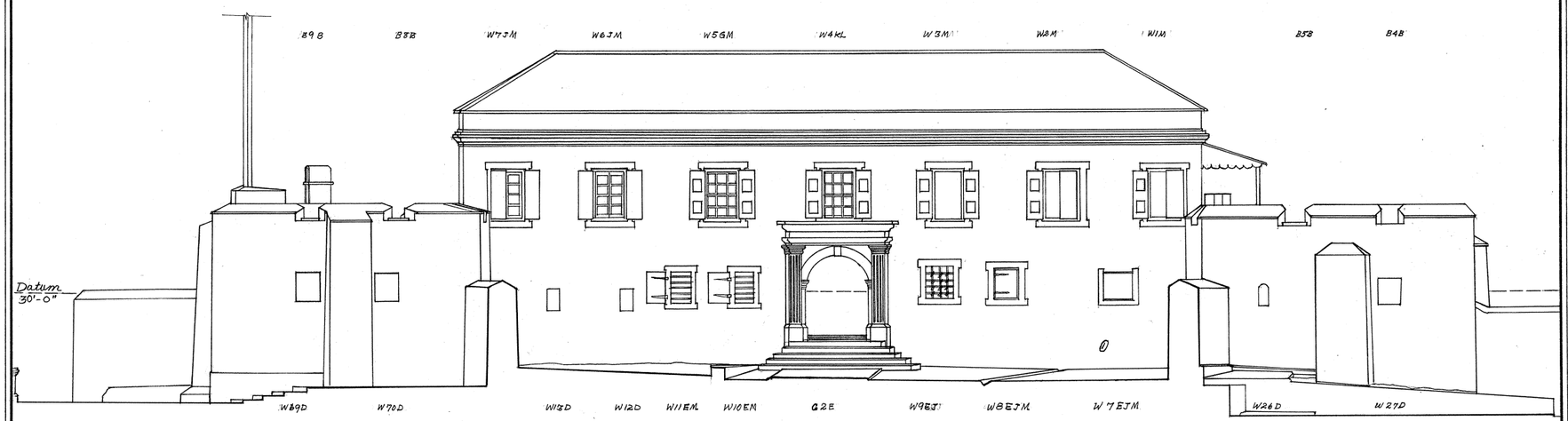
0 8 16 24 feet
Scale 1/8"-1'-0"

J.M. Everett Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 10 OF 26 SHEETS	INDEX NO.



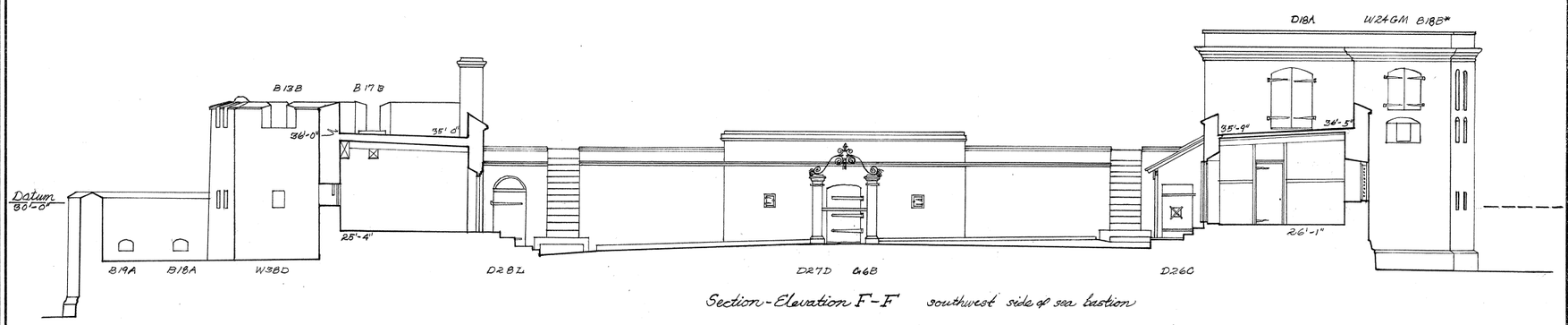
Section - Elevation E - E northeast side of southwest wing



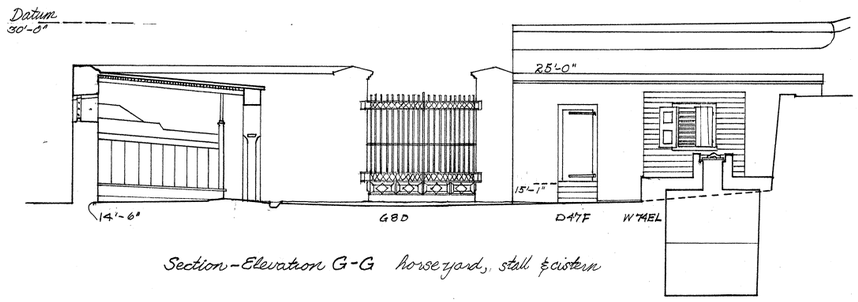
Section - Elevation D-D southwest side of southwest wing. (0 tool shed not shown)

J.M. Everett. Del. 1959

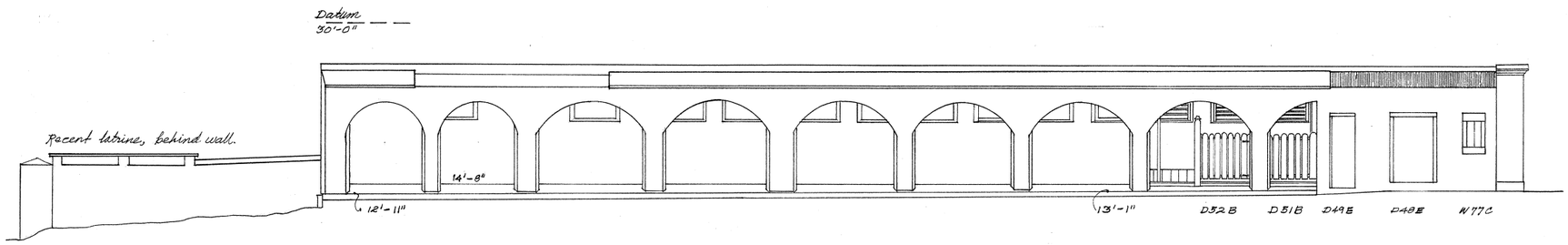
U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 11 OF 26 SHEETS	INDEX NO.



Section-Elevation F-F southwest side of sea bastion



Section-Elevation G-G horseyard, stall & cistern

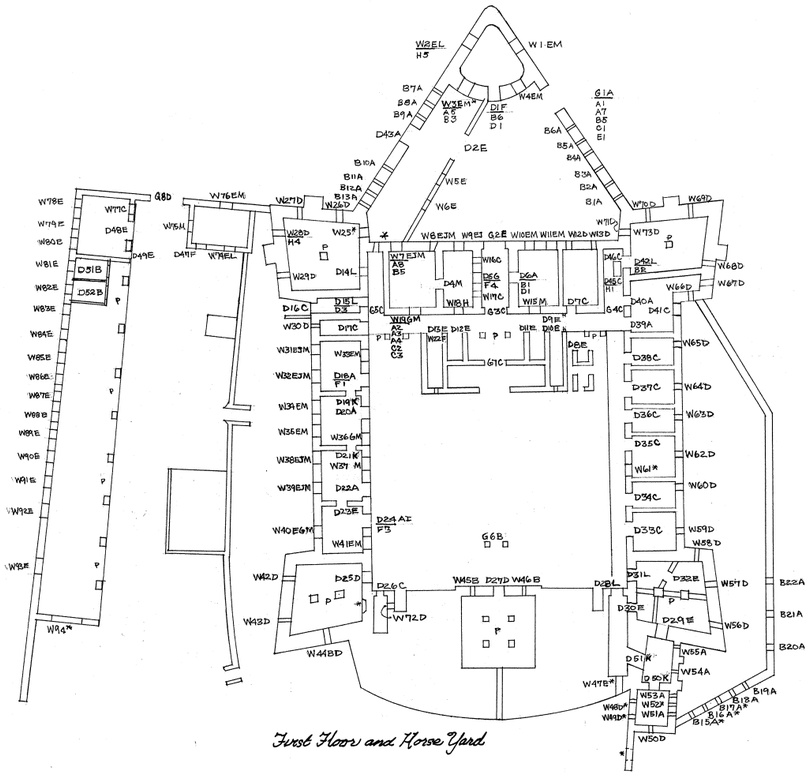


Elevation H-H stables, latrine & stalls

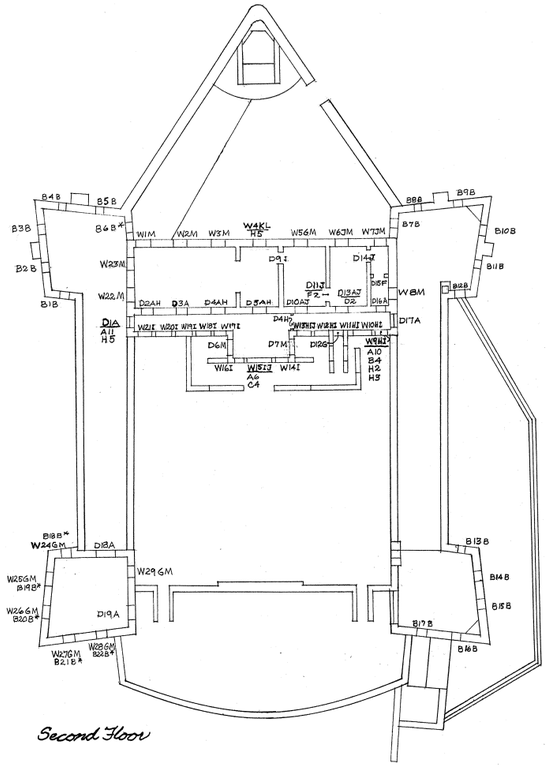
0 8 16 24
Scale 1/8"-1'-0"

J.M. Everett Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted St Croix U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 12 OF 26 SHEETS	INDEX NO.



First Floor and Horse Yard



Second Floor

In coding the various openings the following scheme has been used: -1- Doors are denoted by "D", Windows by "W", Gates by "G", Battlements by "B" and Piers by "P". -2- Each Door, Window etc. has its own location Number. -3- Doors, Windows etc are classified by type indicated by Letter and explained below. These three designations form the Call Number. Example: D2AI explained means: "D" = Door; "2A" = location Number; "A" & "I" = door Types.

Doors - D
- A Two wing shutter door. Two layers of wood boards laid in opposing directions.
- B Stable, wood shell. Vertical boards rounded at the top. (See Sheet 12)
- C Two layer heavy wood door. Call doors have a small square opening with bars or don.
- D Metal covered, two layer heavy wood door with round top.
- E Simple, cross-braced wood door or shutters.
- F Two layer door with panelling on one side.
- G Wood door with panelling both sides and jalousies in the upper half.
- H Double doors, one panel both sides and four glazed lights each wing.
- I Double doors, four panels both sides each wing.
- J Double doors, one panel both sides and jalousies each wing.
- K Opening with no frame or with door removed.
- L Two layer heavy wood door, round top, usually with square opening, barred or plated.
- M Double doors, three panels on one side each wing.

Gates, Battlements and Piers
Gates - G
- A Main Gateway with applied piers and wood doors. (see sheets 14 & 15)
- B Free standing masonry piers for an iron gateway.
- C Masonry archway with quoins. (see sheet 22.)
- D Gateway with applied piers and iron grill gates.
- E Masonry archway with applied piers and wood grill gates. (see sheet 17)

Battlements - B
- A Enclosed defensive openings.
- B Embrasures on the salient bastions.

Piers - P
- P All piers carry masonry vaults or arches.

Notes - Not all original openings have here been noted.
- * Openings partially blocked up.

Windows - W
- A Narrow open slit. No framing or hardware.
- B Opening with small hinged metal cover.
- C Opening with wood door and frame.
- D Small opening with bars. Usually vertical.
- E Large opening with bars. Wood frame.
- F Small window with fixed wood louvers and frame.
- G Jalousie with sliding bar in center. Two wings to an opening.
- H Jalousie without sliding bar. Heavier construction. Two wings to an opening.
- I Glazed fan-light.
- J Glazed casement. Two wings to an opening, varying lights each.
- K Glazed double hung sash. Six over six lights.
- L Shutters, two panels on one side each wing.
- M Shutters, two layers of wood boards laid in opposing directions.

Hardware is broken down into: -1- Categories denoted by Letter. -2- Variations within the category denoted by Number. These two designations form the Hardware Call Number which is shown in the diagram above directly below the Call Number of the opening where the Hardware is found. Example: DIF / B6 explained means: "B" = Hasp category; "6" = variation within the category. "DIF" is the Call Number of the opening as explained in the above key.

Hinges - A - Wrought Iron
- A1 Strap hinges (G1A) Sheet 16
- A2 Shutter strap hinge (W19AM) Sheet 19
- A3 Shutter strap hinge (W19GM) Sheet 19
- A4 Shutter strap hinge (W19BM) Sheet 19
- A5 HL hinge (W3EMK) & (D5G) Sheets 24 & 25.
- A6 L hinge (W15IJ) Sheet 21
- A7 Ornamental strap hinge with scrolls (G1A) Sheet 16
- A8 Iron hinge bracket (W17E) Sheet 26
- A9 Strap hinge without spindle (G1A) Sheet 16
- A10 H hinge (W9HI) Sheet 21
- A11 Strap hinge (D1A) Sheet 26

Hasps - B - Wrought Iron
- B1 Forked hasp (D6A) Sheet 26
- B2 Hasp with button fastening (D42L) Sheet 26
- B3 Hasp of bent 1/4" wire (W3EM*) Sheet 24
- B4 Hasp, fits over spindle on jalousie (W9HI) Sheet 21
- B5 Strap hasp (D26G) Sheet 23
- B6 Hasp. (D1F) Sheet 26

Hooks - C - Wrought Iron
- C1 Storm hook, eyes and plates (G1A) Sheet 16
- C2 Exterior shutter hook (W19GM) Sheet 19
- C3 Interior shutter hook (W19GM) Sheet 19
- C4 Window hook (W15IJ) Sheet 21

Handles, Pulls - D
- D1 Iron ring sash pull (D6A) Sheet 26
- D2 Brass drop handle (D13AJ) Sheet 26
- D3 Iron handle (D6L) Sheet 26

Latches - E - Wrought Iron
- E1 Bolt catch and plate (G1A) Sheet 16

Locks - F
- F1 Wood box lock (D1BA) Sheet 26
- F2 Metal spring lock (D11L) Sheet 26
- F3 Brass knuckle (D24AI) Sheet 26
- F4 Metal box lock (D5G) Sheet 25

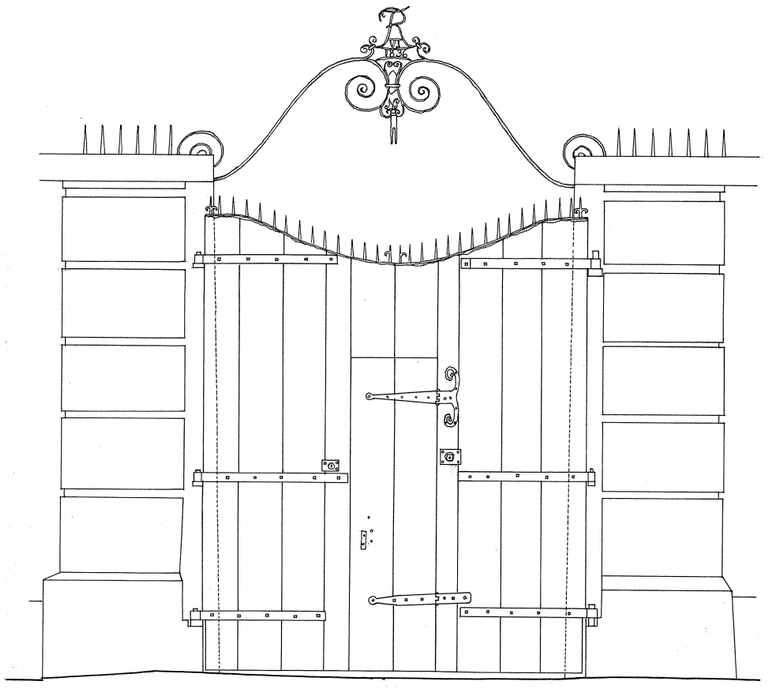
Miscellaneous - H
- H1 Iron grill (W45A) Sheet 26
- H2 Bracket for storm bar (W9HI) Sheet 21
- H3 Bracket for storm bar (W9HI) Sheet 21
- H4 Sheet metal window shield (W28D) Sheet 26
- H5 Iron shutter bar (D1A) Sheet 20

Compiled from data collected by F. Hansen, 1957

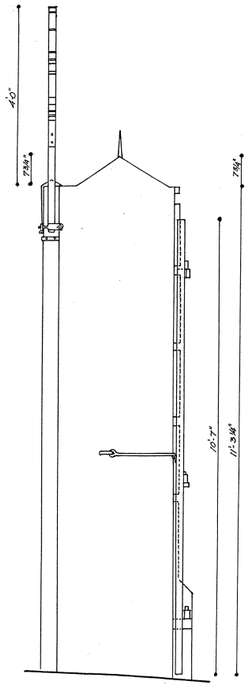
J.M. Everett Del. 1960

UNDER DIRECTION OF UNITED STATES DEPARTMENT OF THE INTERIOR NATIONAL PARK SERVICE, BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE: Fort Christiansvaern, Christiansted, St. Croix U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 13 OF 26 SHEETS	LIBRARY OF CONGRESS INDEX NUMBER

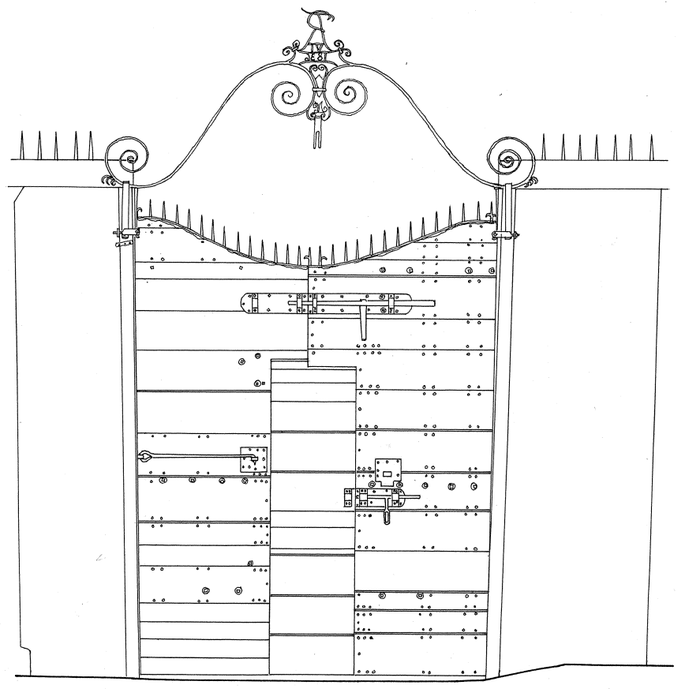
TRIM LINE



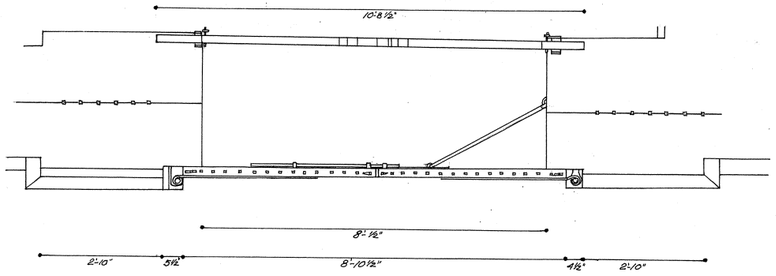
Exterior Elevation



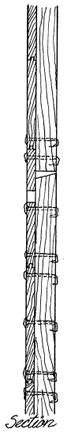
Section thru Gate



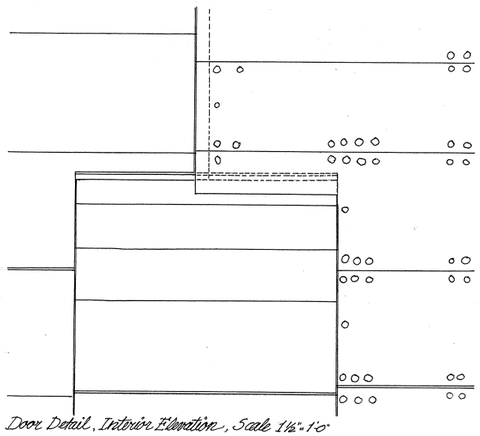
Elevation towards Ravelin Court



Plan Section



Section



Door Detail, Interior Elevation, Scale 1½"=1'-0"



Plan Section

Ravelin Gate, Type G-1A, Plan, Sections and Elevations

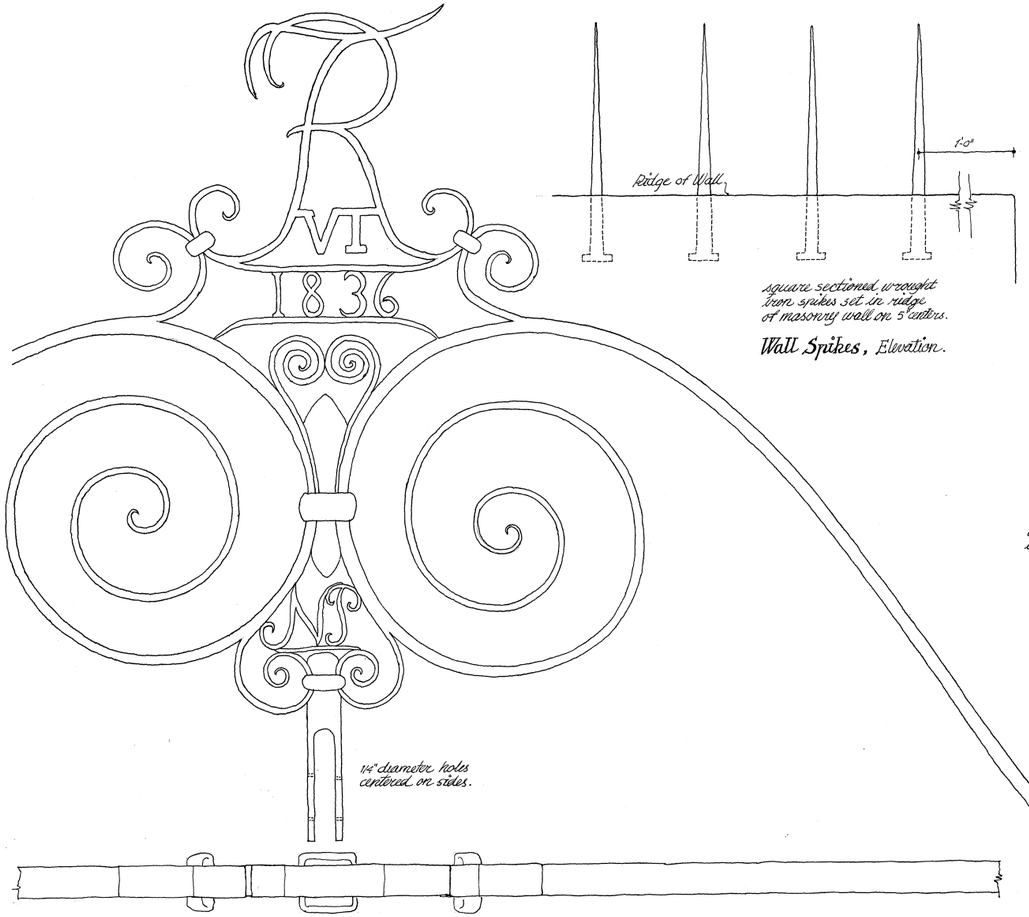
Scale ½"=1'-0" except where otherwise noted.

0 2 4 6 feet
Scale ½"=1'-0"

0 1 2 feet
Scale 1½"=1'-0"

E. Hanson & F.C. Gessner, Del. 1957

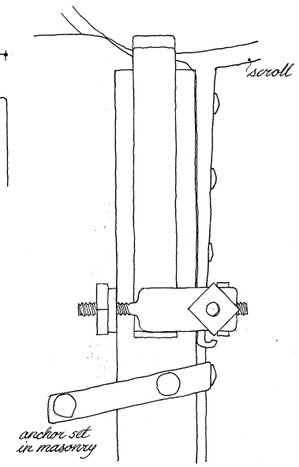
U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern, Christiansted, St. Croix, U.S. Virgin Islands.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 14 OF 26 SHEETS	INDEX NO.



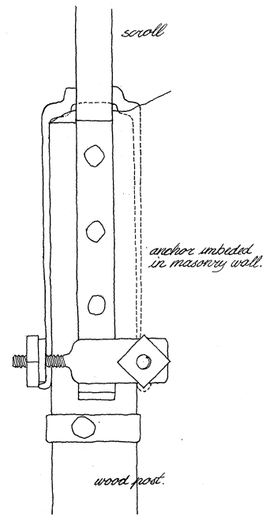
Plan View of Scroll.

square sectioned wrought iron spikes set in ridge of masonry wall on 5" centers.

Wall Spikes, Elevation.



Elevation towards Ravelin

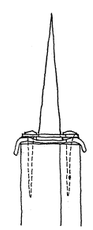


Elevation towards Gate

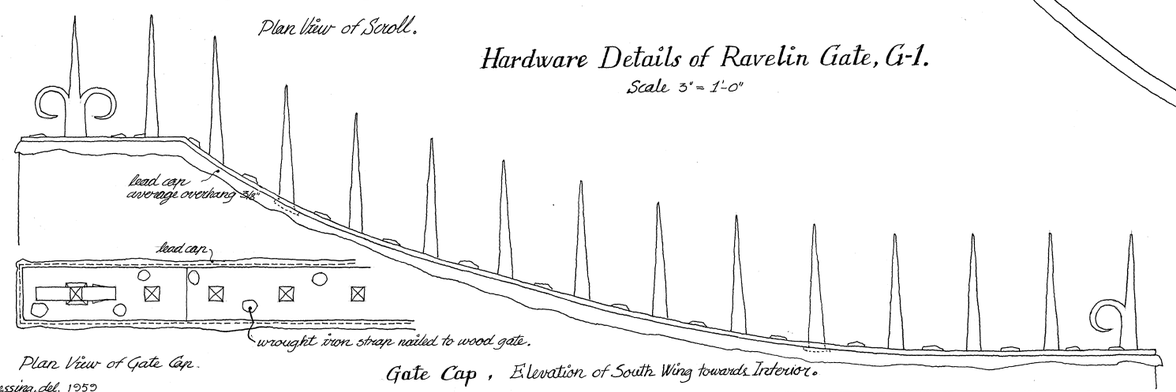
Detail of Scroll Attachment, Elevations.

Hardware Details of Ravelin Gate, G-1.

Scale 3" = 1'-0"



Side View of Gate



Plan View of Gate Cap.

Gate Cap, Elevation of South Wing towards Interior.

Elevation towards Exterior.

Wrought Iron Scroll

0 3 6 9 12 inches

Scale 3"-1'-0"

neil penny & f.c. gessing, del. 1959

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elevation

4'-0"

Sliding Surface Bolt E1 and Plates C1 on G1A scale 3"-1'0"

bolt side elevation

1'-1½"

4"

4⅜"

3"

elevation

8¼"

8¼"

6"

elevation

plan

C1 on G1A scale 3"-1'0"

section

Storm Hook C1 on G1A scale 3"-1'0"

3'-0⅜"

plan

7⅞"

elevation

6⅜"

C1 on G1A scale 3"-1'0"

elevation

section

8⅝"

4"

elevation

Ornamental Strap Hinge with Scrolls A7 on G1A scale 3"-1'0"

1'-9⅜"

elevation

plan

2'-1⅝"

3'-2⅞"

5¼"

elevation

Strap Hinges A1 on G1A scale 3"=1'-0"

plan

3'-7⅛"

3⅜"

elevation

Strap Hinge A9 on G1A scale 3'-1'0"

3"

2'-6½"

elevation

plan

plan

0 1 feet

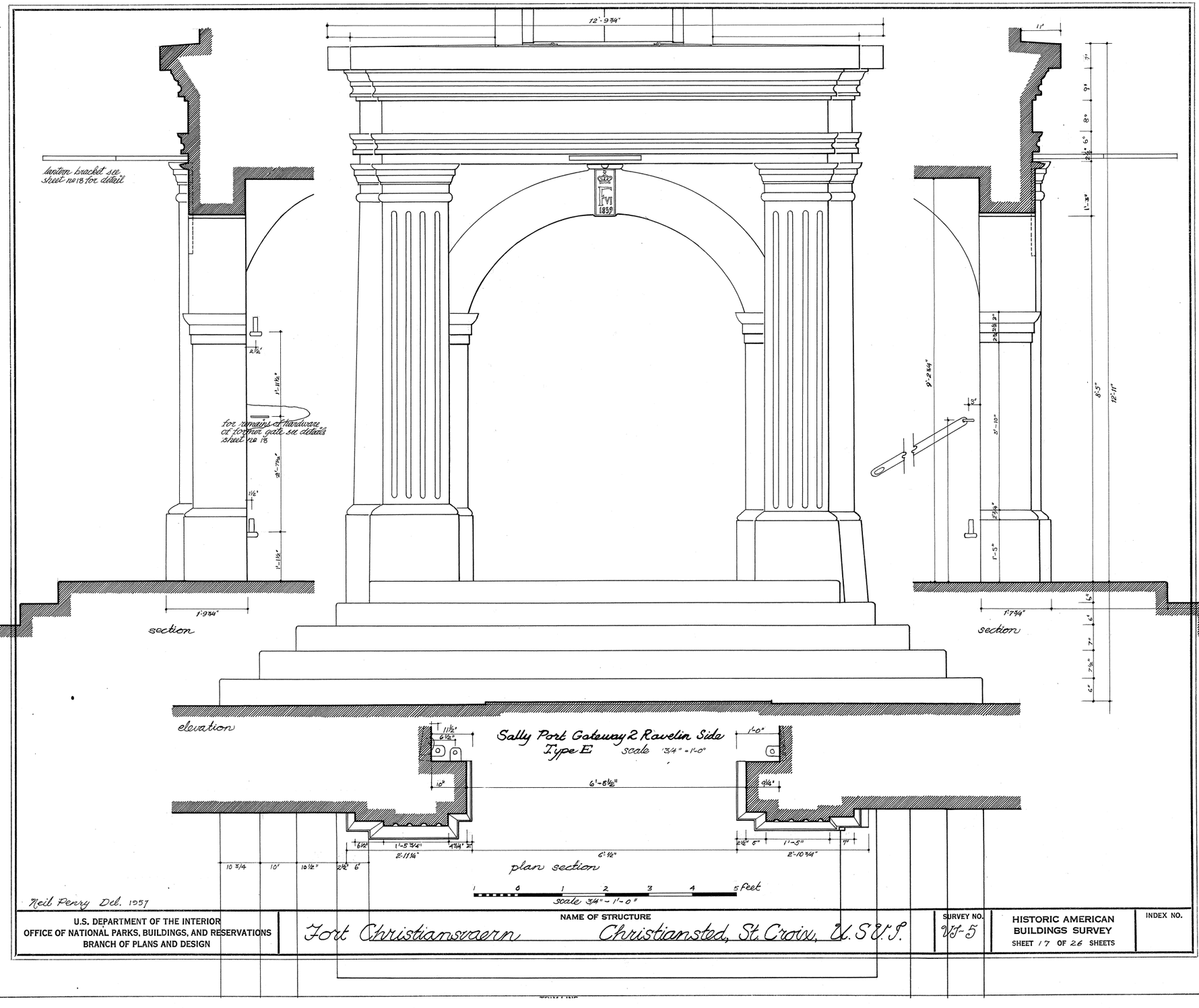
scale : 3'-1'0"

Fred. Hansen Del. 1957

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U. S. V. I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 16 OF 26 SHEETS	INDEX NO.

U. S. GOVERNMENT PRINTING OFFICE: 1936 27867

TRIM LINE



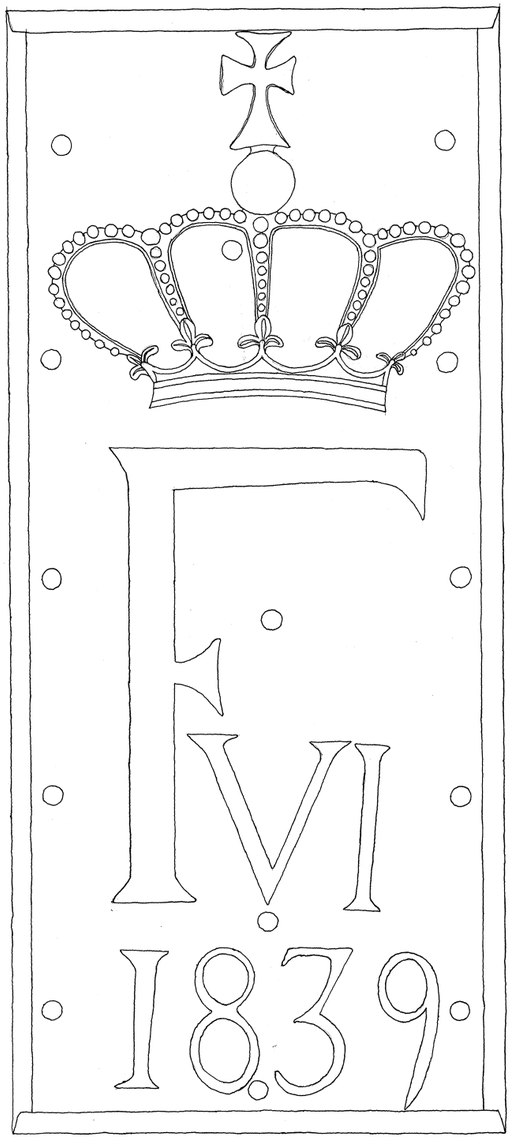
U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
BRANCH OF PLANS AND DESIGN

NAME OF STRUCTURE: Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.

SURVEY NO. VI-5

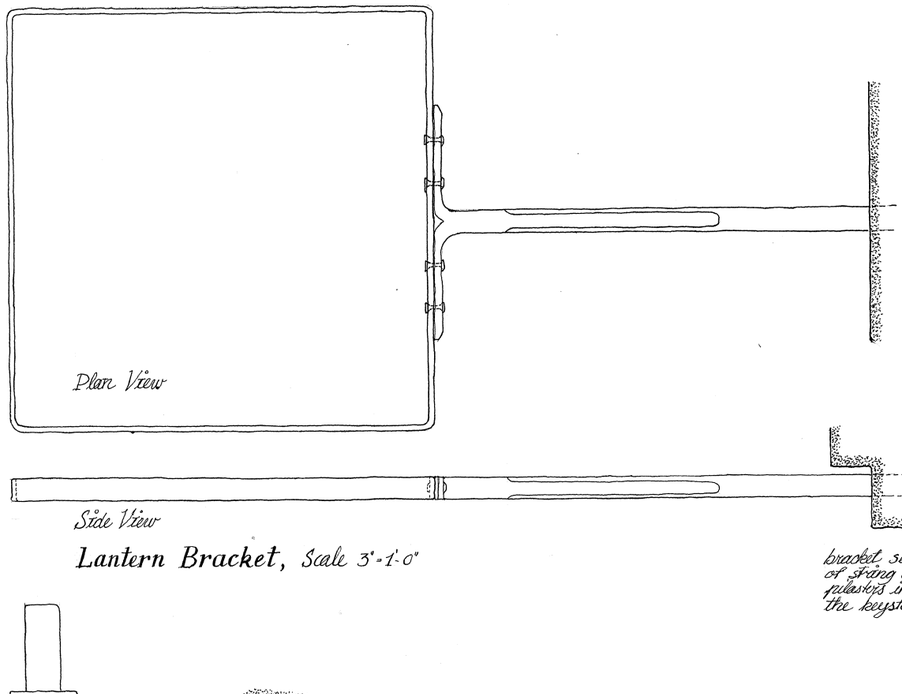
HISTORIC AMERICAN BUILDINGS SURVEY
SHEET 17 OF 26 SHEETS

INDEX NO.



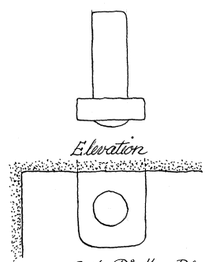
plaque of brass with a back plate of tin bent around edges to form border, figures and letters in lead raised approximately ¼".

Keystone Plague, Full Scale.

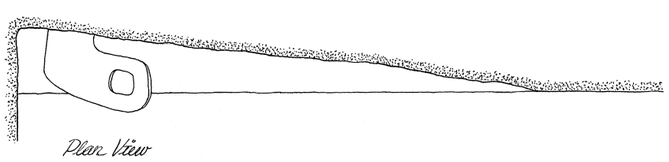


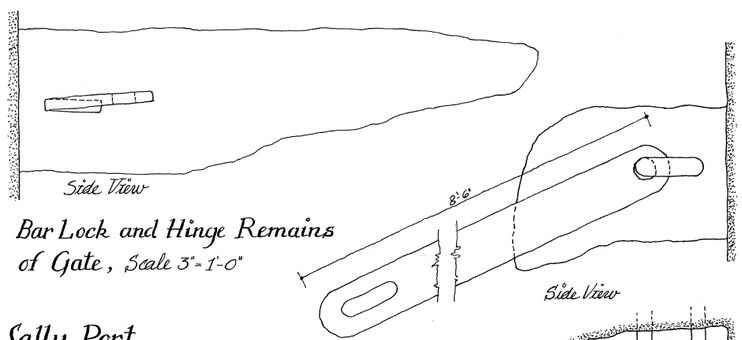
Lantern Bracket, Scale 3'-1'-0"

bracket set in masonry of string course above pilasters in center over the keystone.



Gate Pintle, Plan View





Bar Lock and Hinge Remains of Gate, Scale 3"=1'-0"

Hardware Details of Sally Port.

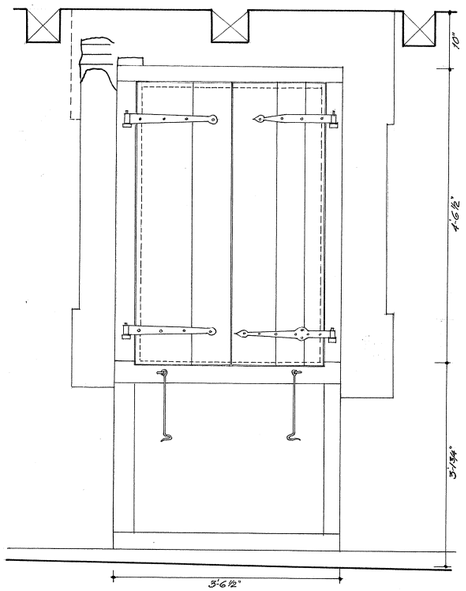
0 1 2 3 inches
Full Scale

0 3 6 9 12 inches
Scale 3'-1'-0"

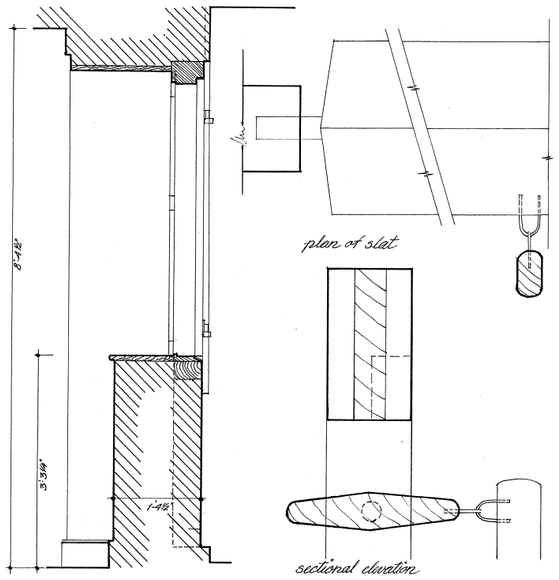
T. b. hanson & F. c. gressing del. 1957

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansværn, Christiansted, St. Croix, U.S. Virgin Islands.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 18 OF 26 SHEETS	INDEX NO.

Window 19 Type GM 3/4"=1'-0"

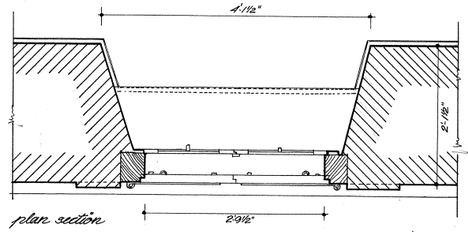


exterior elevation

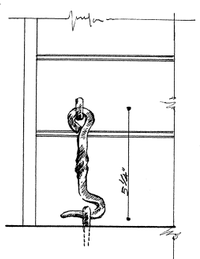


section

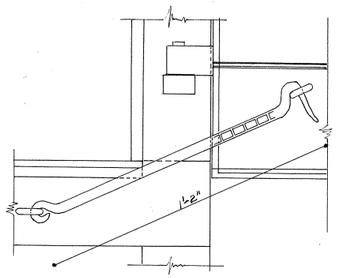
Jalousie Details Full size



plan section

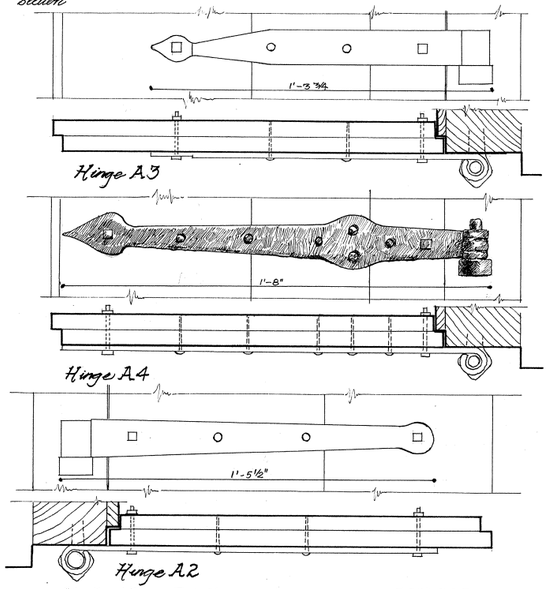


interior shutter hook C3



exterior shutter hook C2

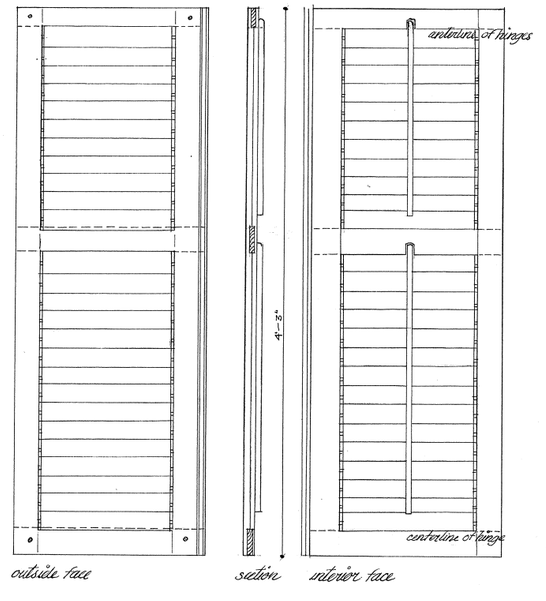
Shutter Hooks Details scale 3"=1'-0" on W19GM



Shutter Hinges Details scale 3"=1'-0" on W19GM

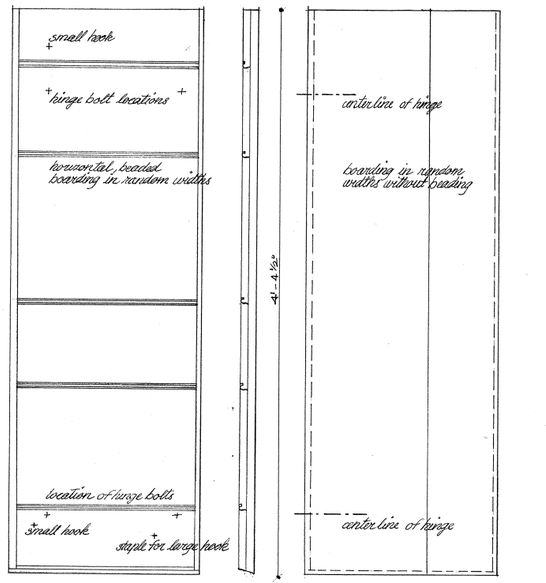
Scale 3/4"=1'-0"

Interior Jalousie Shutter Panel G scale 1½"=1'-0" on W19GM



outside face section interior face

Exterior Shutter Panel M scale 1½"=1'-0" on W19GM



interior face section exterior face

Scale 1½"=1'-0" Scale 3"=1'-0"

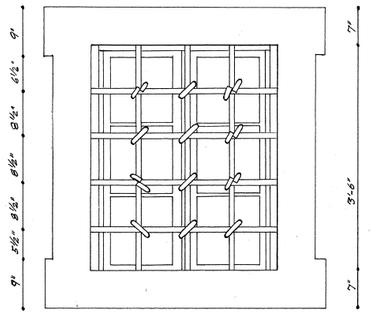
Fred Hansen & Phil Gardner Del. 1937

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 19 OF 26 SHEETS	INDEX NO.

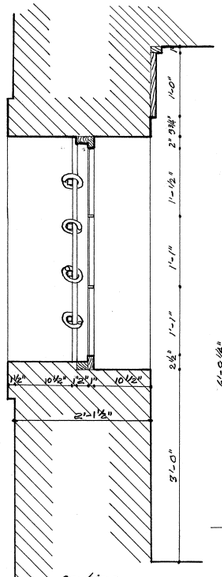
TRIM LINE

Window 9, South West Curtain, 1st Floor, Type EJ

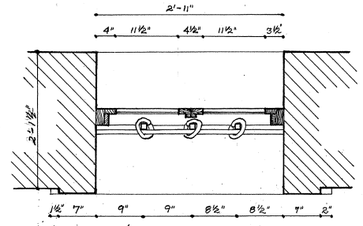
3/4" = 1'-0"



exterior elevation

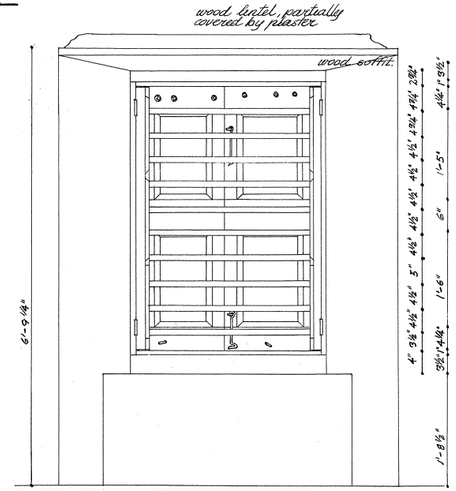


section

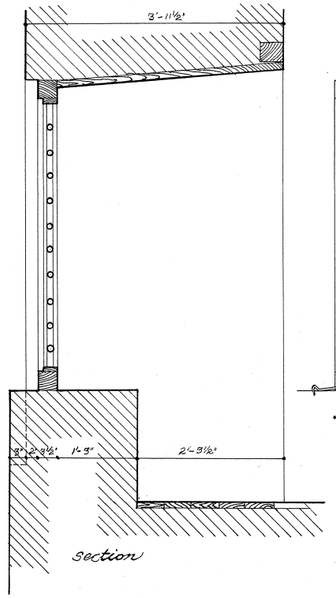


plan section

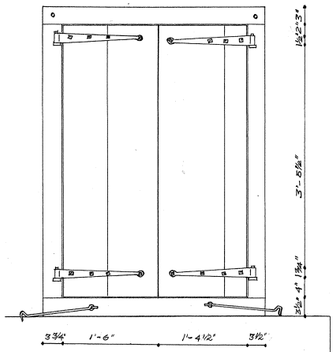
Window 2, Guard House, Type EJL 3/4" = 1'-0"



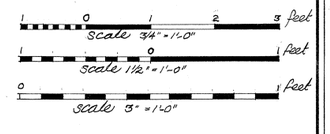
interior elevation



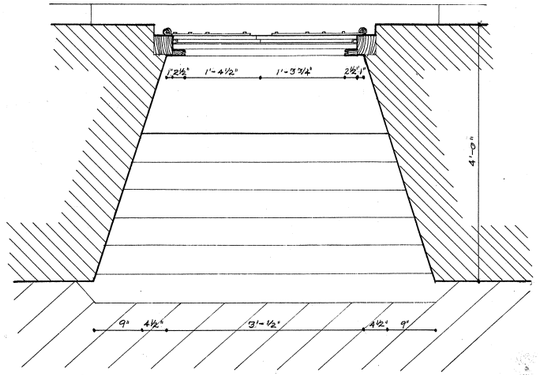
section



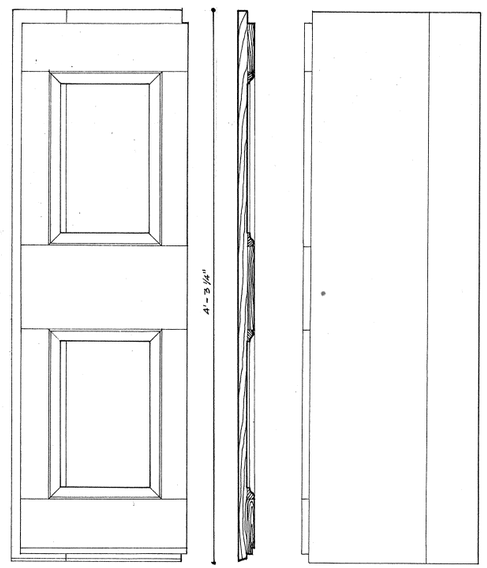
exterior elevation



plan section

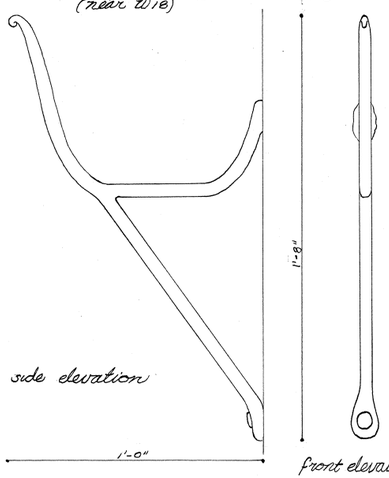


Shutter Type L on W2EJL 1 1/2" = 1'-0"



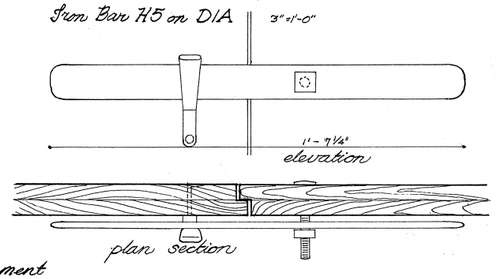
interior elevation — section — exterior elevation

Iron Ladder Bracket (near W16) 3" = 1'-0"

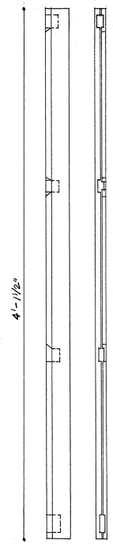


side elevation — front elevation

Iron Bar H5 on D1A 3" = 1'-0"



elevation — plan section



Remains of Casement W2EJL 1 1/2" = 1'-0"

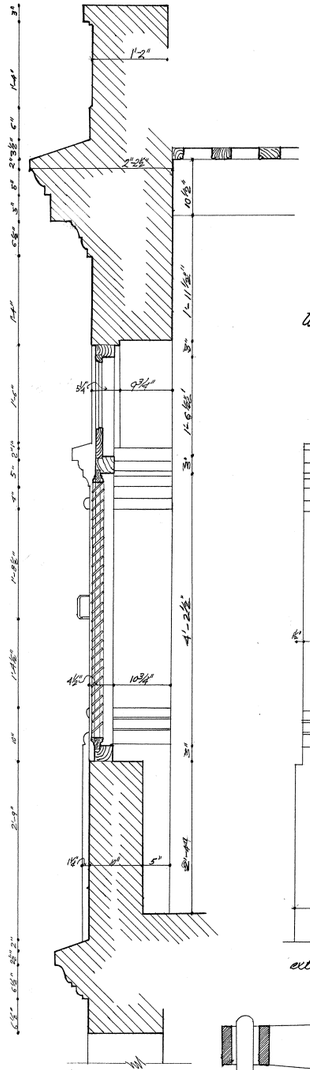
Fred. Hansen, Neil Penry, & Phil Gardner. Del. 1959

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 20 OF 26 SHEETS	INDEX NO.

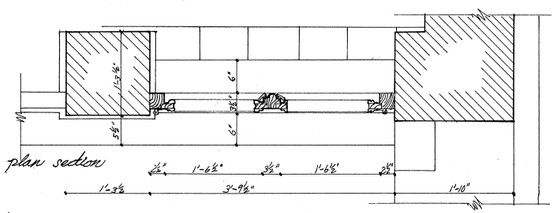


exterior elevation

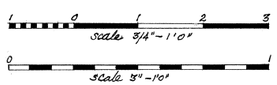
Window 9, Type H1
Second Floor Gallery
3/4"-1'0"



section



plan section



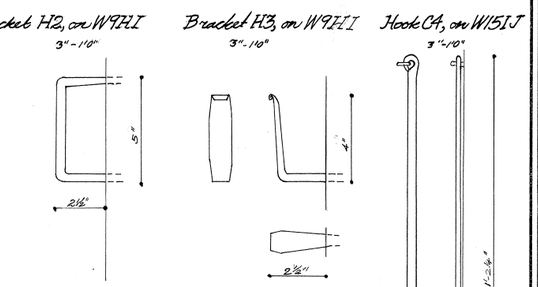
scale 3/4"-1'0"

scale 3"-1'0"

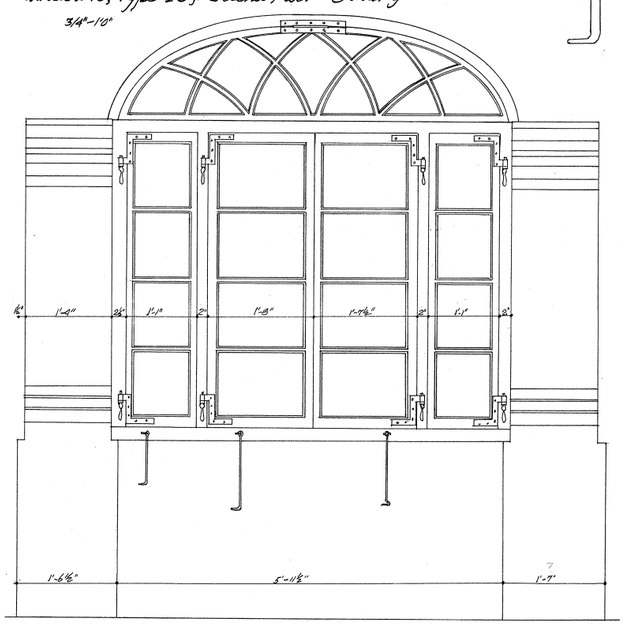
Bracket H2, on W9H1
3"-1'0"

Bracket H3, on W9H1
3"-1'0"

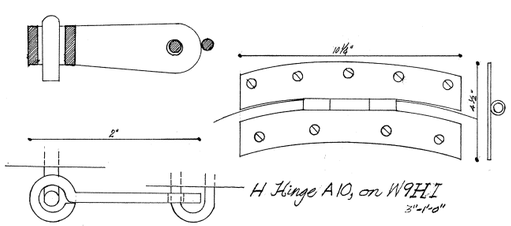
Hook C4, on W15IJ
3"-1'0"



Window 15, Type IJ, Second floor Gallery
3/4"-1'0"

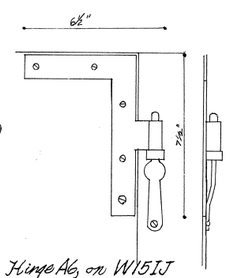


exterior elevation



Detail of Hasp B4, on Jalousie W9H1
full scale

H Hinge A10, on W9H1
3"-1'0"

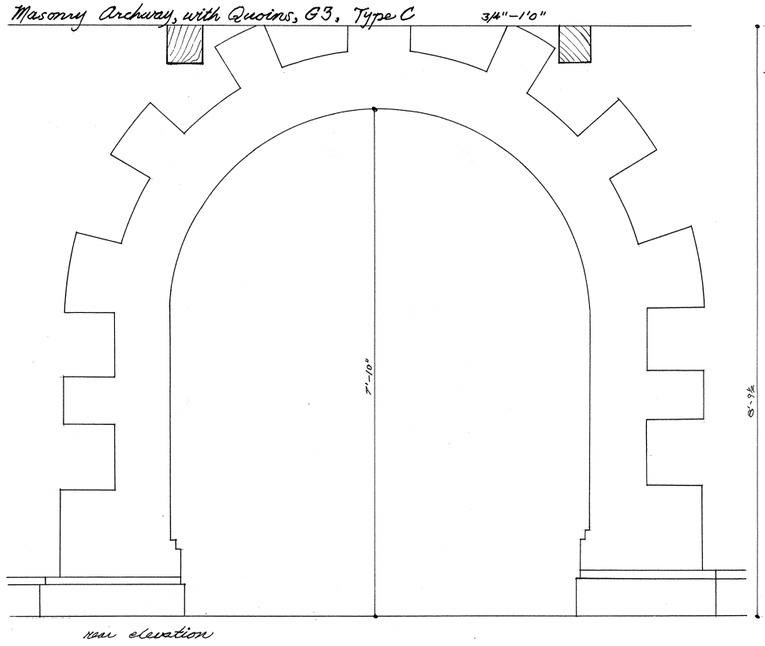


L Hinge A6, on W15IJ
3"-1'0"

Fred Hansen Del. 1957

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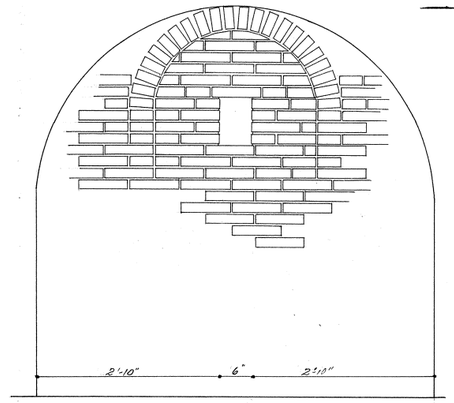
Masonry Archway, with Quoins, G3, Type C 3/4"-1'0"



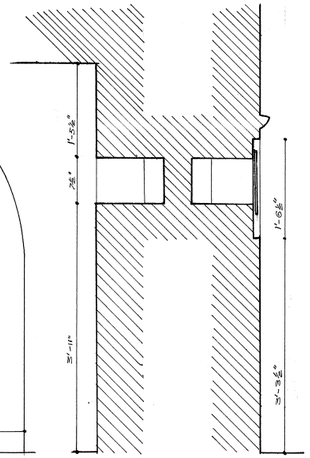
wall elevation

section

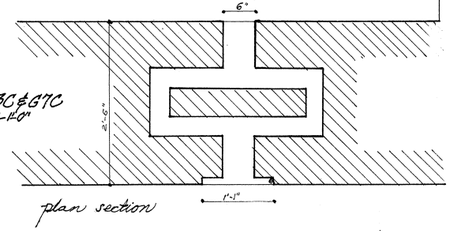
Window, With Small Hinged Metal Cover, 45, Type B 3/4" -1'0"



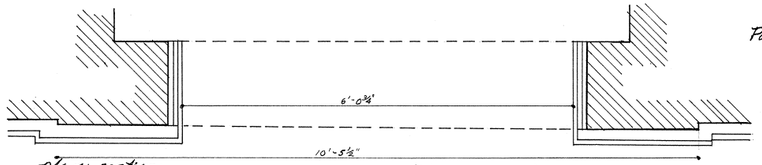
interior elevation showing position of window



section

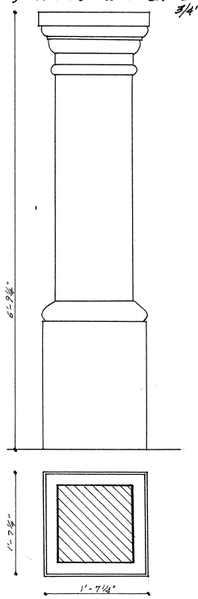


plan section

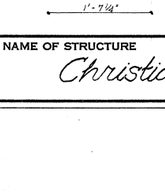


plan section

Pier, located between G3C & G7C 3/4"-1'0"

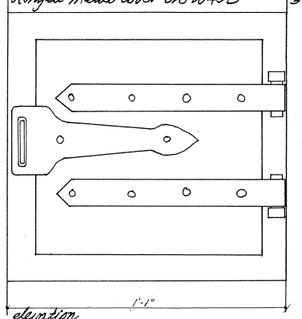


elevation

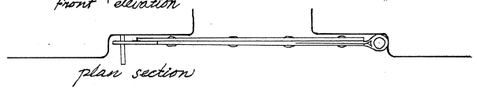


plan section

Hinged Metal Cover on W45B 3-1'0"

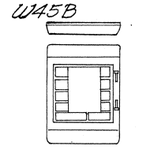


front elevation

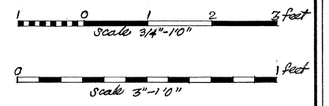


plan section

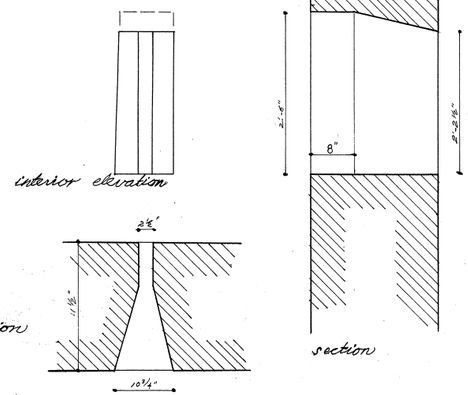
W45B



exterior elevation with door removed

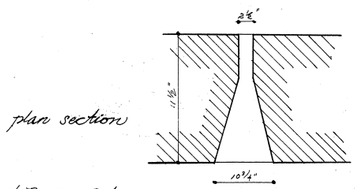


Open Slit Window 51, Type A 3/4"-1'0"



interior elevation

section



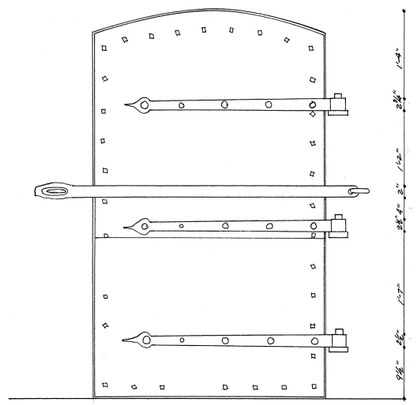
plan section

Neil Penry Del. 1957

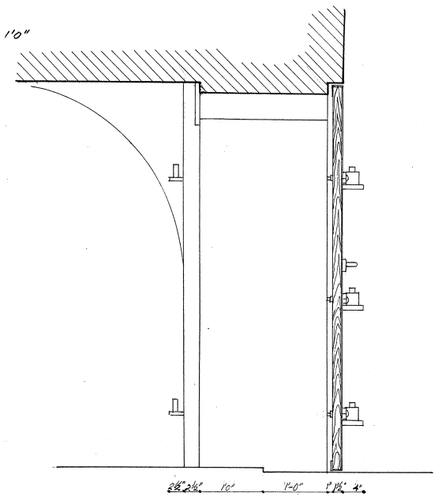
U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 22 OF 26 SHEETS	INDEX NO.

Metal Covered Wood Door 27, Type D

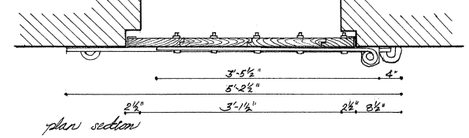
3/4" - 1'0"



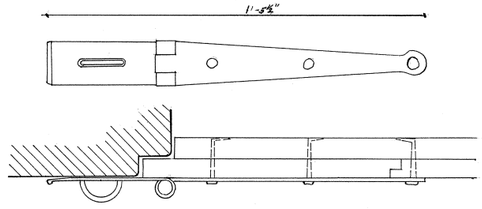
exterior elevation



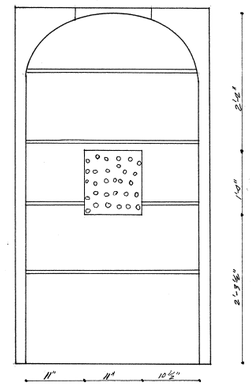
section



plan section

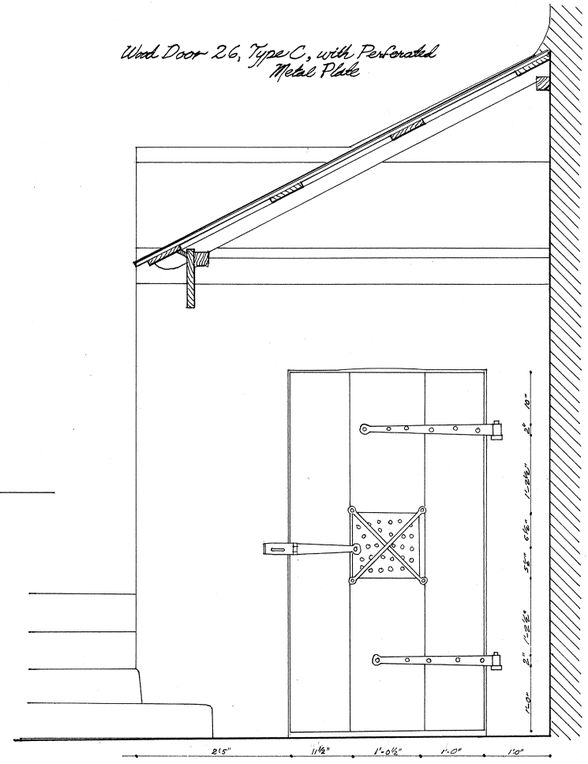


Hasp B5, on D26C 3"=1'-0"



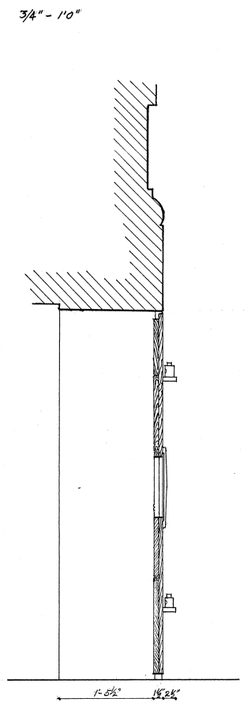
interior elevation

Wood Door 26, Type C, with Perforated Metal Plate

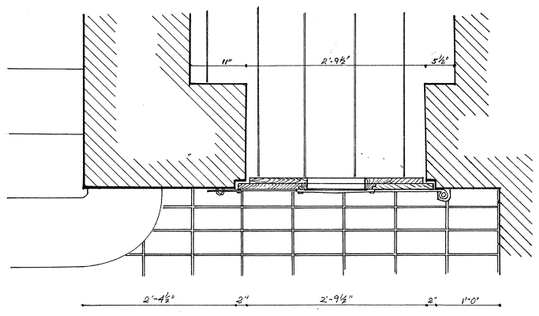


exterior elevation

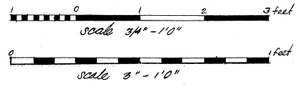
3/4" - 1'0"



section



plan section

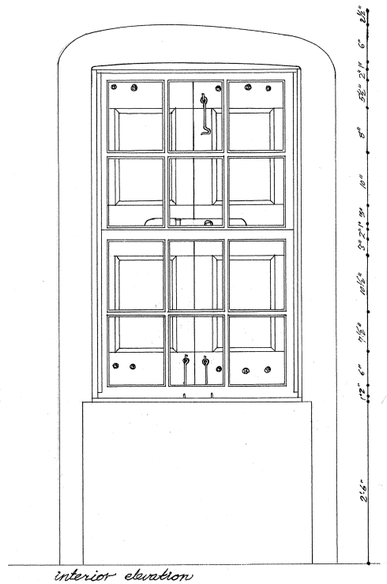


Neil Penny Del. 1957

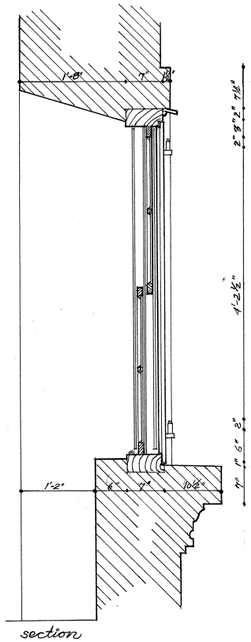
U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 23 OF 26 SHEETS	INDEX NO.

TRIM LINE

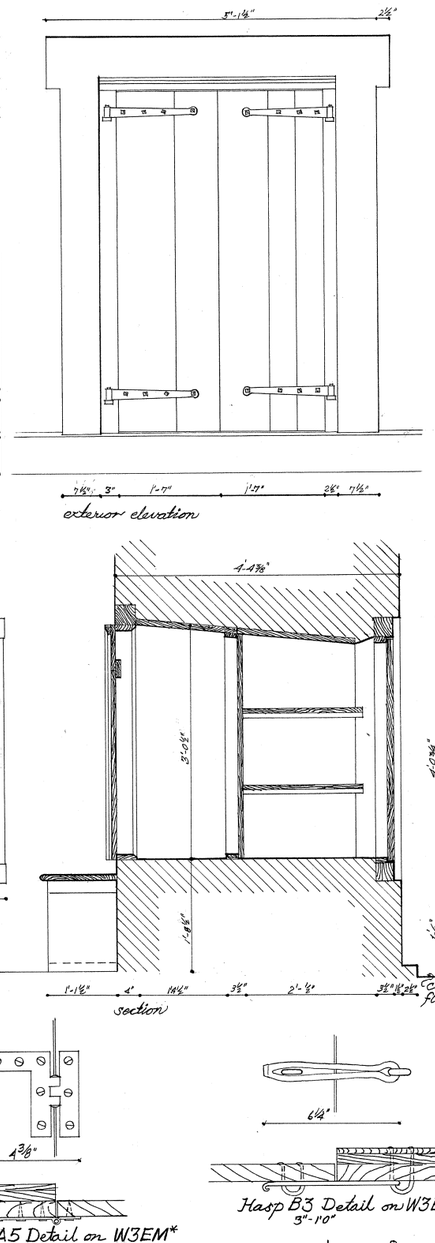
Window 4, Courtroom, Type KL, 2nd floor, South
scale 3/4"-1'0"



interior elevation

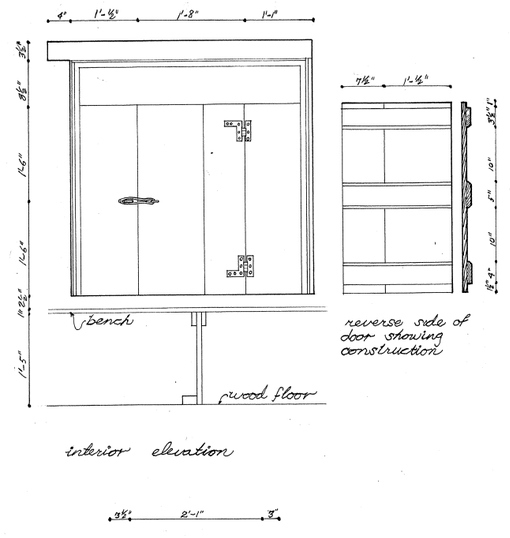


section



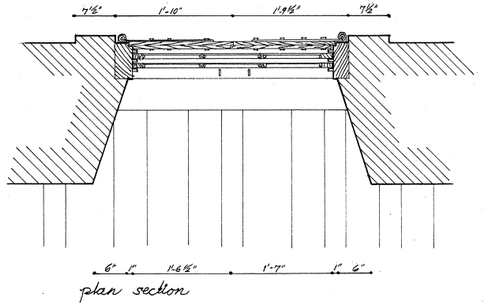
exterior elevation

Window 3, Guardhouse, Type EM* scale 3/4"-1'0"

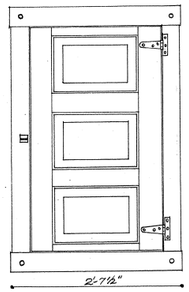


reverse side of door showing construction

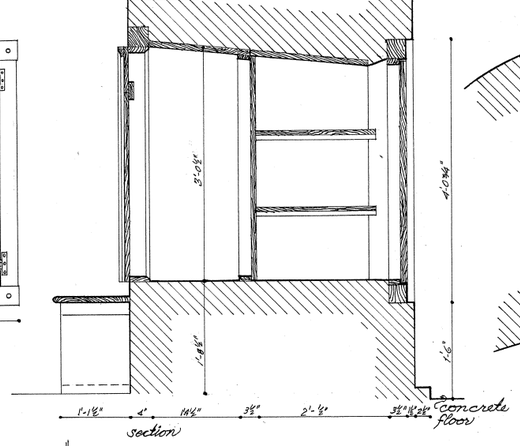
interior elevation



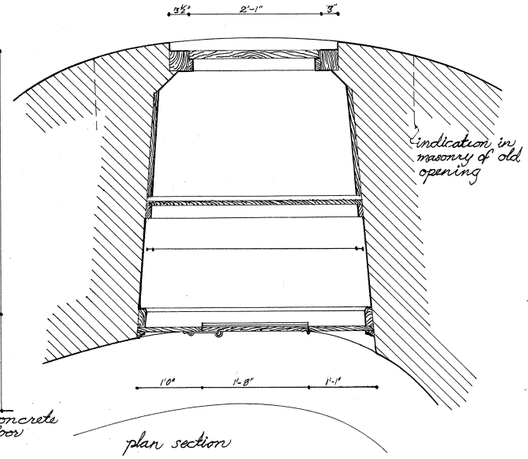
plan section



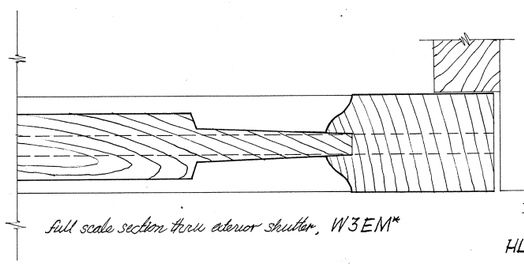
exterior elevation



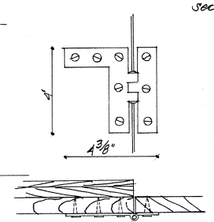
section



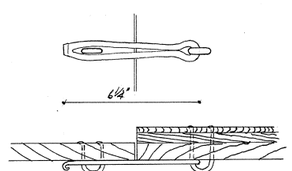
plan section



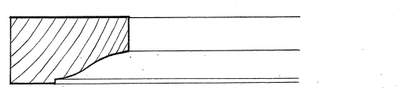
full scale section thru exterior shutter, W3EM*



HL Hinge A5 Detail on W3EM*
3"-1'0"



Hasp B3 Detail on W3EM*
3"-1'0"



full scale detail moulding of interior shutter, W3EM*

scale: 3/4"-1'0"

scale: 3"-1'0"

Neil Penny & Fred Hansen Del. 1959

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Hasp B6, on D1F 3"-1'-0"

1'-4¼"

Guardhouse Door 1, Type 1F 3/4"-1'-0"

11" 10½" 23¼" 10" 2" 1'-1½" 1'-0½"

exterior elevation

section

Door 5, Type G 3/4"-1'-0"

interior elevation

section

Louver Detail, D5G, 2"-1'-0"

plan section

interior elevation

Metal Box Lock F4, on D5G 3"-1'0"

HL Hinge A5, on D5G 3"-1'0"

plan section

Panel Moulding Detail, D5G, full scale

plan section

scale 3/4"-1'0"

scale 6"-1'0"

scale 3"-1'0"

Neil Perry Del. 1961

U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
BRANCH OF PLANS AND DESIGN

NAME OF STRUCTURE
Fort Christiansvaern Christiansted, St. Croix, U.S.V.I.

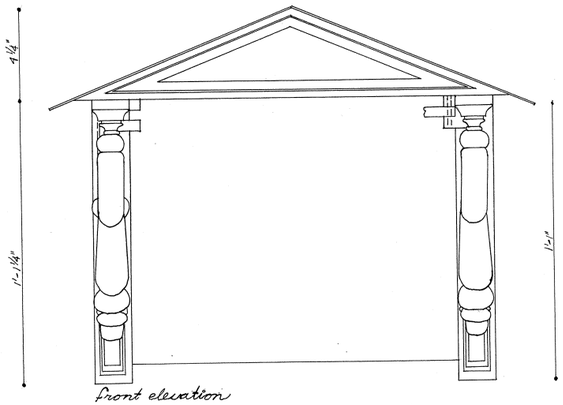
SURVEY NO. VI-5

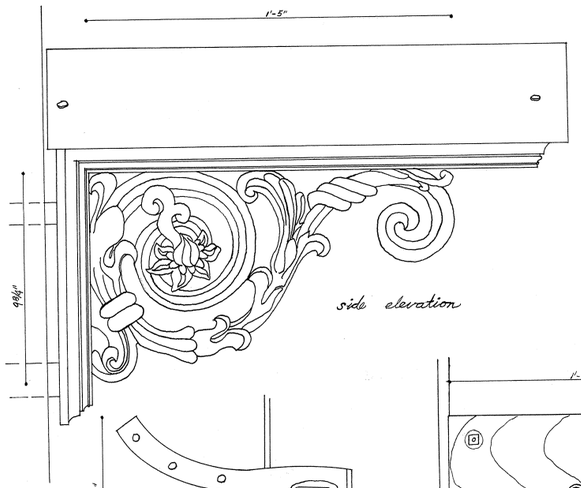
HISTORIC AMERICAN BUILDINGS SURVEY
SHEET 25 OF 26 SHEETS

INDEX NO.

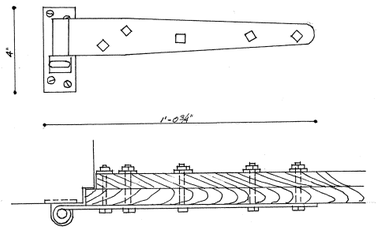
TRIM LINE

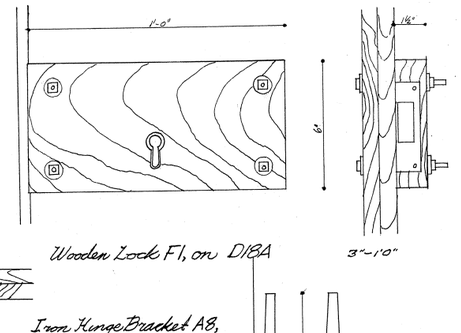
Cast Iron Bell Hood on Guardhouse 3"-1'0"





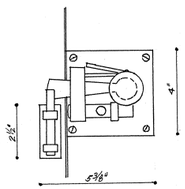
Hinge A11, on D1A, Second Floor 3"-1'0"

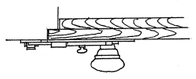




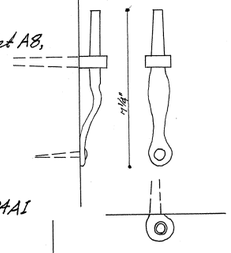
Forked Hasp B1, on D6A 3"-1'0"

Wooden Lock F1, on D18A

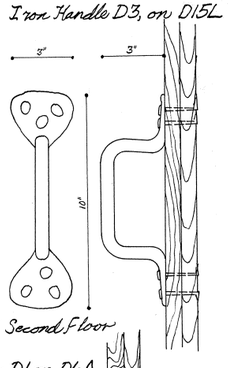




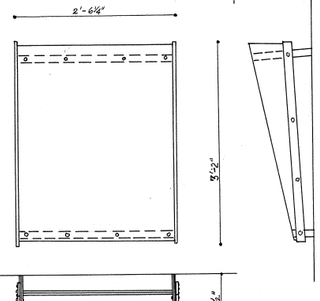
Iron Hinge Bracket A8, on W7E 3'-1'0"



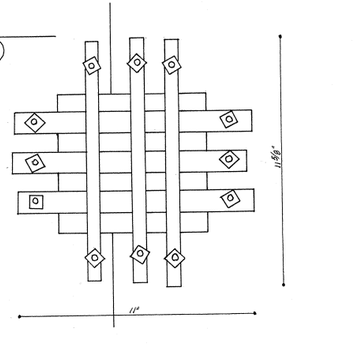
Iron Handle D3, on D15L 3"-1'0"

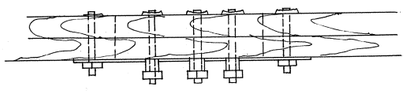


Brass Keyhole F3, on D24A1 3"-1'0"



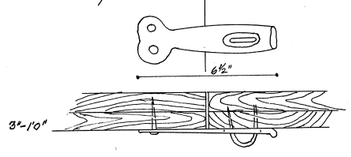
Metal Spring Lock F2, on D11L, Second Floor 3"-1'0"



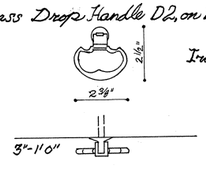


Grill H1, on D45C 3"-1'0"

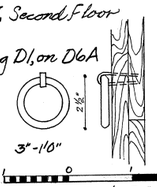
Hasp B2, on D42L

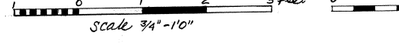


Brass Drop Handle D2, on D13A1, Second Floor

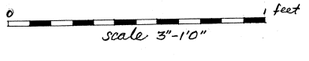


Iron Ring D1, on D6A





Sheet Metal Window Shield H4, on W28D ¾"-1'0"



Fred Hansen & Neil Parry Del. 1961

U.S. DEPARTMENT OF THE INTERIOR OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS BRANCH OF PLANS AND DESIGN	NAME OF STRUCTURE Fort Christiansvaern — Christiansted, St. Croix, U.S.V.I.	SURVEY NO. VI-5	HISTORIC AMERICAN BUILDINGS SURVEY SHEET 26 OF 26 SHEETS	INDEX NO.

TRIM LINE

Appendix B: Historical Epochs Drawings

This appendix includes historic plans of the fort for five identified epochs, including: 1780, 1836, 1919, 1953, and 1959. Each plan after 1780 is followed by an annotated version calling out changes since the previous epoch. Changes since 1959 are included in Appendix C.

Sheet 1: 1778-1780 First-floor plan by Peter Lotharius Oxholm

Sheet 2: 1778-1780 Second-floor plan by Peter Lotharius Oxholm

Sheet 3: 1836 First-floor plan by First Lieutenant Gjellurup and Second Lieutenant Friis.

Sheet 4: 1836 First-floor plan with changes annotated

Sheet 5: 1836 Second-floor plan by First Lieutenant Gjellurup and Second Lieutenant Friis

Sheet 6: 1836 Second-floor plan with changes annotated

Sheet 7: 1836 Roof plan by First Lieutenant Gjellurup and Second Lieutenant Friis

Sheet 8: 1836 Roof plan with changes annotated

Sheet 9: 1919 First-floor plan by Tyge Hvass

Sheet 10: 1919 First-floor plan with changes annotated

Sheet 11: 1919 Second-floor plan by Tyge Hvass

Sheet 12: 1919 Second-floor plan with changes annotated

Sheet 13: 1953 First-floor plan by Frederick Gjessing

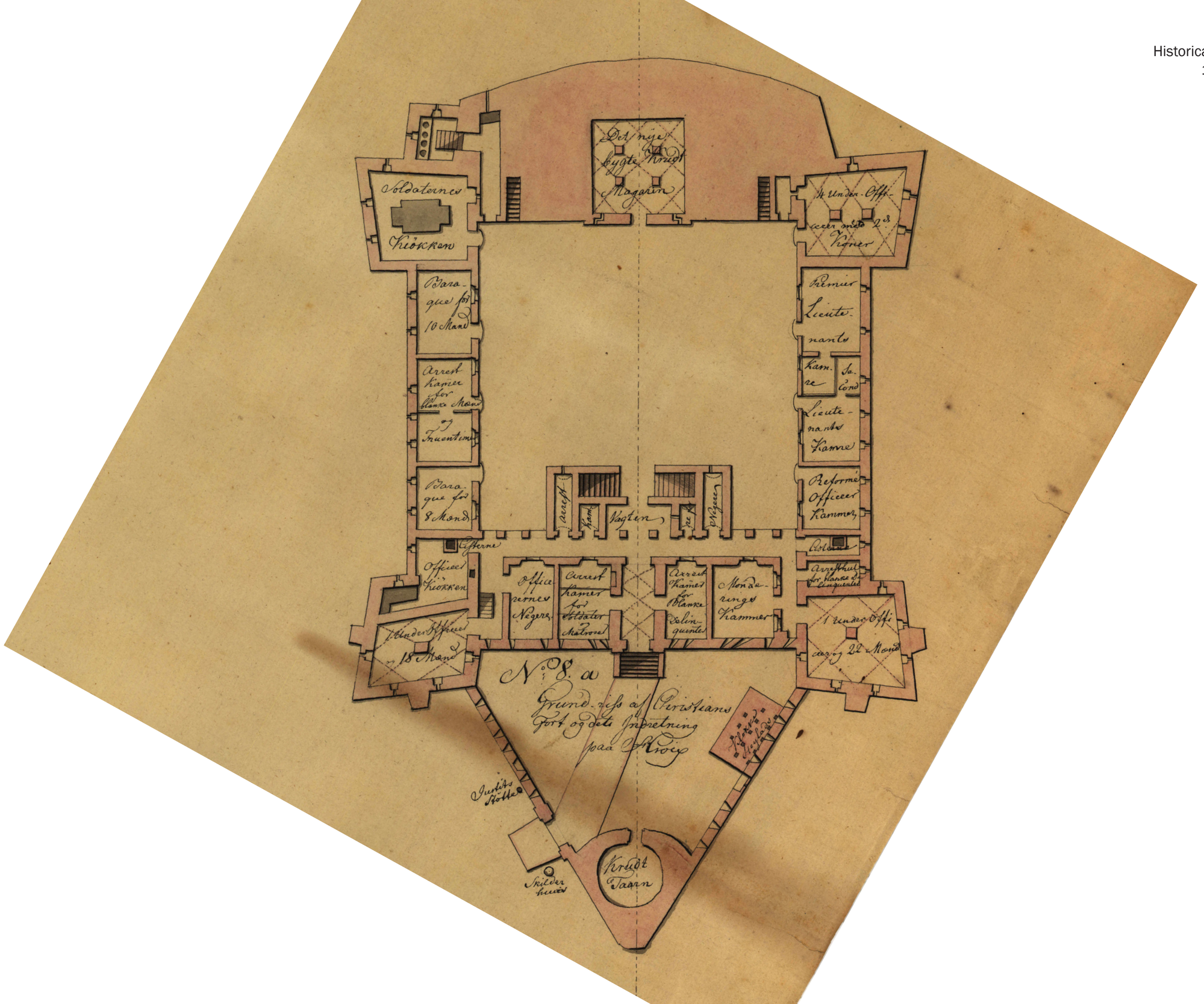
Sheet 14: 1953 First-floor plan with changes annotated

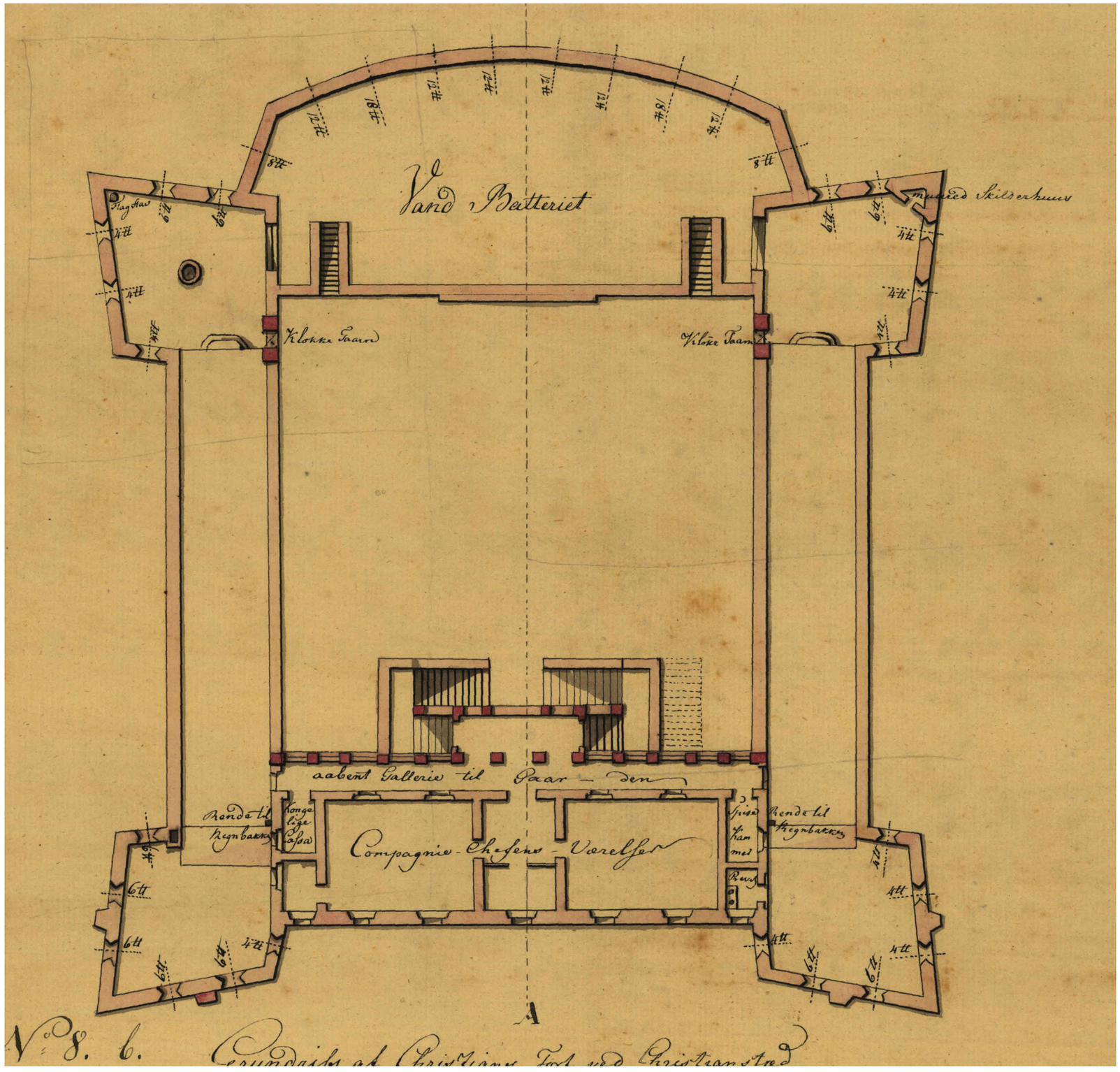
Sheet 15: 1953 Second-floor plan by Frederick Gjessing

Sheet 16: 1953 Second-floor plan with changes annotated

Sheet 17: 1959 First-floor plan, Historic American Buildings Survey (HABS)
(No substantive changes since 1953)

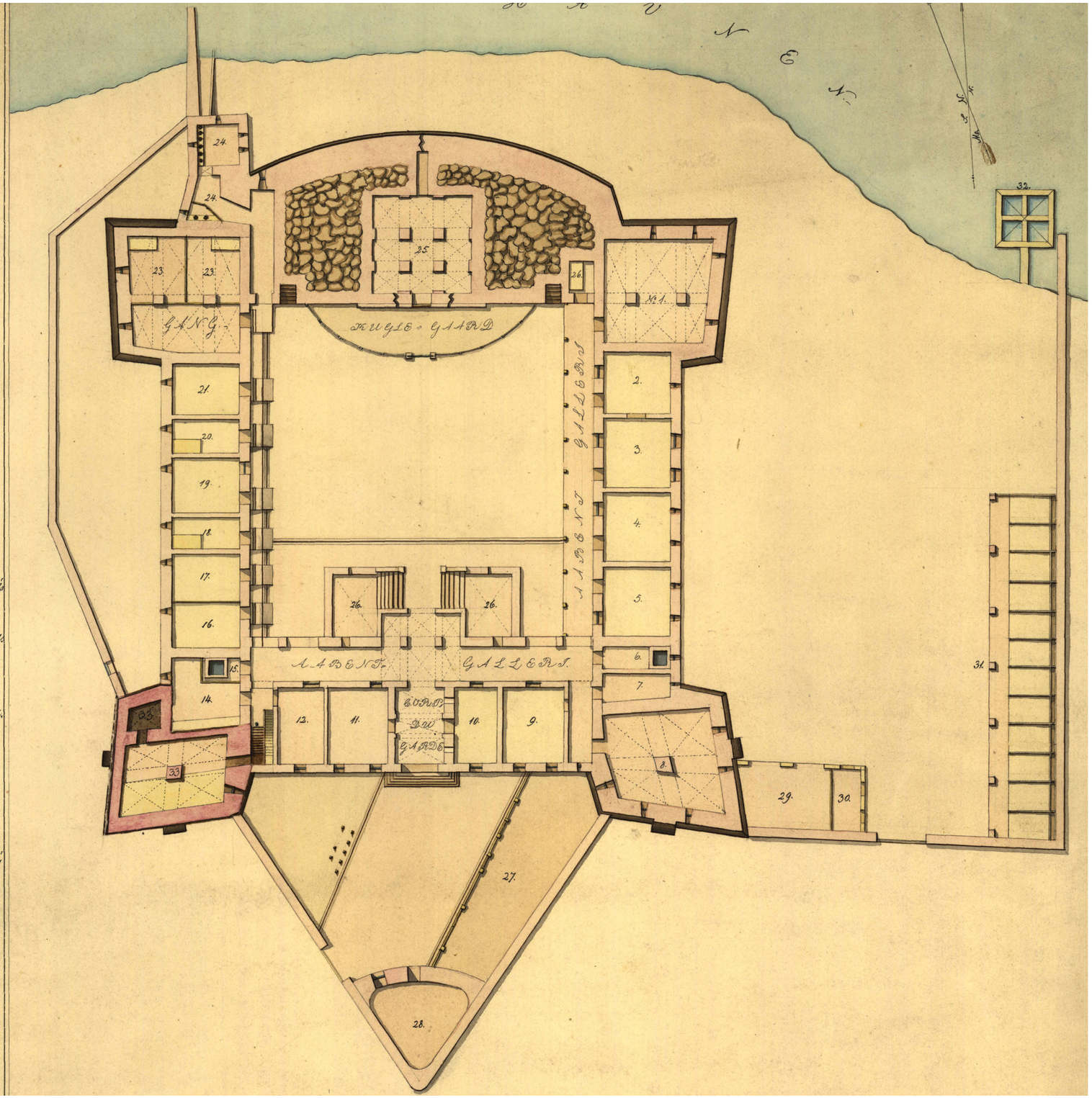
Sheet 18: 1959 Second-floor plan, HABS (No substantive changes since 1953)


Det nye bygte Krudt Magazin
Soldaternes Stokkeen
Baraque for 10 Mand
Arrest Kamer for blanke Mand
Baraque for 8 Mand
Officeer Stokkeen
Officernes Negers
Arrest Kamer for Soldater Natrosse
Arrest Kamer for blanke Delinquenter
Mondurings Kammer
Underofficeer 18 Mand
Premier Lieutenants Kamre
Lieutenants Kamre
Reformé Officeer Kammer
Arrestlokal for blanke Delinquenter
Underofficeer 22 Mand
Vagten
No 8. a
Grund-riss af Christians Fort og dets Indretning paa Holmen
Krudt Taarn

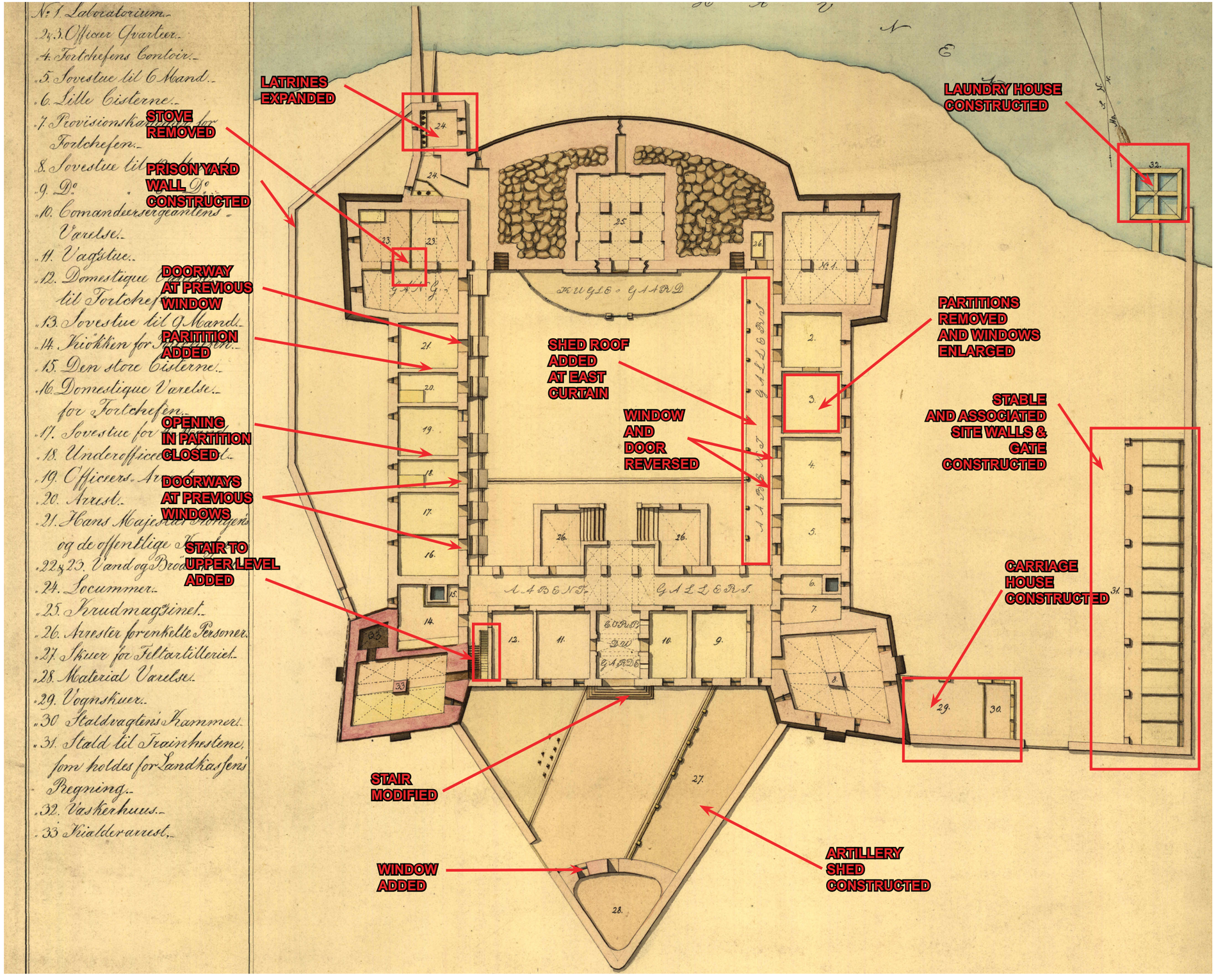


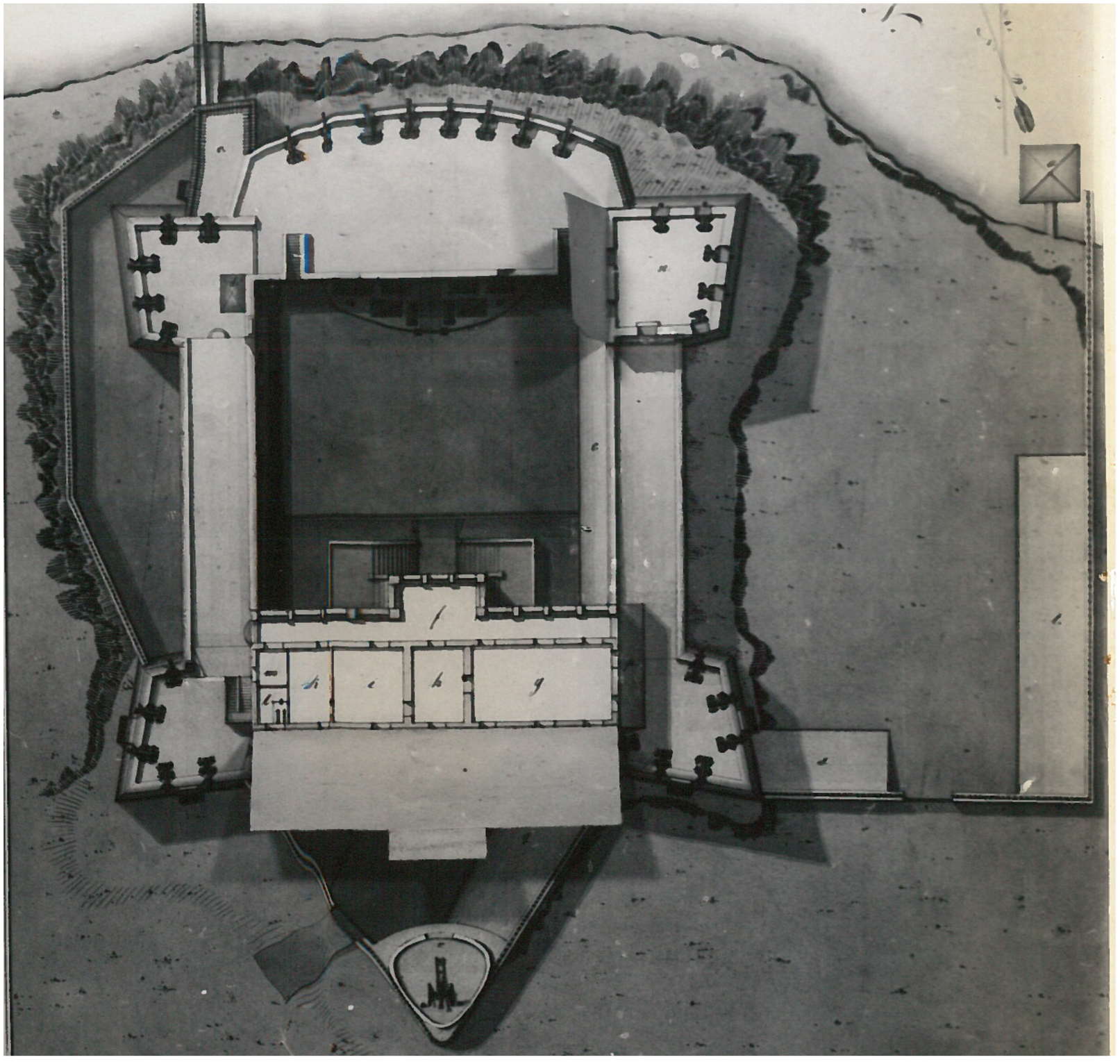
No 8. 6. Grundrids af Christians Fort ved Christianstad

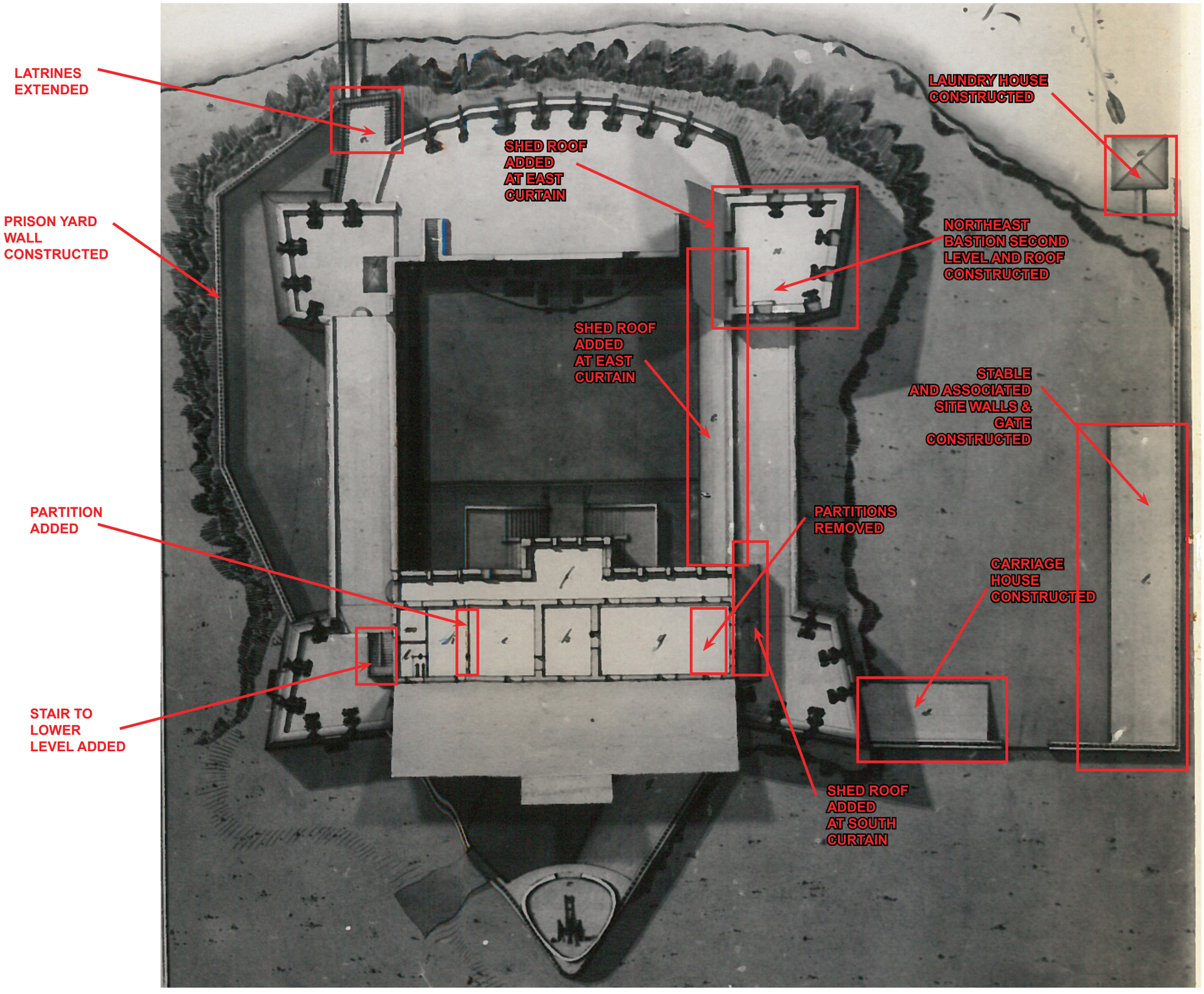
№ 1. Laboratorium.
„ 2 & 3. Officer Quarter.
„ 4. Fortchefens Contoir.
„ 5. Sovestue til 6 Mand.
„ 6. Lille Cisterne.
„ 7. Provisionskammer for Fortchefen.
„ 8. Sovestue til 12 Mand.
„ 9. Do . 6 Do.
„ 10. Comandersergeantens Varelse.
„ 11. Vagtstue.
„ 12. Domestique Varelse til Fortchefen.
„ 13. Sovestue til 9 Mand.
„ 14. Kiökken for Fortchefen.
„ 15. Den store Cisterne.
„ 16. Domestique Varelse for Fortchefen.
„ 17. Sovestue for 4 Mand.
„ 18. Underofficers Arrest.
„ 19. Officers Arrest.
„ 20. Arrest.
„ 21. Hans Majestæt Kongens og de offentlige Kasser.
„ 22 & 23. Vand og Brods Arrester.
„ 24. Locummer.
„ 25. Krudmagzinet.
„ 26. Arrester for enkelte Personer.
„ 27. Skuer for Feltartilleriet.
„ 28. Material Varelse.
„ 29. Vognskuer.
„ 30 Staldvagtens Kammer.
„ 31. Stald til Trainhestene, som holdes for Landkassens Regning.
„ 32. Vaskerhuus.
„ 33 Kvalderarrest.

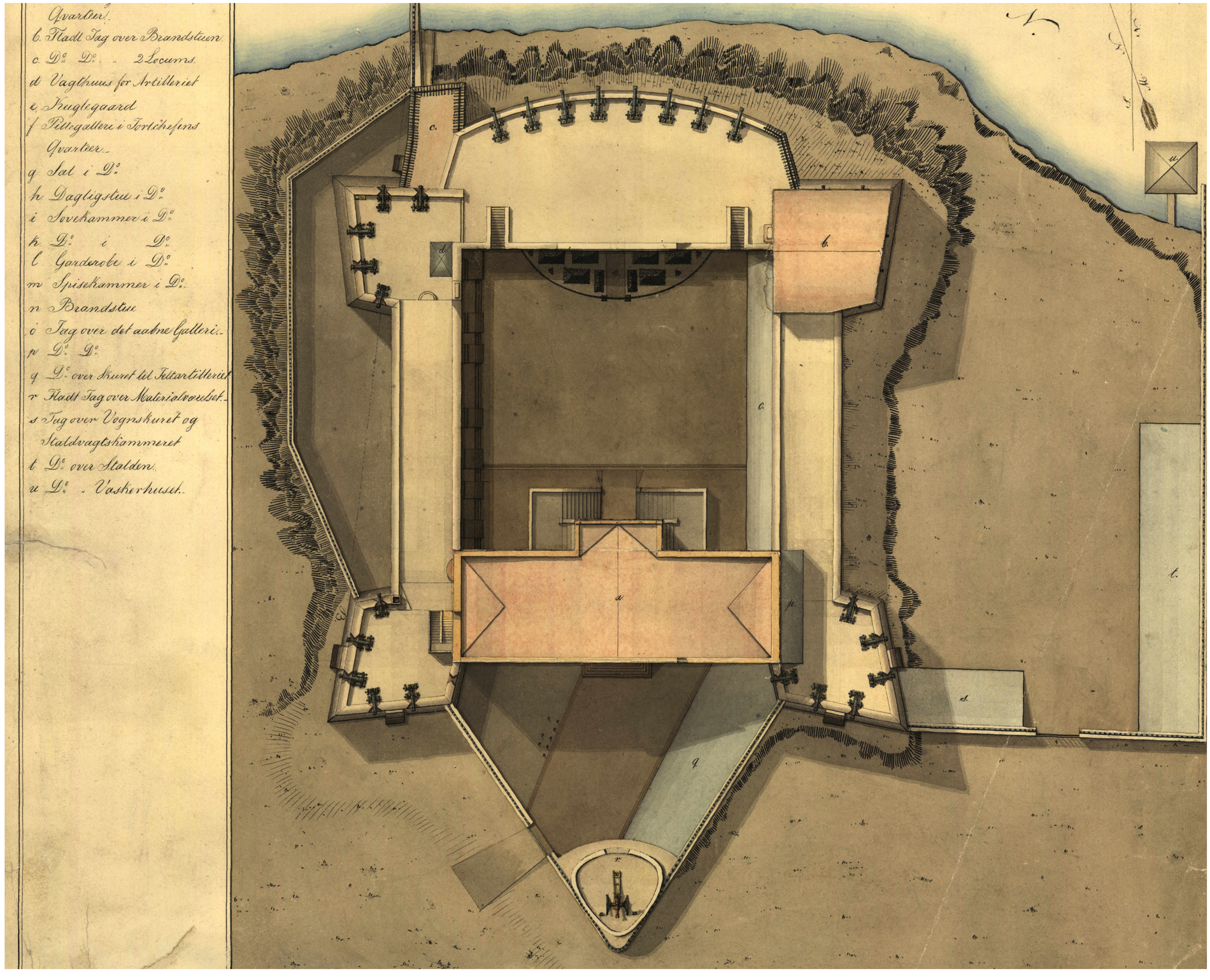

KRUDT-GAARD
GANG
GALLERI
GALLERI
GALLERI

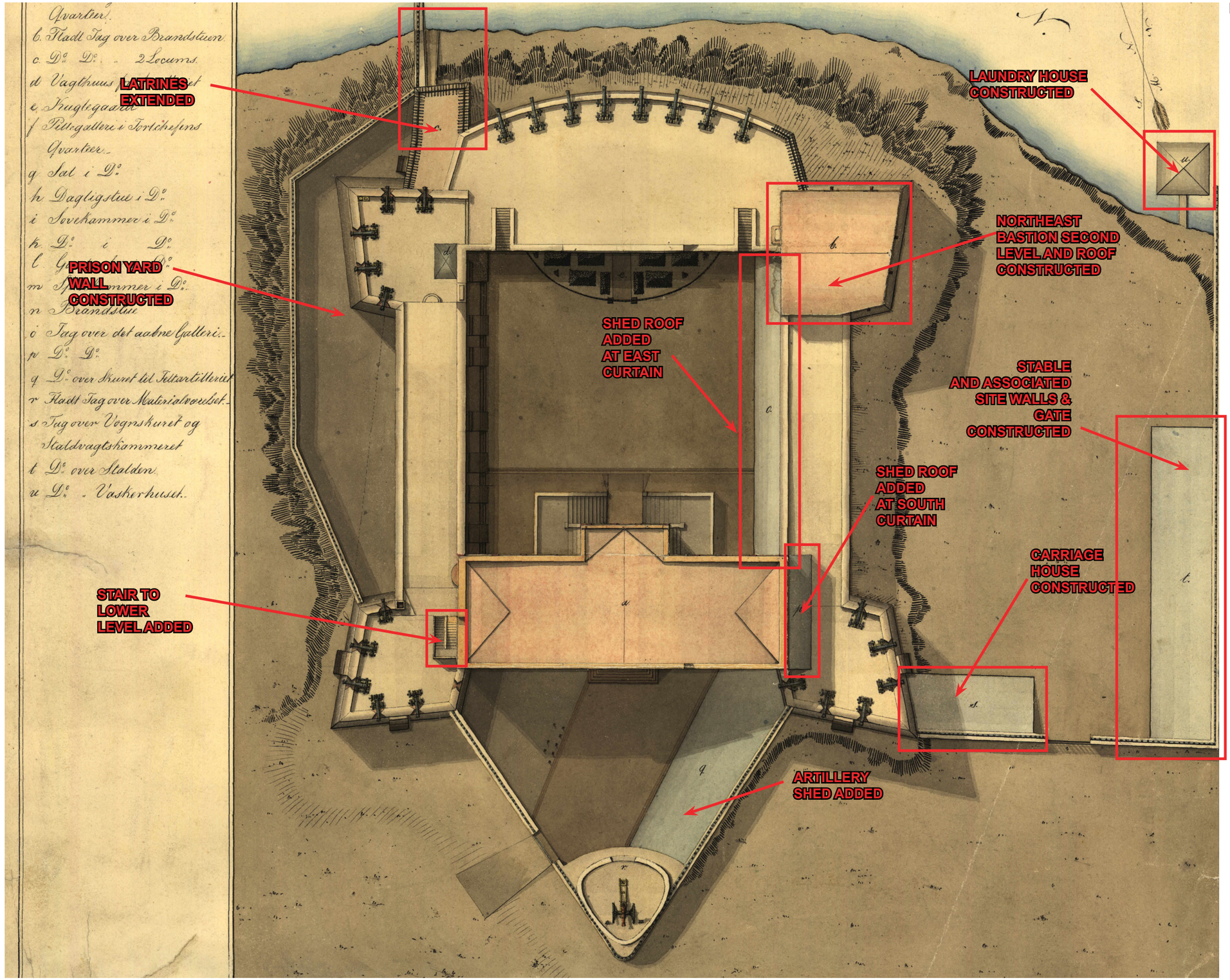
Historical Epoch Drawings 4 of 18
1836 First-floor Plan
(Annotated)

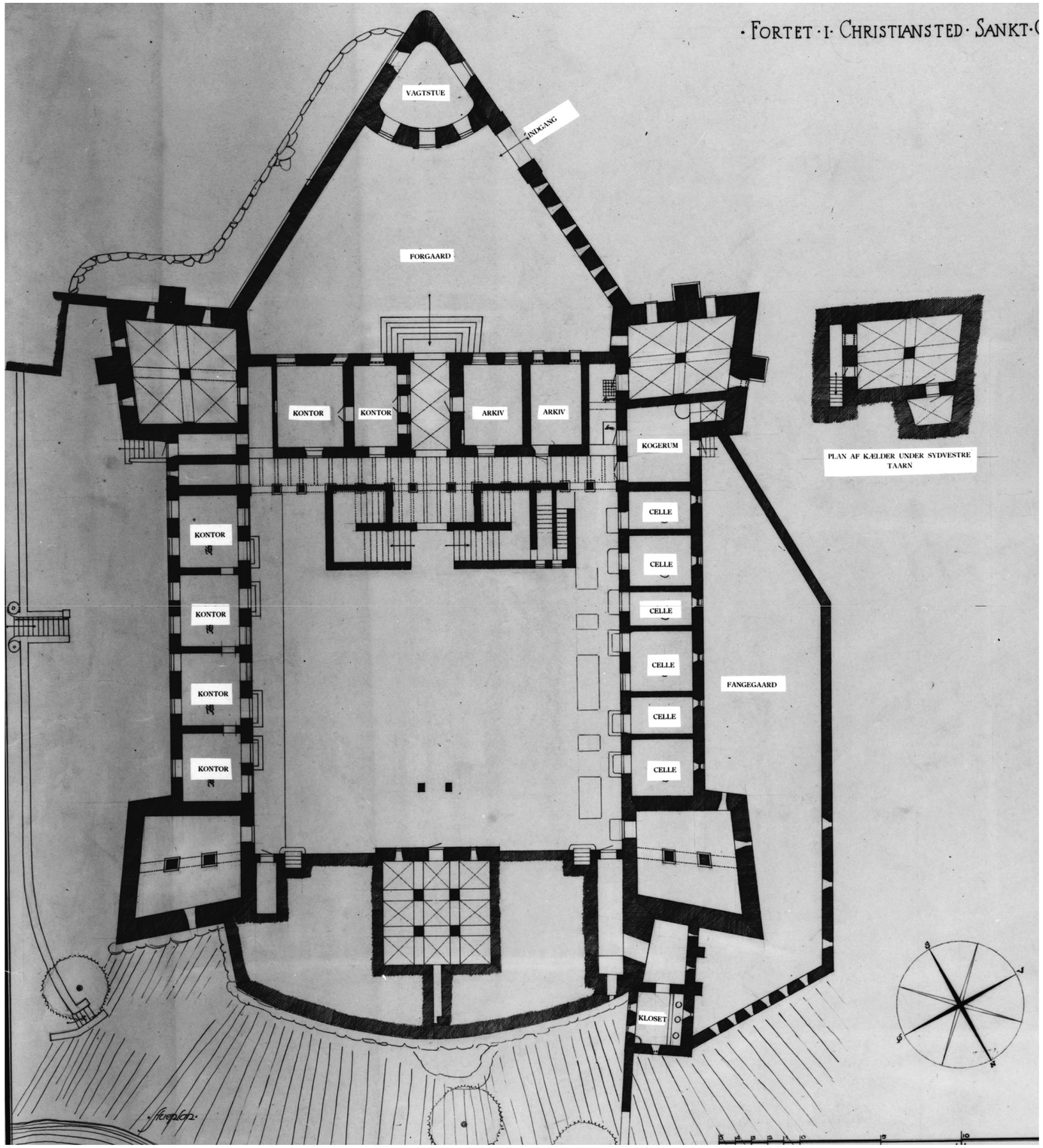


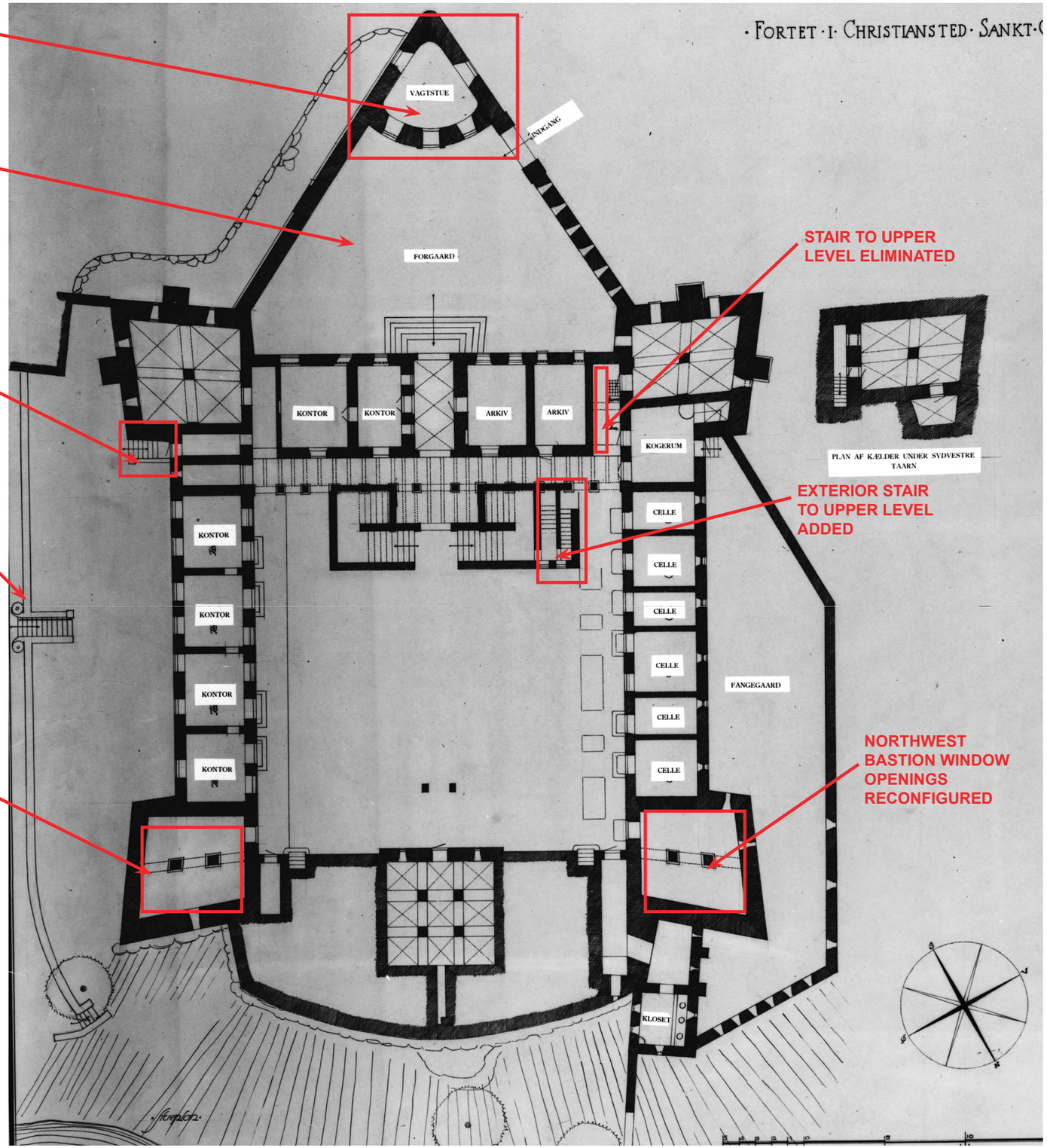

f
h
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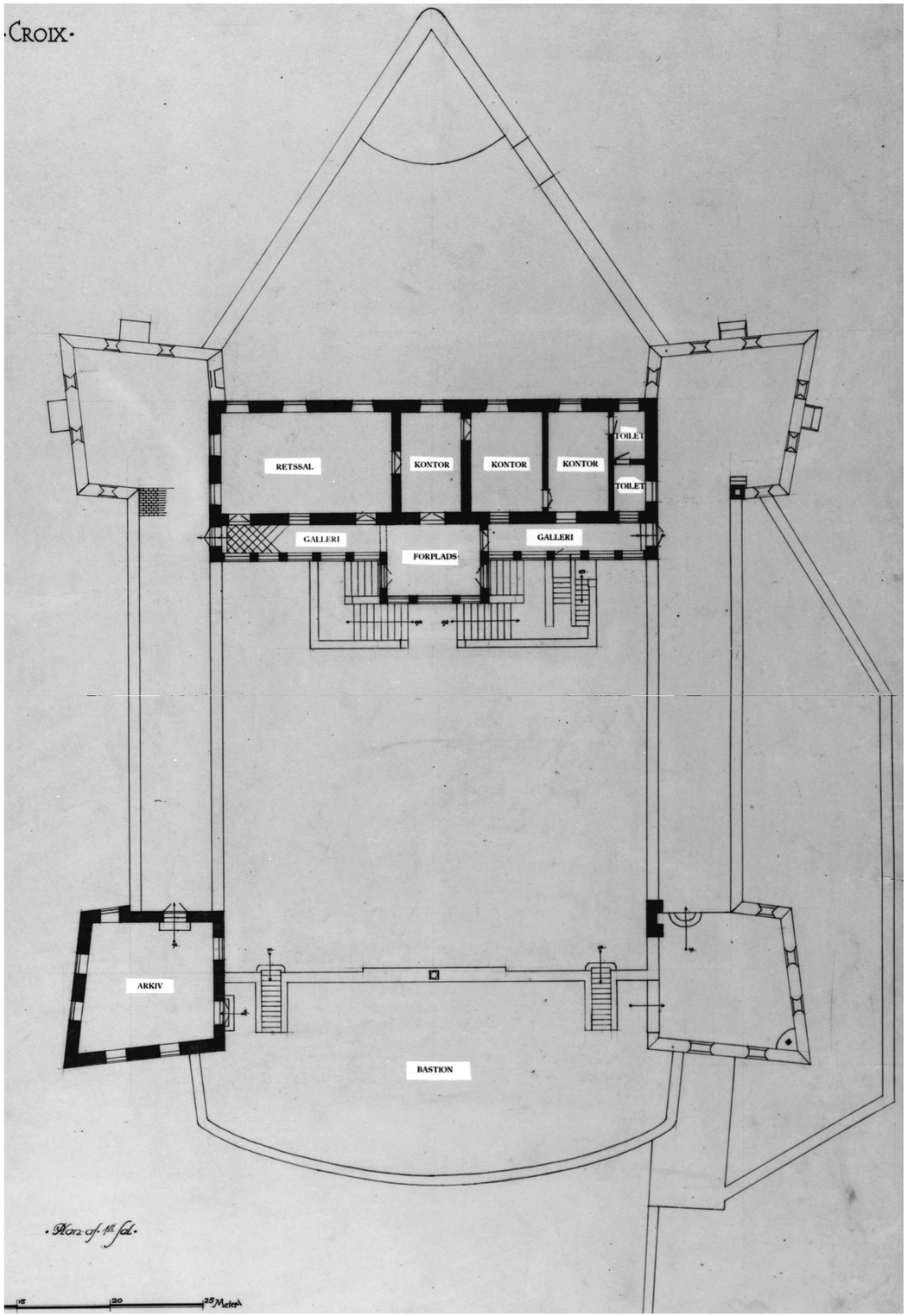

LATRINES EXTENDED
PRISON YARD WALL CONSTRUCTED
PARTITION ADDED
STAIR TO LOWER LEVEL ADDED
SHED ROOF ADDED AT EAST CURTAIN
SHED ROOF ADDED AT EAST CURTAIN
LAUNDRY HOUSE CONSTRUCTED
NORTHEAST BASTION SECOND LEVEL AND ROOF CONSTRUCTED
STABLE AND ASSOCIATED SITE WALLS & GATE CONSTRUCTED
PARTITIONS REMOVED
CARRIAGE HOUSE CONSTRUCTED
SHED ROOF ADDED AT SOUTH CURTAIN

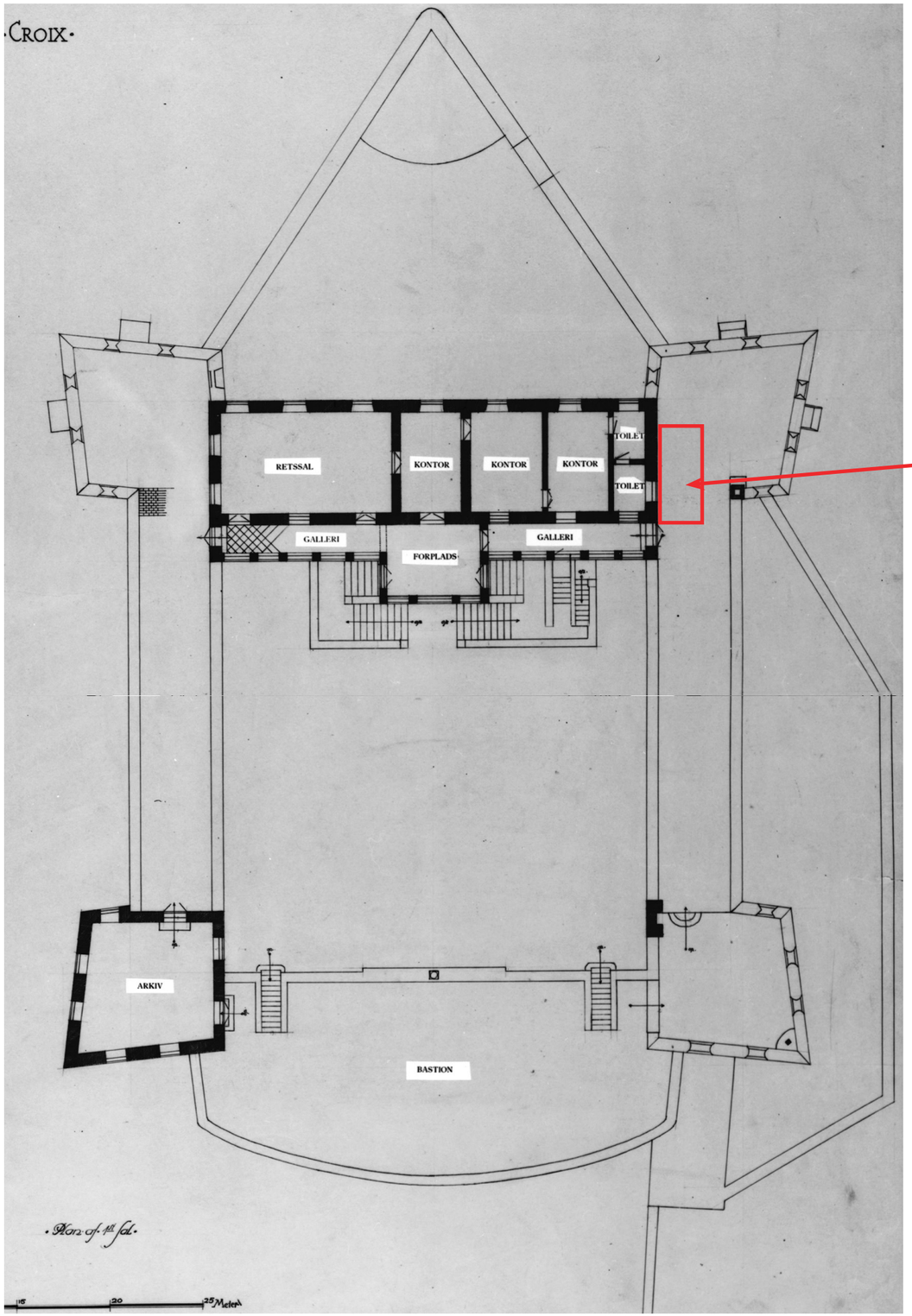

Qvarteer.
b. Fladt Tag over Brandstuen
c. D:o D:o .. 2 Locums
d Vagthuus for Artilleriet
e Krudtegaard
f Pillegalleri i Fortchefens Qvarteer
g Sal i D:o
h Dagligstue i D:o
i Sovekammer i D:o
k D:o i D:o
l Garderobe i D:o
m Spisekammer i D:o
n Brandstue
o Tag over det aabne Galleri
p D:o D:o
q D:o over Skuur til Feltartilleriet
r Fladt Tag over Materialvorudset
s Tag over Vognskuret og Staldvagtskammeret
t D:o over Stalden
u D:o .. Vasherhuset.


LATRINES EXTENDED
LAUNDRY HOUSE CONSTRUCTED
PRISON YARD WALL CONSTRUCTED
NORTHEAST BASTION SECOND LEVEL AND ROOF CONSTRUCTED
SHED ROOF ADDED AT EAST CURTAIN
STABLE AND ASSOCIATED SITE WALLS & GATE CONSTRUCTED
SHED ROOF ADDED AT SOUTH CURTAIN
CARRIAGE HOUSE CONSTRUCTED
STAIR TO LOWER LEVEL ADDED
ARTILLERY SHED ADDED

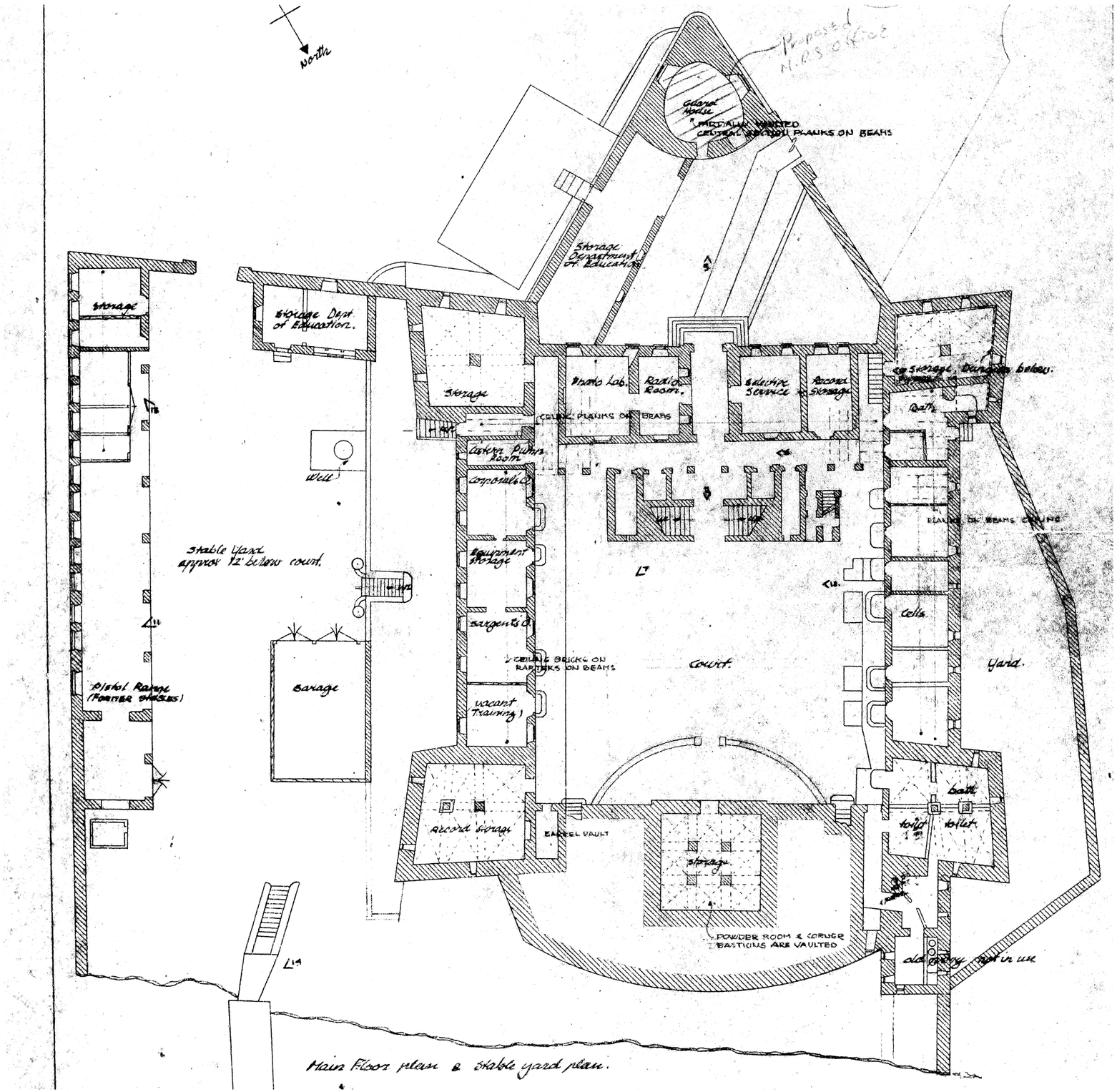

· FORTET · I · CHRISTIANSTED · SANKT ·
VAGTSTUE
INDGANG
FORGAARD
KONTOR
KONTOR
ARKIV
ARKIV
KOGERUM
KONTOR
KONTOR
KONTOR
CELLE
CELLE
CELLE
CELLE
CELLE
FANGEGAARD
KLOSET
PLAN AF KÆLDER UNDER SYDVESTRE TAARN

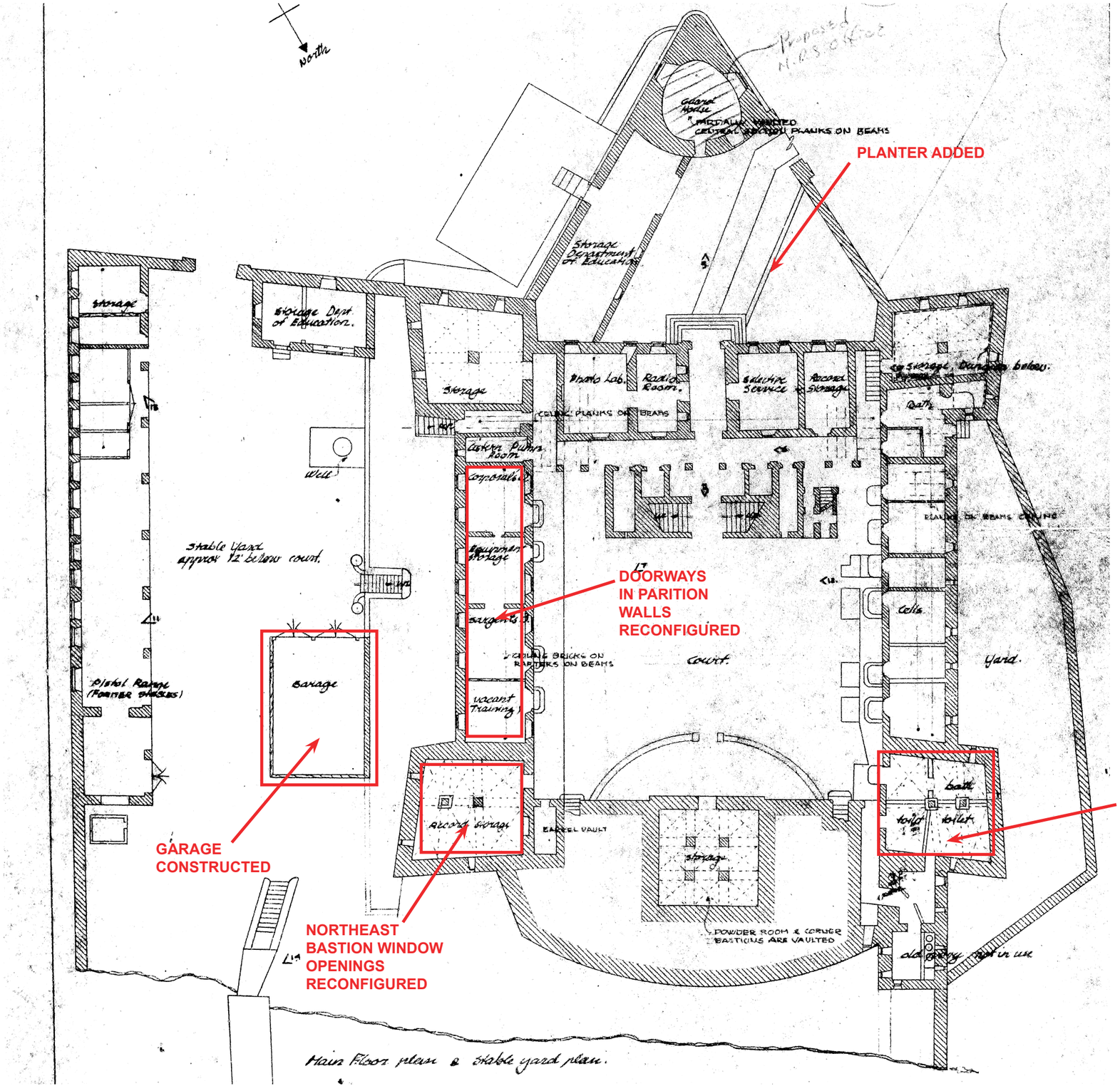

WINDOW OPENINGS ADDED/ RECONFIGURED
ARTILLERY SHED NOT SHOWN
STAIR TO STABLEYARD ADDED
RETAINING WALL AND EXTERIOR STAIR ADDED
NORTHEAST BASTION WINDOW OPENINGS RECONFIGURED
STAIR TO UPPER LEVEL ELIMINATED
EXTERIOR STAIR TO UPPER LEVEL ADDED
NORTHWEST BASTION WINDOW OPENINGS RECONFIGURED
· FORTET · I · CHRISTIANSTED · SANKT ·
VAGTSTUE
INDGANG
FORGAARD
KONTOR
KONTOR
ARKIV
ARKIV
KOGERUM
KONTOR
KONTOR
KONTOR
CELLE
CELLE
CELLE
CELLE
CELLE
FANGEGAARD
KLOSET
PLAN AF KÆLDER UNDER SYDVESTRE TAARN

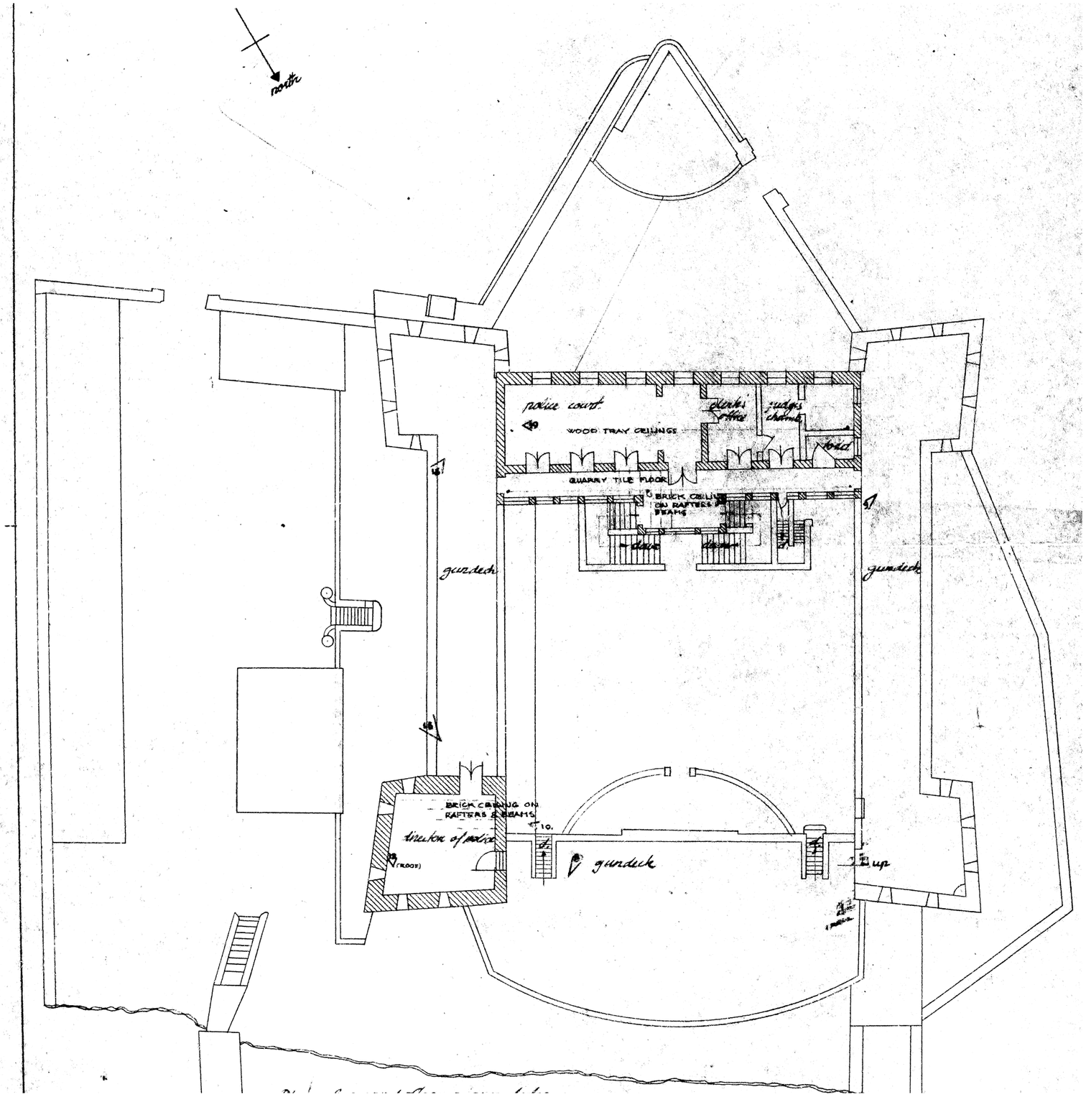

·Croix·
RETSSAL
KONTOR
KONTOR
KONTOR
TOILET
TOILET
GALLERI
FORPLADS
GALLERI
ARKIV
BASTION
·Plan af 1st Sal·
15
20
25 Meter

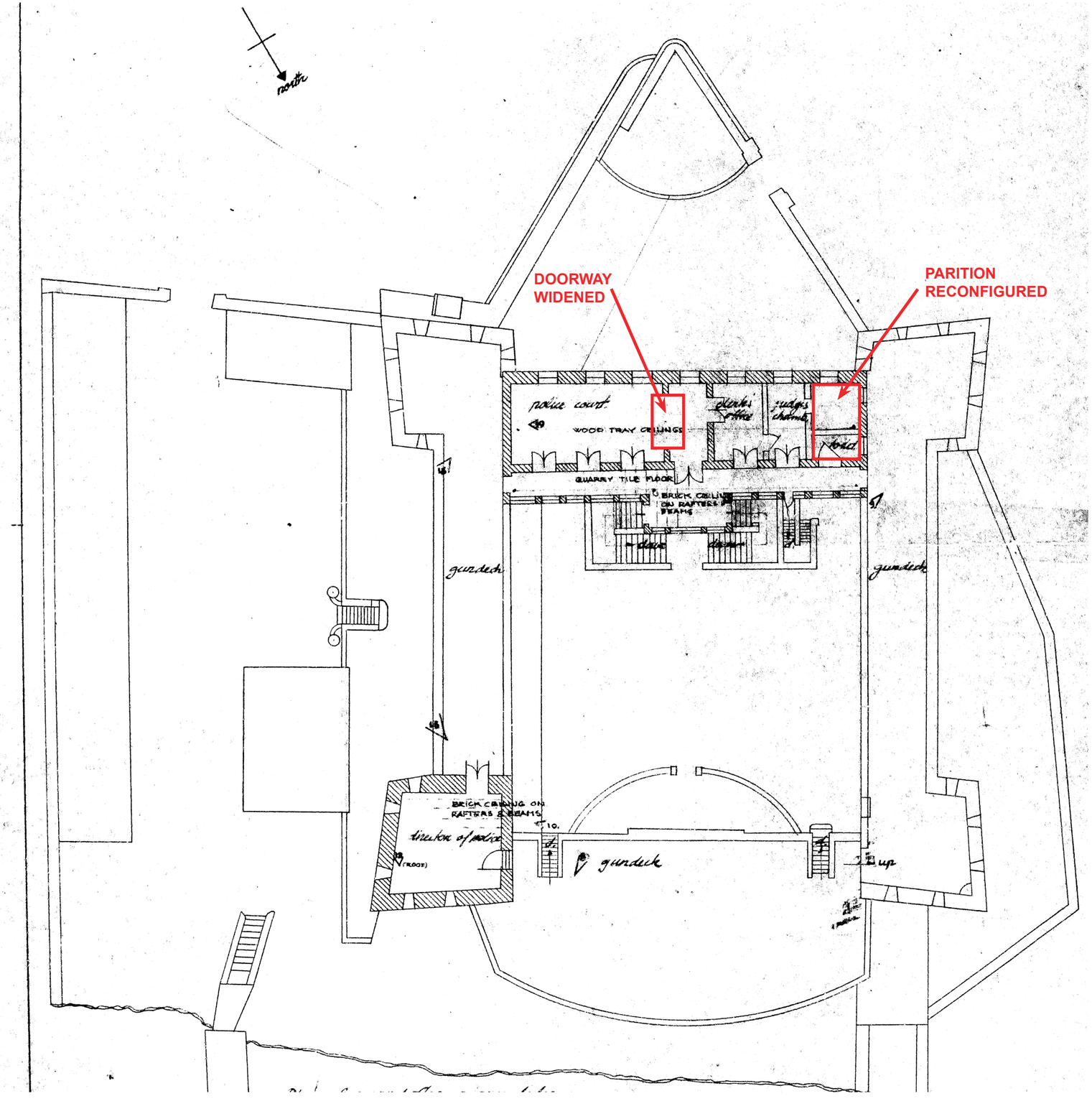


STAIR TO LOWER LEVEL ELIMINATED

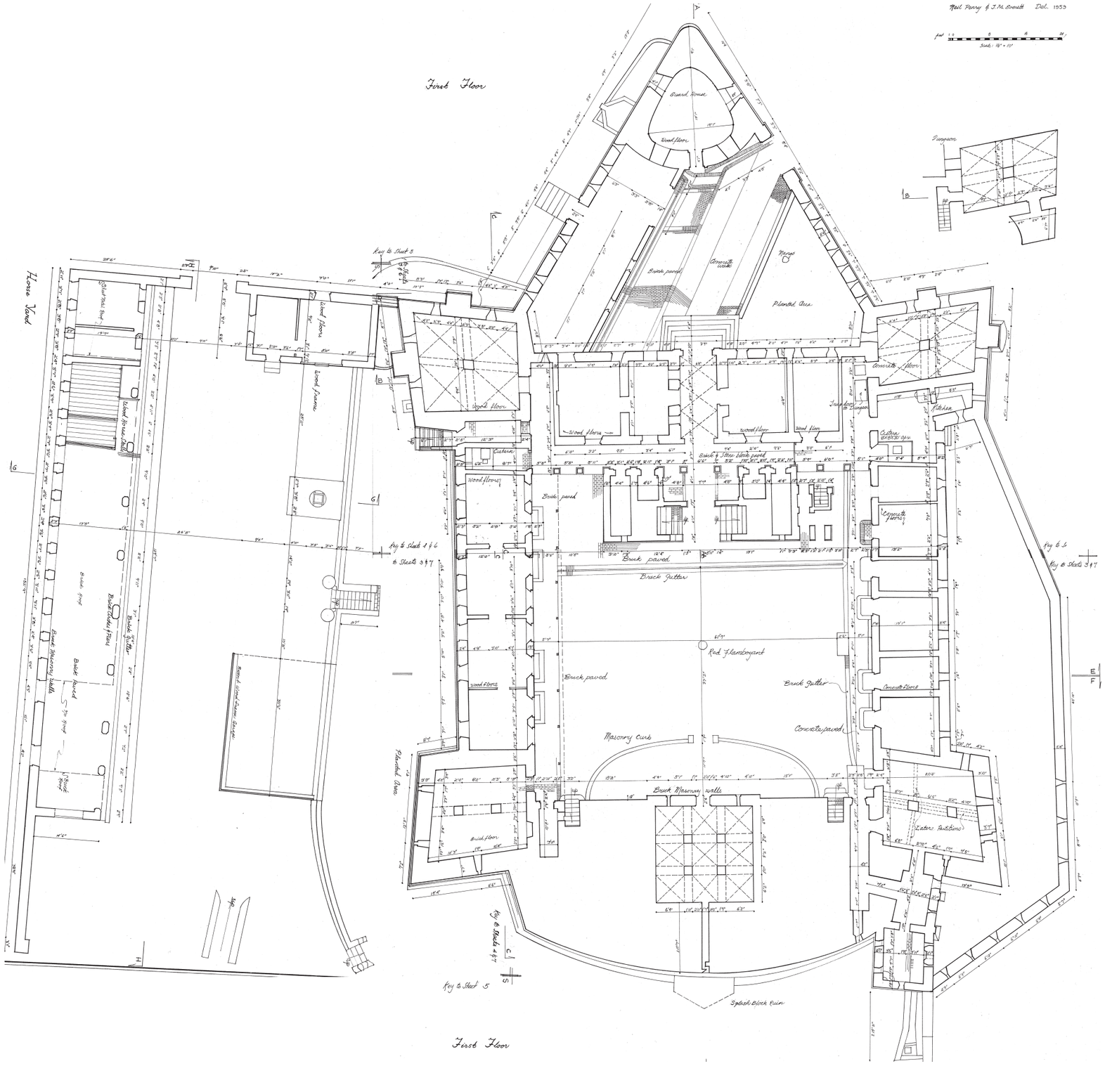

North
Proposed N.A.S. Office
Glass House
" METALLIC VAULTED CEILING
CONCRETE PLANKS ON BEAMS
Storage Dept of Education
Storage
Storage Dept of Education.
Radio Lab.
Radio Room.
Electric Service
Record Storage
CONCRETE PLANKS ON BEAMS
Cistern Pump Room
Corporal's Q
Well
Equipment Storage
Sergeant's Q
CEILING BRICKS ON RAFTERS ON BEAMS
Vacant (Training)
Garage
Pistol Range (FORMER STABLES)
Stable Yard approx 12' below court.
Court.
Cells
Yard.
Bath
toilet
toilet
Record Storage
BARREL VAULT
Storage
POWDER ROOM & CORNER BASTIONS ARE VAULTED
Main Floor plan & Stable yard plan.


North
Storage
Storage Dept of Education.
Storage
Storage Department of Education
Proposed N.R.S.O.F.O.T.
Glazed House
METALLIC VAULTED CEILING
CEILING PLANKS ON BEAMS
PLANTER ADDED
Radio Lab.
Radio Room.
Electric Service
Record Storage
CEILING PLANKS ON BEAMS
Cistern Pump Room
Corporal's
Equipment Storage
Sergeant's
Vacant Training
Well
Stable Yard approx 12' below court.
Garage
Pistol Range (Former Stables)
CEILING BRICKS ON RAFTERS ON BEAMS
Court
Record Storage
BARREL VAULT
Storage
POWDER ROOM & CORNER BASTIONS ARE VAULTED
Cells
Yard
Bath
Toilet
Toilet
Main Floor plan & Stable yard plan.
DOORWAYS IN PARITION WALLS RECONFIGURED
GARAGE CONSTRUCTED
NORTHEAST BASTION WINDOW OPENINGS RECONFIGURED
BATHROOM PARITIONS ADDED; WINDOW OPENINGS RECONFIGURED

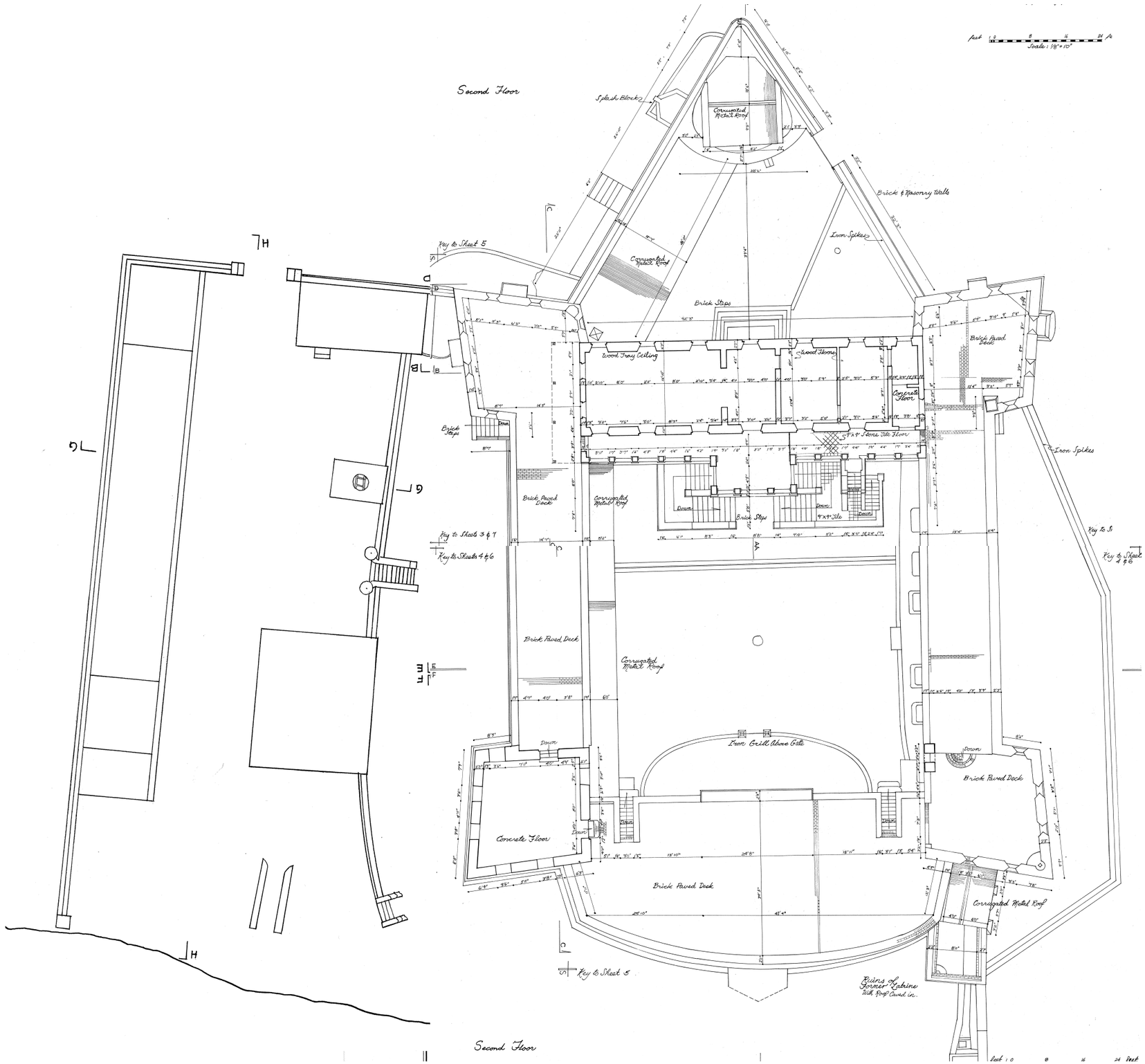

north
police court
clerk's office
judge's chambers
WOOD TRAY CEILINGS
QUARRY TILE FLOOR
BRICK CEILING ON RAFTERS & BEAMS
gundeck
gundeck
BRICK CEILING ON RAFTERS & BEAMS
director of police
(ROOF)
gundeck
up


DOORWAY
WIDENED
PARITION
RECONFIGURED
north
police court
WOOD TRAY CEILINGS
QUARRY TILE FLOOR
BRICK CEILING ON RAFTERS & BEAMS
gundeck
gundeck
gundeck
BRICK CEILING ON RAFTERS & BEAMS
direction of police
(ROOF)
up

Historical Epoch Drawings 17 of 18
1959 First-floor Plan
(No substantive changes since 1953)



Historical Epoch Drawings 18 of 18
1959 Second-floor Plan
(No substantive changes since 1953)



Appendix C:
Annotated HABS Documentation
Drawings Showing Present Conditions

Sheet 1: Context Plan

Sheet 2: First-floor Plan (South)

Sheet 3: First-floor Plan (North)

Sheet 4: Stableyard Plan

Sheet 5: Second-floor Plan (South)

Sheet 6: Second-floor Plan (North)

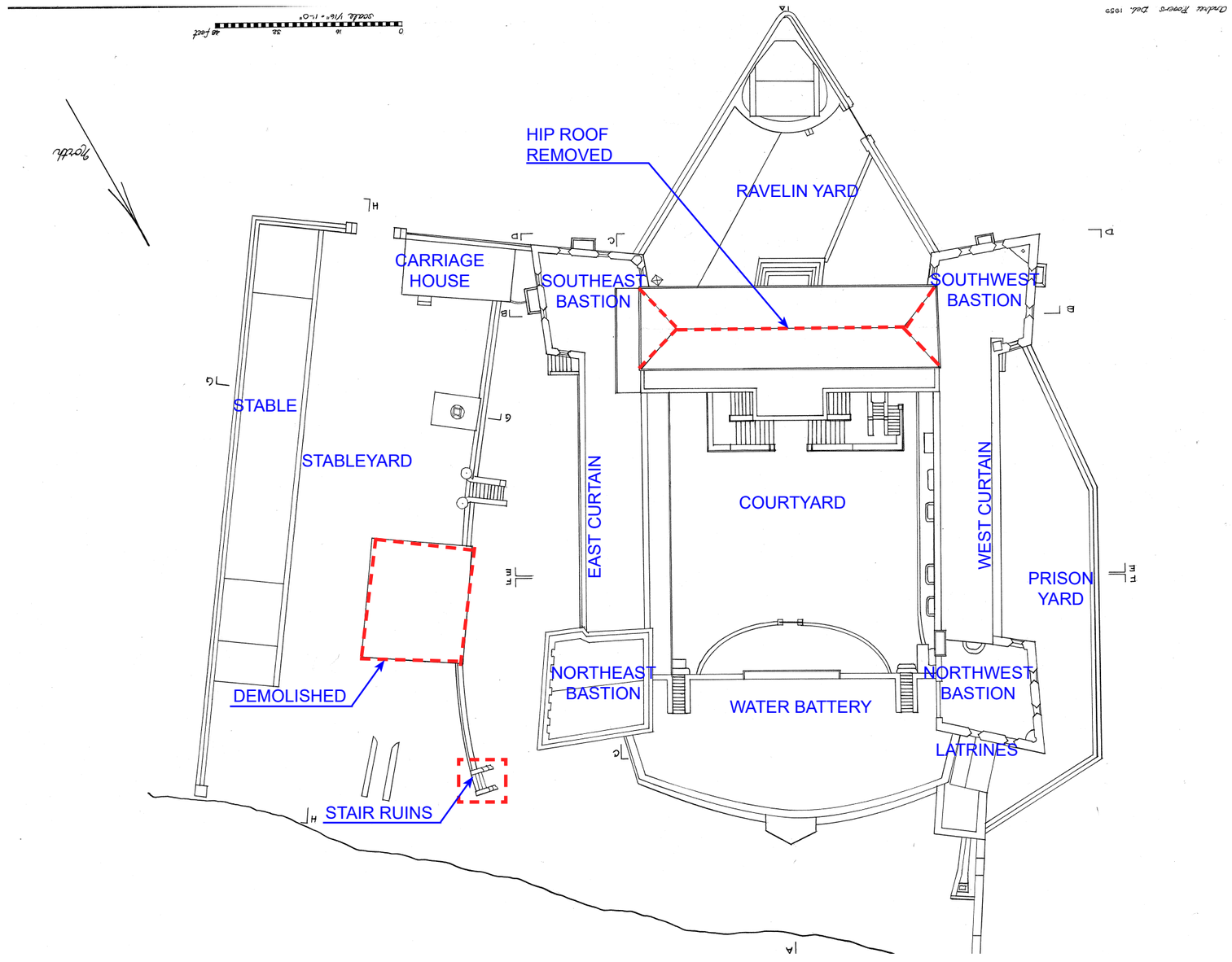
Sheet 7: Southwest, West, and East Elevations

Sheet 8: Sections - Ravelin, South Curtain, and Water Battery

Sheet 9: Sections - South and East Curtains

Sheet 10: Section-Elevations - South Curtain

Sheet 11: Section-Elevations - Stableyard and Courtyard



CONTEXT PLAN
SCALE: 1/32” = 1’-0”

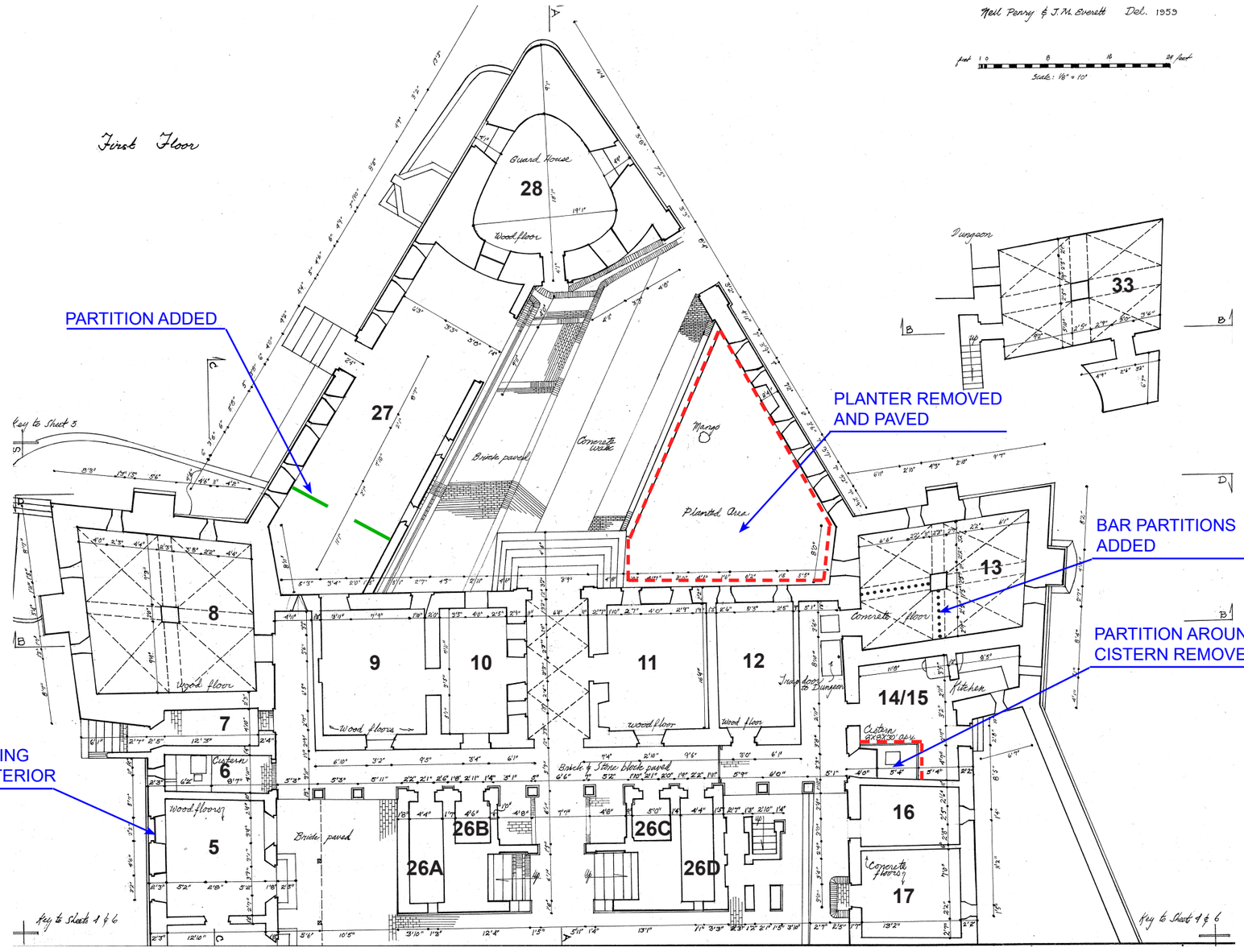
PLAN
NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN

CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE: 07.01.2021
RECORDED BY: JKO, RJH, JPA
SCALE: 1/32” =1’-0”
HSR APPENDIX C: SHEET 1



FIRST-FLOOR PLAN (SOUTH)
SCALE: 1/16” = 1’-0”

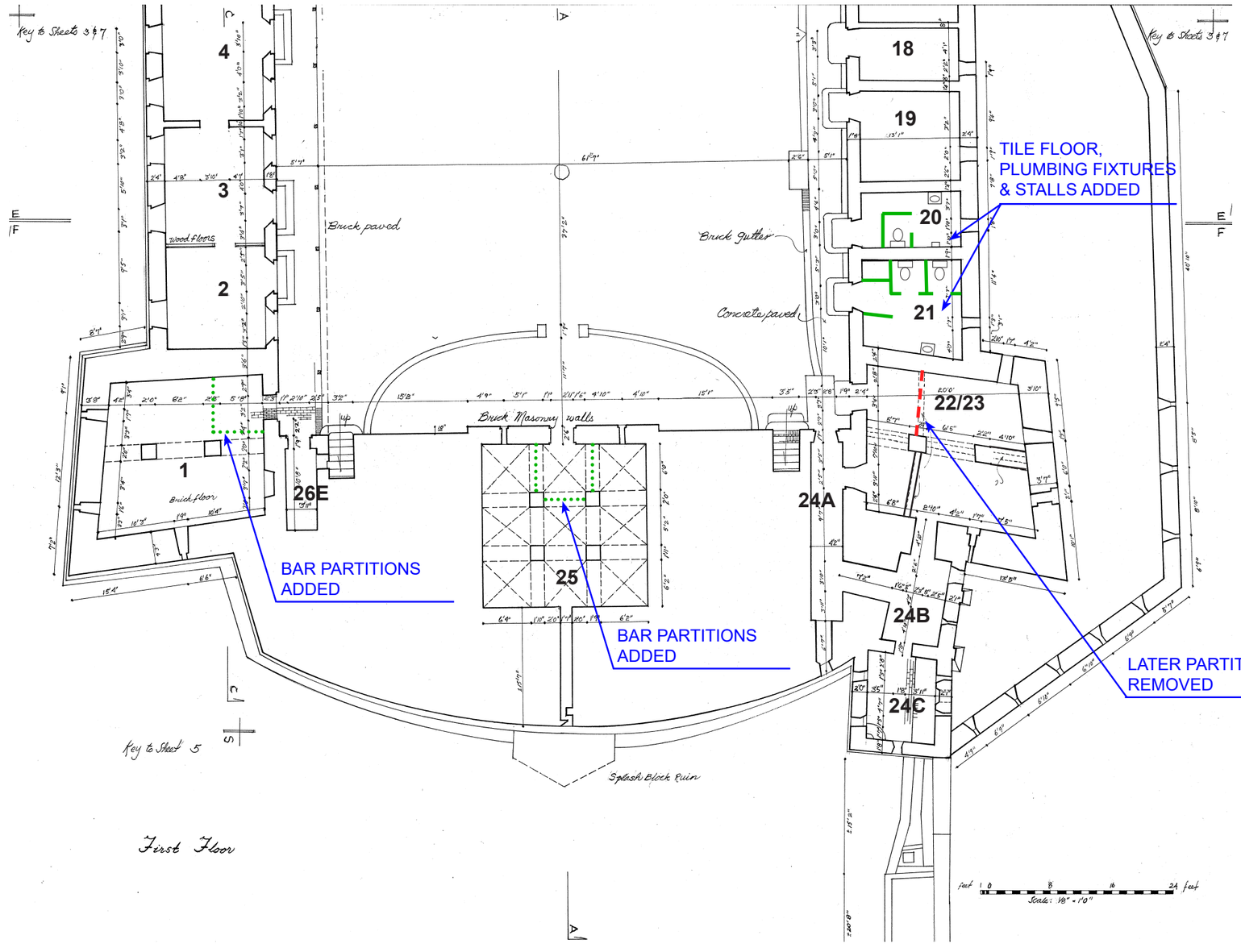
PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN

CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE: 07.01.2021
RECORDED BY: JKO, RJH, JPA
SCALE: 1/16” =1’-0”
HSR APPENDIX C: SHEET 2



First Floor

FIRST-FLOOR PLAN (NORTH)
SCALE: 1/16” = 1’-0”

PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

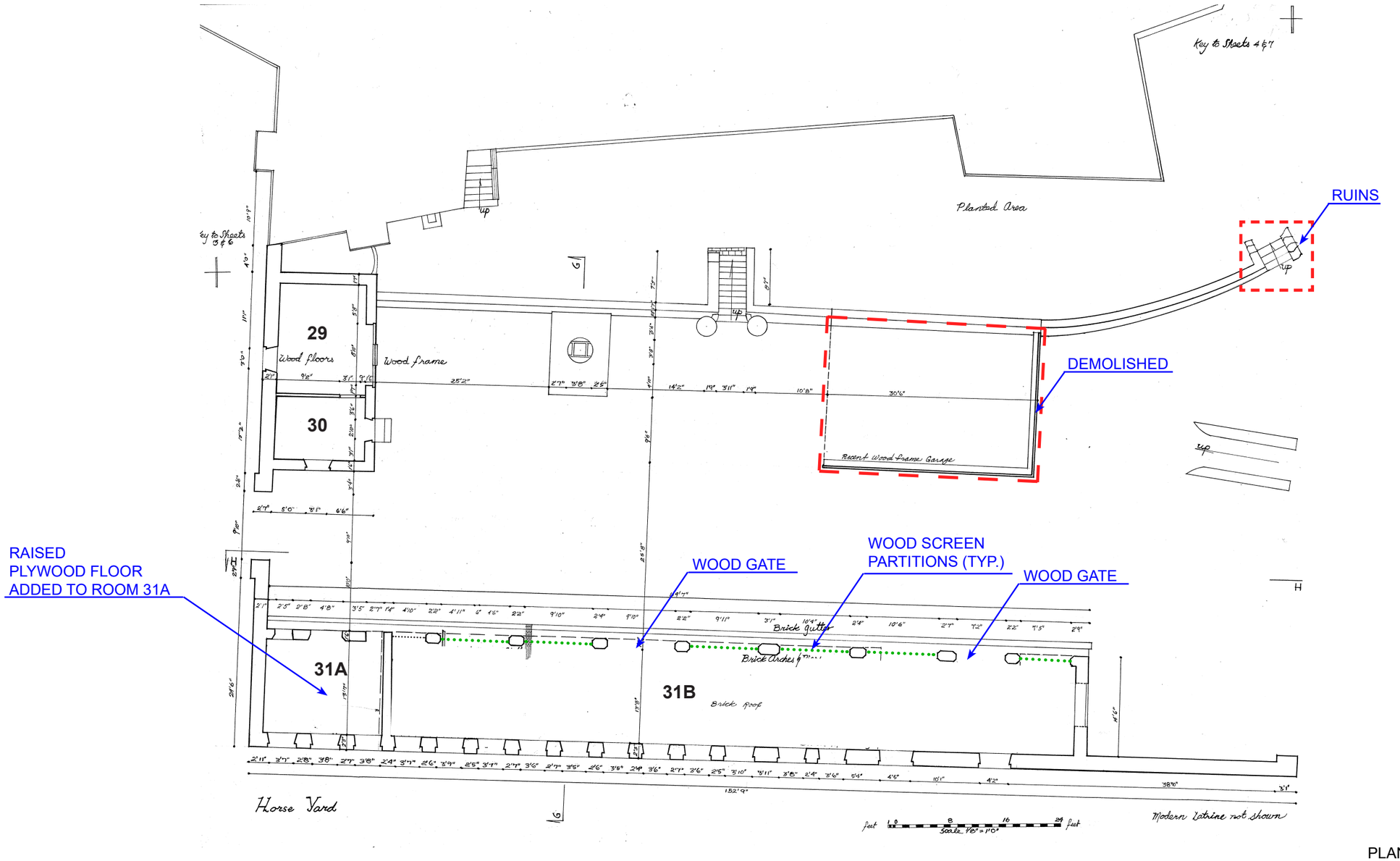
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR APPENDIX C: SHEET
3



STABLEYARD PLAN
SCALE: 1/16” = 1’-0”

PLAN
NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

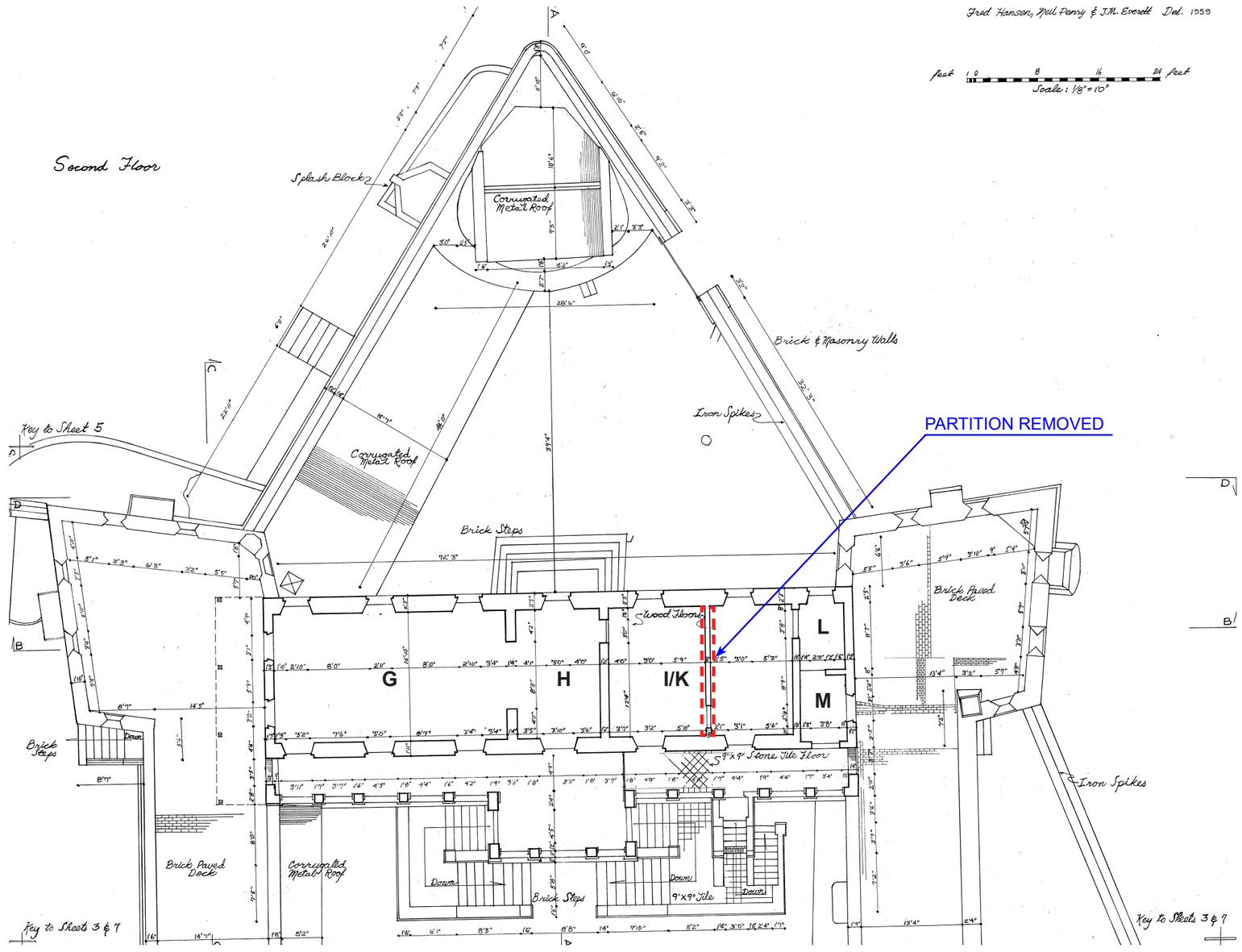
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR
APPENDIX C:
SHEET
4



SECOND-FLOOR PLAN (SOUTH)
SCALE: 1/16” = 1’-0”

PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

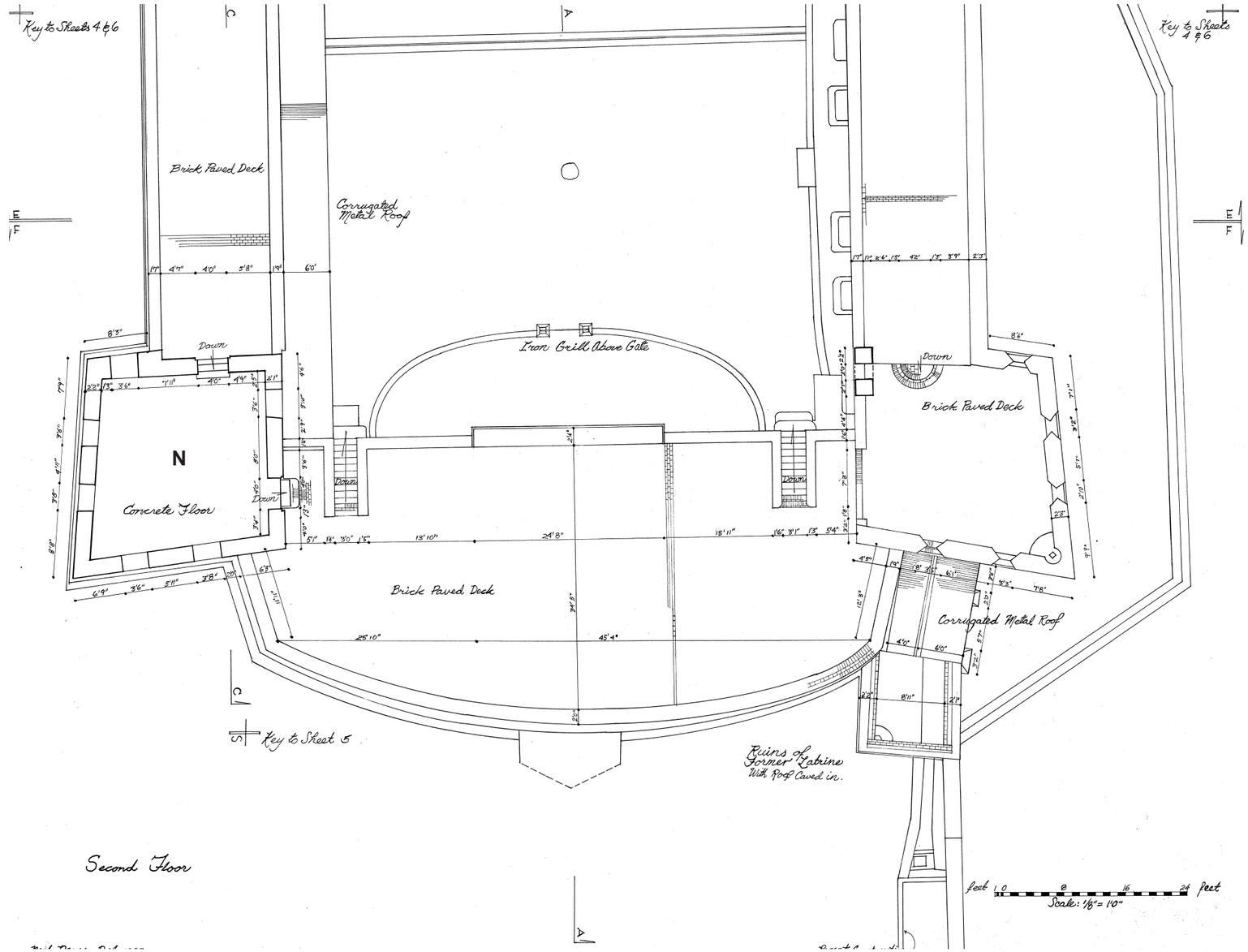
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR APPENDIX C: SHEET
5



SECOND-FLOOR PLAN (NORTH)
SCALE: 1/16” = 1’-0”

PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

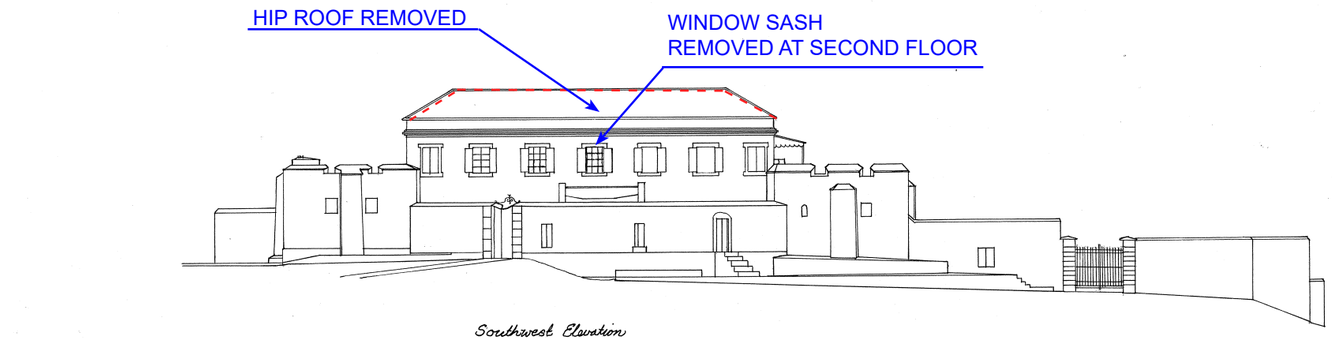
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

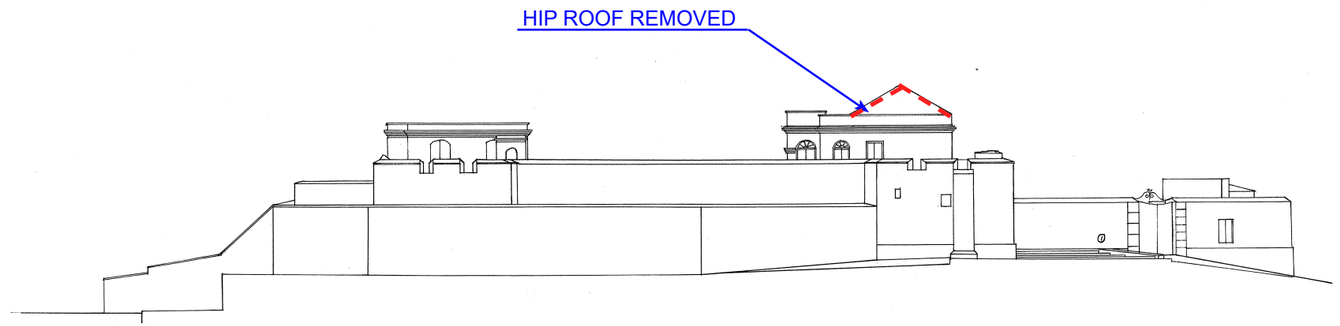
RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

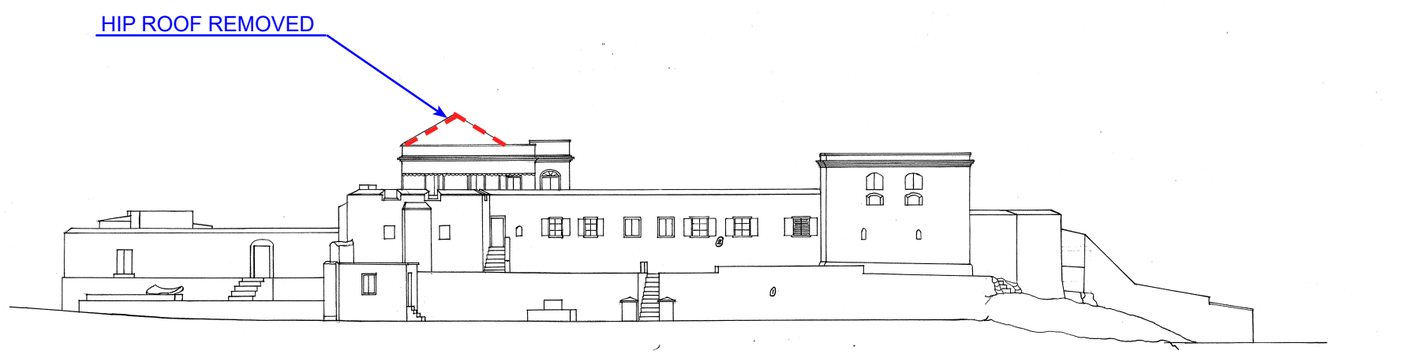
HSR APPENDIX C: SHEET
6



Southwest Elevation



West Elevation (@ modern balustrade and flower pots not shown)



East Elevation (@ shed in horse yard not shown. @ bars on casement windows not shown)

SOUTHWEST, WEST, AND EAST ELEVATIONS
SCALE: 1/32” = 1’-0”

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WINSTON-SALEM, NORTH CAROLINA

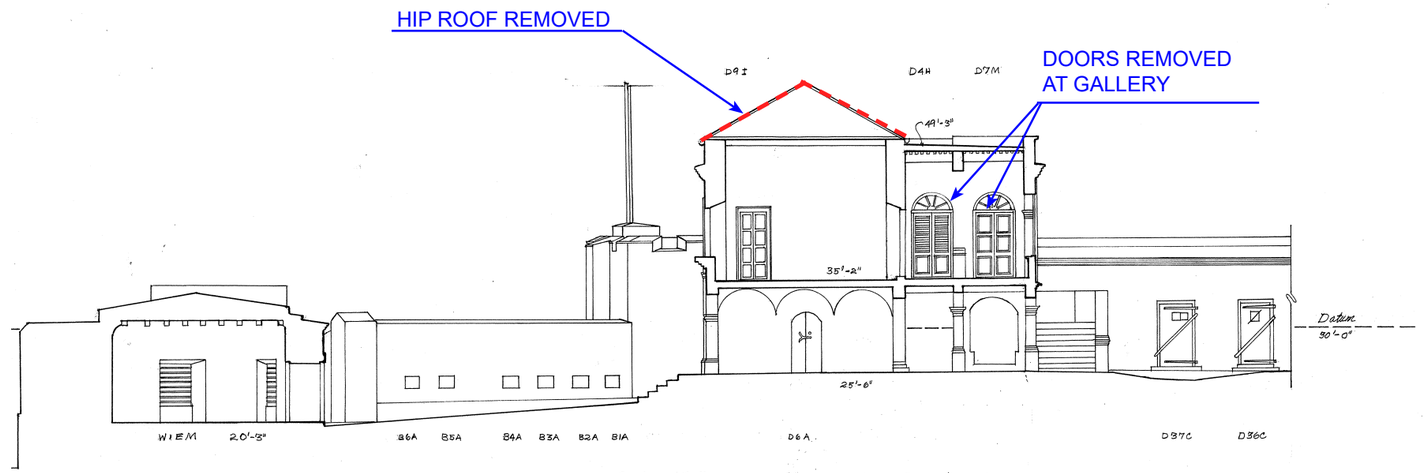
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
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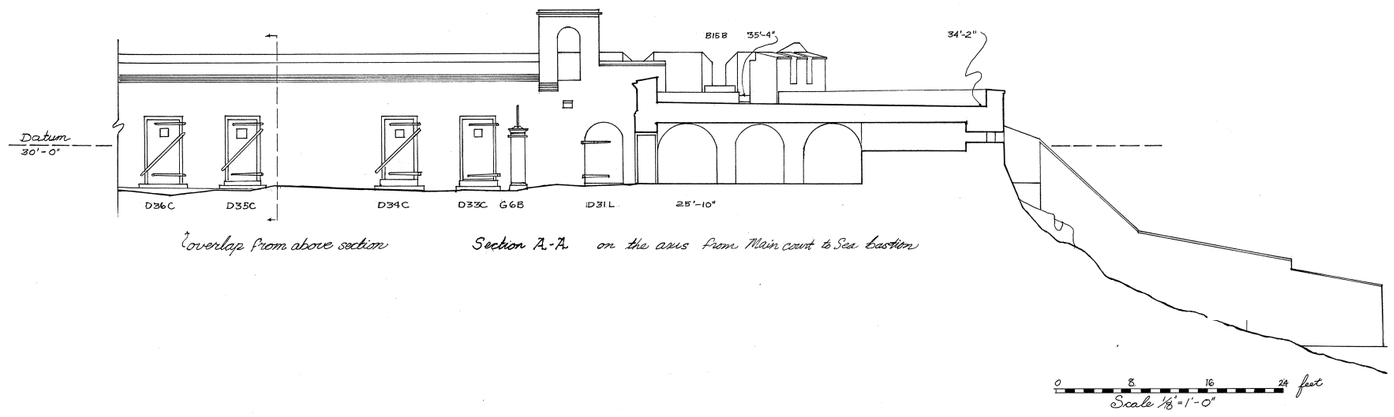
RECORDED BY:
JKO, RJH, JPA

SCALE:
1/32” =1’-0”

HSR APPENDIX C: SHEET
7



Section A-A on the axis from Guardhouse to Main court



Overlap from above section

Section A-A on the axis from Main court to Sea bastion

SECTIONS - RAVELIN, SOUTH CURTAIN, AND WATER BATTERY

SCALE: 1/16” = 1’-0”

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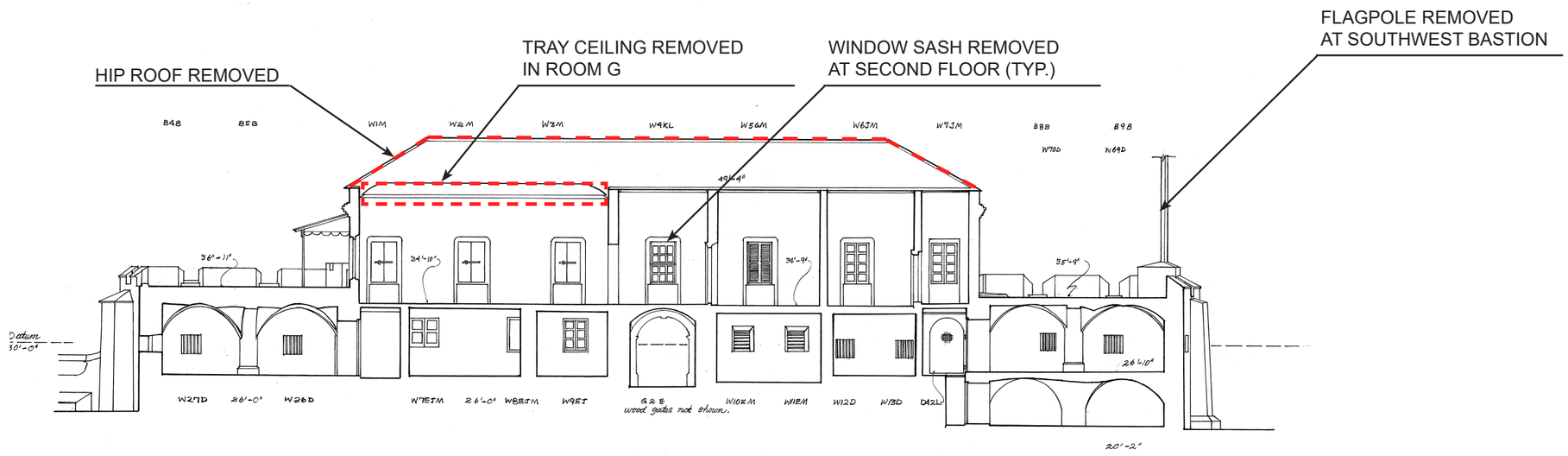
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

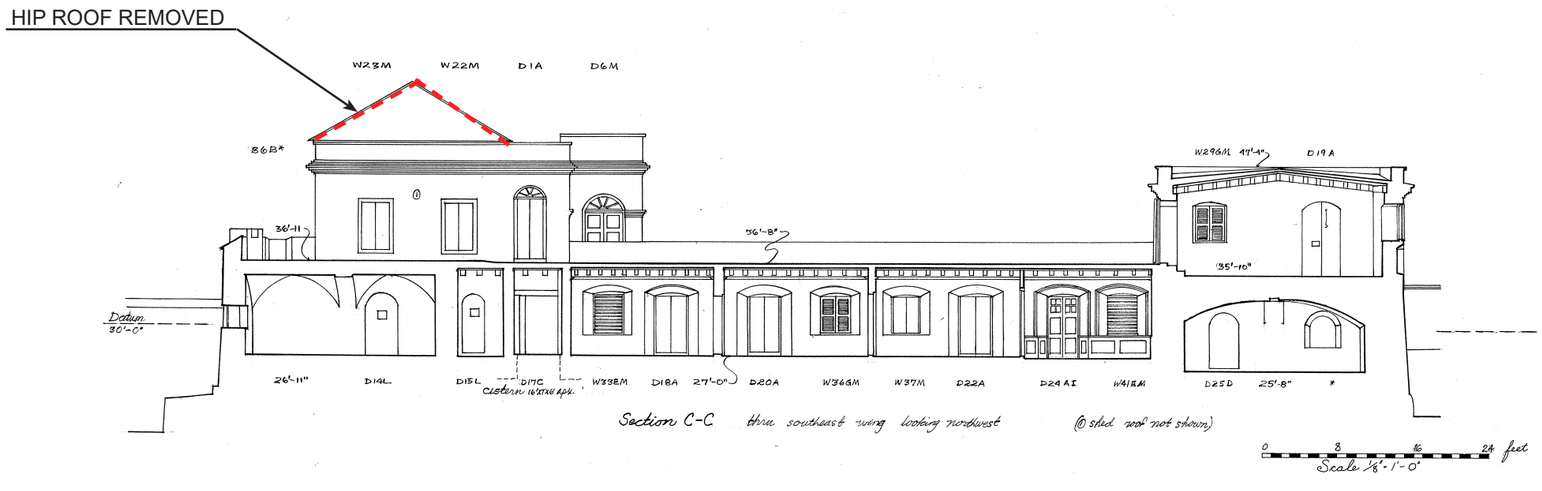
RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR APPENDIX C: SHEET
8



Section B-B thru southwest wing looking southwest



Section C-C thru southeast wing looking northwest (C shed roof not shown)

SECTIONS - SOUTH AND EAST CURTAINS
SCALE: 1/16” = 1’-0”

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WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN

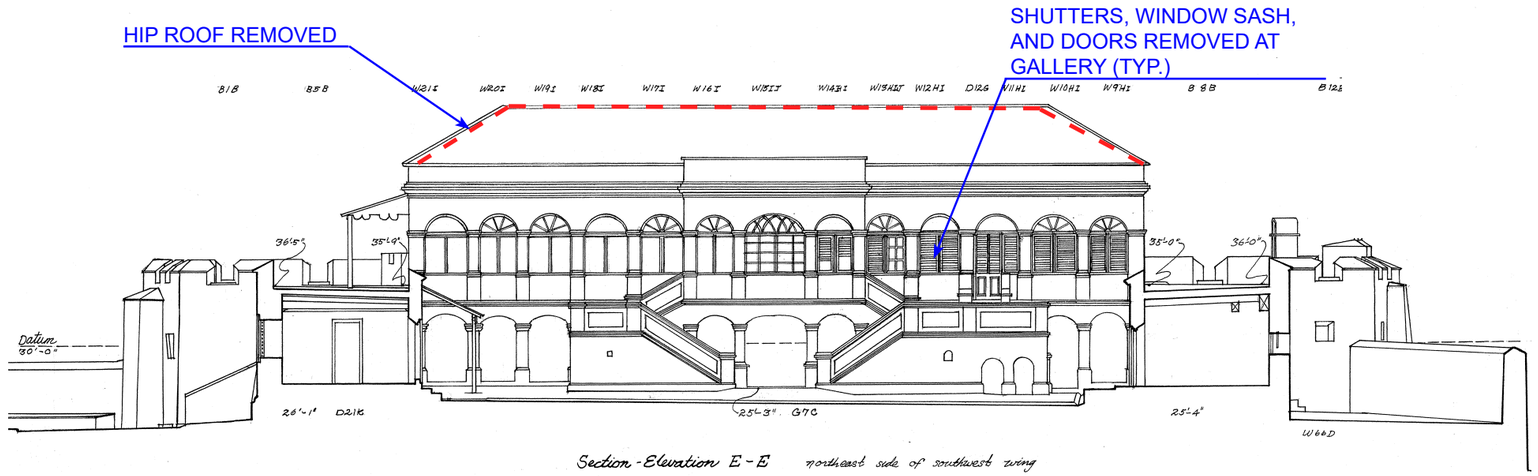
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

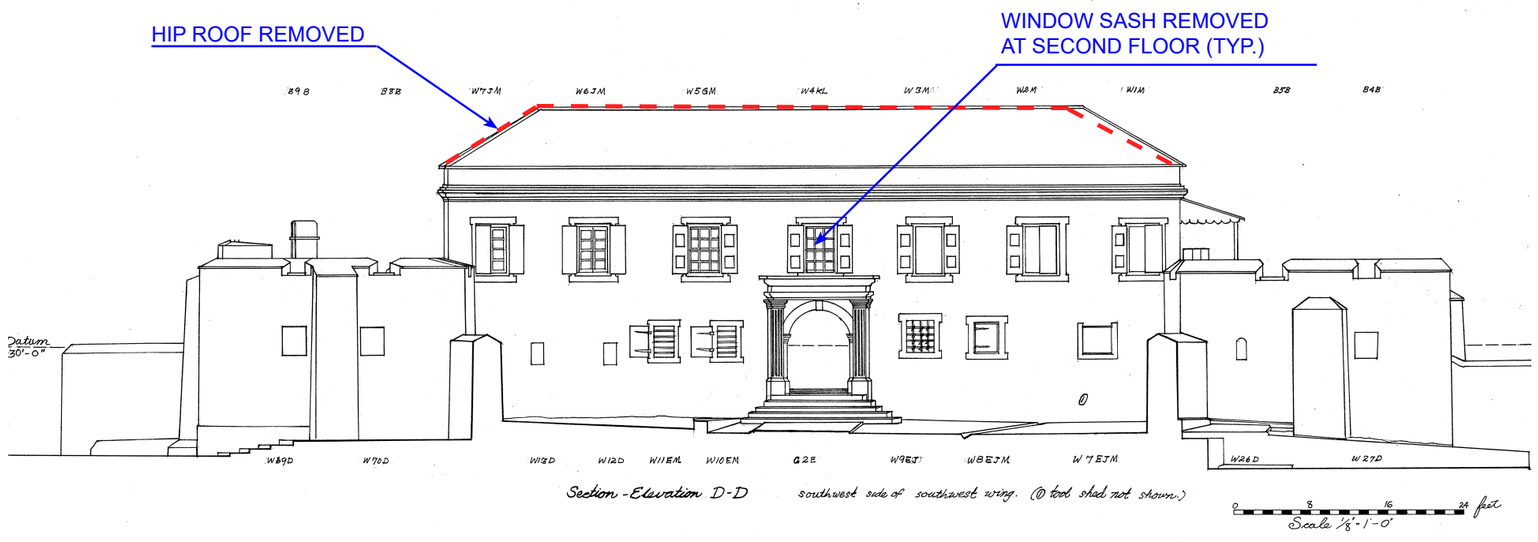
RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR APPENDIX C: SHEET
9



Section-Elevation E-E northeast side of southwest wing



Section-Elevation D-D southwest side of southwest wing. (@ tool shed not shown.)

SECTION-ELEVATIONS - SOUTH CURTAIN
SCALE: 1/16” = 1’-0”

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WINSTON-SALEM, NORTH CAROLINA

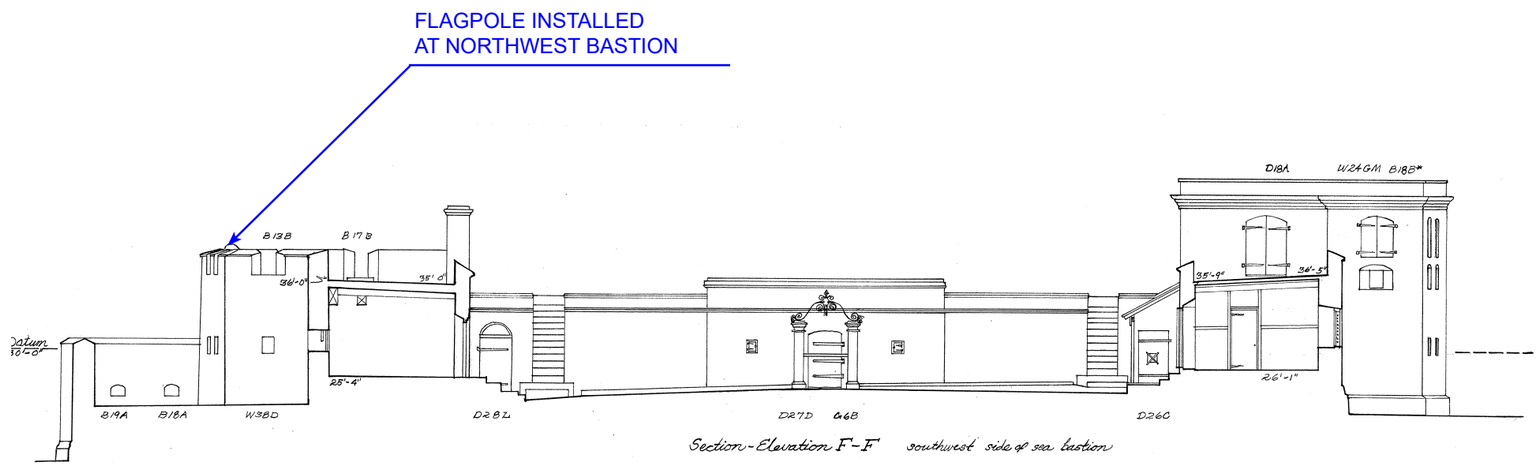
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
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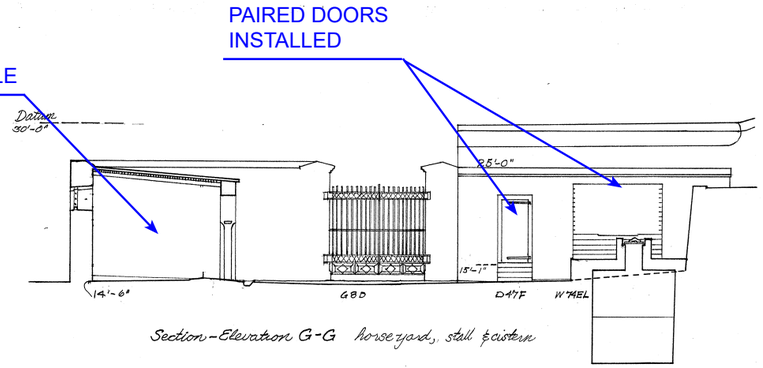
RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

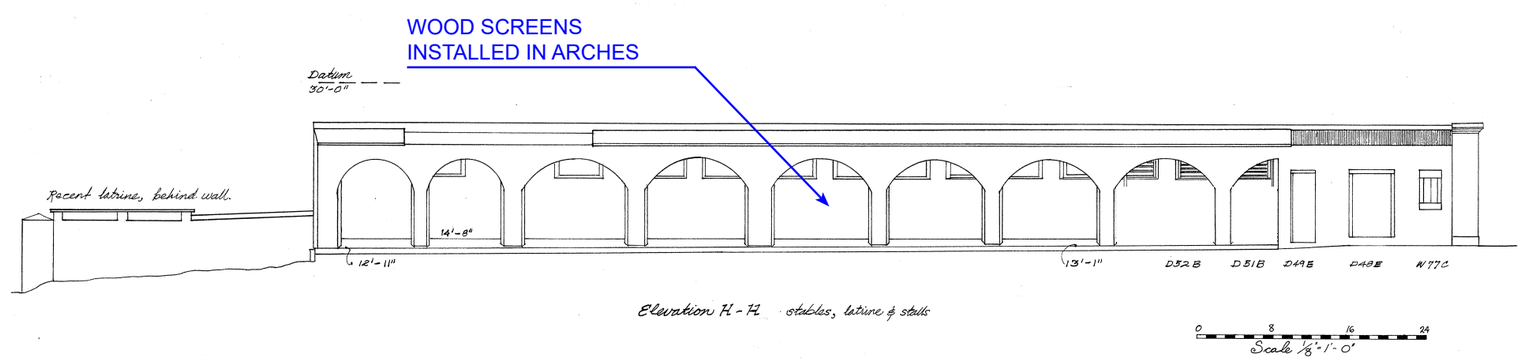
HSR APPENDIX C: SHEET
10



Section-Elevation F-F southwest side of sea bastion



Section-Elevation G-G horseyard, stall & cistern



Elevation H-H stables, latrine & stalls

0 8 16 24
Scale 1/8"-1'-0"

SECTION-ELEVATIONS - COURTYARD AND STABLEYARD
SCALE: 1/16" = 1'-0"

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16" =1'-0"

HSR APPENDIX C:
SHEET
11

Appendix D:
Selected Utility Drawings

Sheet 1: Electrical Plan, 2010

Sheet 2: Ground Floor HVAC Drain Layout Plan, 2010

Sheet 3: Ground Floor HVAC Layout Plan Details, 2010

Sheet 4: Fire Alarm Networking Detail of Buildings, 2016

Sheet 5: First-floor Fire Alarm System Plan, 2016

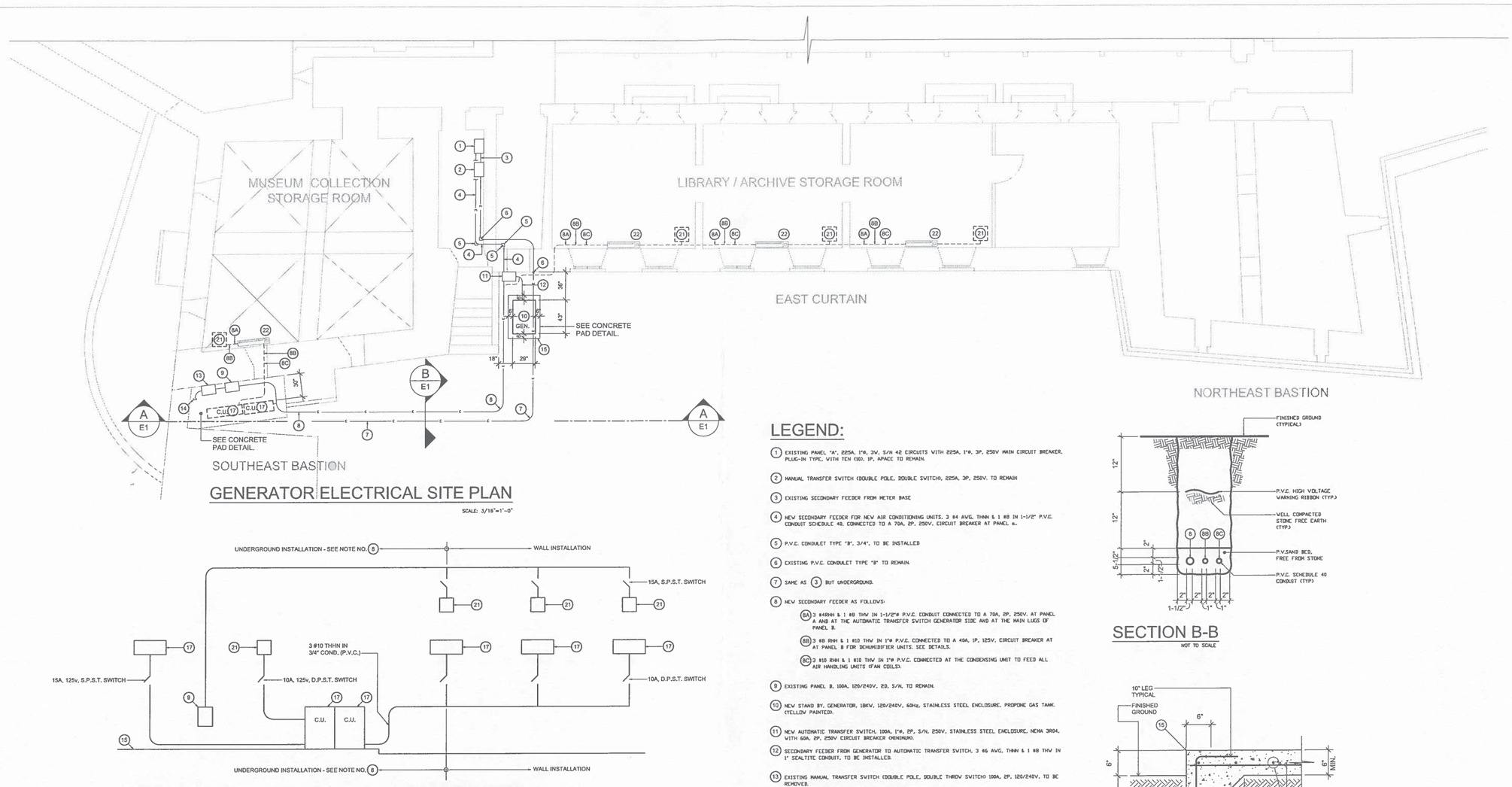
Sheet 6: Second-floor Fire Alarm System Plan, 2016

Sheet 7: Stable Fire Alarm Plan, 2016

Sheet 8: Fire Alarm Riser Diagram, 2016

Sheet 9: Fire Alarm System Calculations, 2016

Sheet 10: Fire Alarm Details and Specifications, 2016

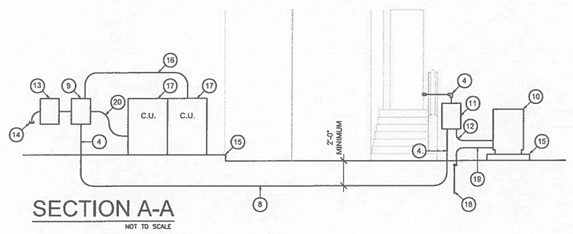


GENERATOR ELECTRICAL SITE PLAN

SCALE: 3/16"=1'-0"

DISCONNECT SWITCH FOR AIR HANDLING UNITS

NOT TO SCALE



SECTION A-A

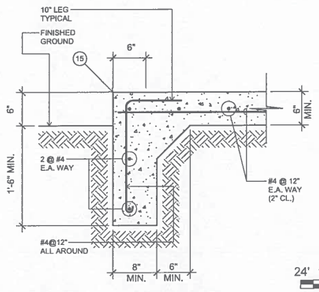
NOT TO SCALE

LEGEND:

1. EXISTING PANEL "A", 225A, 1"Ø, 3W, S/N 42 CIRCUITS WITH 225A, 1"Ø, 3P, 250V MAIN CIRCUIT BREAKER, PLUG-IN TYPE, WITH TEN (10), 1P, APACE TO REMAIN.
2. MANUAL TRANSFER SWITCH (DOUBLE POLE, DOUBLE SWITCH), 225A, 3P, 250V. TO REMAIN
3. EXISTING SECONDARY FEEDER FROM METER BASE
4. NEW SECONDARY FEEDER FOR NEW AIR CONDITIONING UNITS. 3 #4 AWG, THHN & 1 #8 IN 1-1/2" P.V.C. CONDUIT SCHEDULE 40, CONNECTED TO A 70A, 2P, 250V, CIRCUIT BREAKER AT PANEL a.
5. P.V.C. CONDULET TYPE "B", 3/4", TO BE INSTALLED
6. EXISTING P.V.C. CONDULET TYPE "B" TO REMAIN.
7. SAME AS (3) BUT UNDERGROUND.
8. NEW SECONDARY FEEDER AS FOLLOWS:
   - (8A) 3 #4RHH & 1 #8 THW IN 1-1/2"Ø P.V.C. CONDUIT CONNECTED TO A 70A, 2P, 250V. AT PANEL A AND AT THE AUTOMATIC TRANSFER SWITCH GENERATOR SIDE AND AT THE MAIN LUGS OF PANEL B.
   - (8B) 3 #8 RHH & 1 #10 THW IN 1"Ø P.V.C. CONNECTED TO A 40A, 1P, 125V, CIRCUIT BREAKER AT AT PANEL B FOR DEHUMIDIFIER UNITS. SEE DETAILS.
   - (8C) 3 #10 RHH & 1 #10 THW IN 1"Ø P.V.C. CONNECTED AT THE CONDENSING UNIT TO FEED ALL AIR HANDLING UNITS (FAN COILS).
9. EXISTING PANEL B, 100A, 120/240V, 2Ø, S/N, TO REMAIN.
10. NEW STAND BY, GENERATOR, 18KW, 120/240V, 60Hz, STAINLESS STEEL ENCLOSURE, PROPANE GAS TANK. (YELLOW PAINTED).
11. NEW AUTOMATIC TRANSFER SWITCH, 100A, 1"Ø, 2P, S/N, 250V, STAINLESS STEEL ENCLOSURE, NEMA 3R04, WITH 60A, 2P, 250V CIRCUIT BREAKER OMINIMUM.
12. SECONDARY FEEDER FROM GENERATOR TO AUTOMATIC TRANSFER SWITCH, 3 #6 AWG, THHN & 1 #8 THW IN 1" SEALTITE CONDUIT, TO BE INSTALLED.
13. EXISTING MANUAL TRANSFER SWITCH (DOUBLE POLE, DOUBLE THROW SWITCH) 100A, 2P, 120/240V. TO BE REMOVED.
14. EXISTING ELECTRICAL CORD, TO BE REMOVED
15. CONCRETE PAD.
16. SECONDARY FEEDER FROM PANEL B TO CONDENSING UNITS, 3 #8 AWG THHN & 1 #10 THW IN 3/4" SEALTITE CONDUIT TO BE INSTALLED.
17. AIR CONDITIONING UNIT, TO BE INSTALLED.
18. COPPERWELD GROUND AND CLAMP, 5/8" x 8'-0", TO BE INSTALLED
19. #6 THN IN 1/2"Ø RIG. GALVANIZED CONDUIT, TO BE INSTALLED.
20. SECONDARY FEEDER FROM PANEL B TO CONDENSING UNIT, 3 #10 AWG, THHN & 1 #12 THW IN 3/4" SEALTITE CONDUIT TO BE INSTALLED
21. DEHUMIDIFIER
22. AIR CONDITIONING UNITS

SECTION B-B

NOT TO SCALE



CONC. PAD DETAIL

NOT TO SCALE

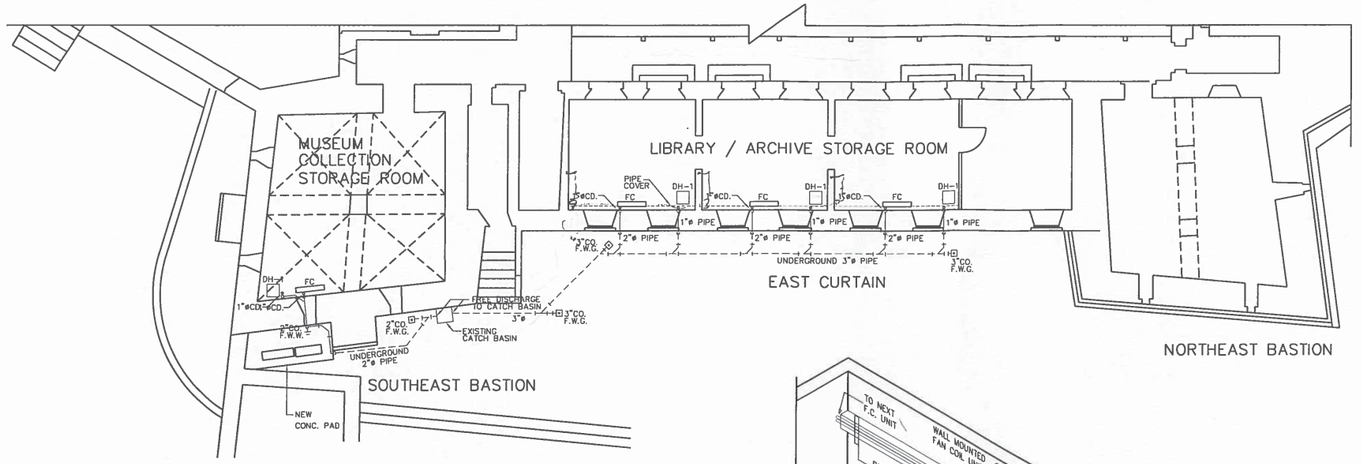
24' 18' 12' 6' 0' 12' 24'

12' 9' 6' 3' 0' 6' 12'

SCALE OF FEET

DESIGNED: PJMV; CADD JLR; TECH. REVIEW: ASR; DATE: 08/24/10	SUB SHEET NO. E1	TITLE OF SHEET: ELECTRICAL PLAN — FORT CHISTIANSVAERN, CHRISTIANSTED NATIONAL HISTORIC SITE	DRAWING NO. 399 80,057; PMIS/PKG NO. CHRI 136136; SHEET 3 OF 3

8/24/10 11:25 23127 R18 P:\MASTER\PROJECTS\100012630_NPS ST CROIX SERVICES\FORT CHR HVAC DESIGN SERV\ACAD\MISC\VICTOR ARCHIVE\E-1.DWG



GROUND FLOOR HVAC DRAIN LAYOUT PLAN

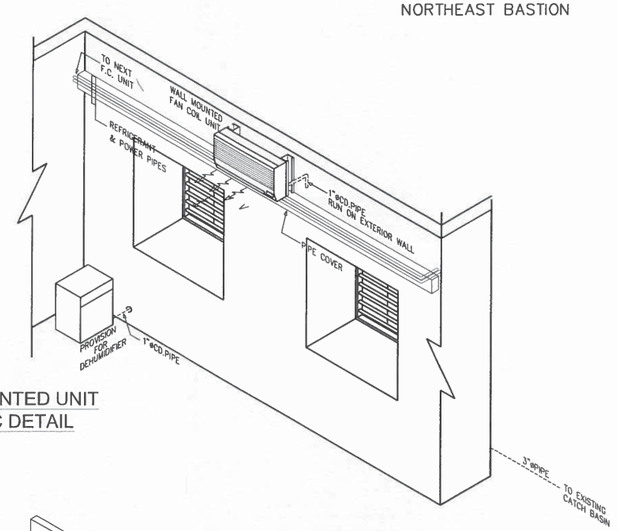
SCALE: 1/8"=1'-0"

LEGEND:

- - - - -	UNDERGROUND DRAIN PIPE
———	TRHU WALL DRAIN PIPE
FC.	FAN COIL
CD.	CONDENSATE DRAIN
DH-1	PROVISION FOR DEHUMIDIFIER
CO. F.W.G.	CLEANOUT FLUSH WITH GRADE
CO. F.W.W.	CLEANOUT FLUSH WITH WALL
	P-TRAP
	ELBOW
	PIPE DOWN

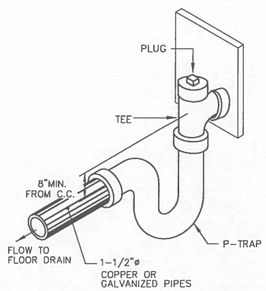
GENERAL PLUMBING PIPING MATERIAL SPECS.

SERVICE	LOCATION		P.V.C. TYPE DWV-35 A.S.T.M.-D-2665	P.V.C.D.W.V. SCH 40 A.S.T.M.-D-2665	COPPER PIPE TYPE "K" A.S.T.M.-B-88-66a	ALL WELDED PIPE SCH. 40 A.S.T.M.	COPPER PIPE TYPE "L" A.S.T.M.-B-88-66a	CROSS LINKED POLYETHYLENE WITH ANTI-OXIDANT BARRIER SYSTEM AS MANUFACTURED BY UPONOR	BLACK STEEL PIPE A.S.T.M. A-53 GRADE A-120	C.I.D.W.V. NO HUB COUPLINGS	P.V.C. S.D.R. - 14	P.V.C. SCH 40 DWV JOINTS SOLVENT WELDED	COPPER PIPE TYPE "DWV" A.S.M.E.-SFS-296a
SOIL DRAINS	BRANCHES THRU SLAB	ALL SIZES		•									
	BRANCHES HUNG FROM CEILING	ALL SIZES		•									
	VERTICAL STACKS	ALL SIZES		•									
	BUILDING DRAIN UNDERGROUND (3" OR LESS)			•									
	BUILDING SEWER UNDERGROUND (4"ø& ABOVE) EXTERIOR		•										
	BRANCHES ABOVE FLOOR SLAB			•									
	IN RETURN AIR PLENUMS									•			•
WASTE & DRAINS	BRANCHES THRU SLABS			•									
	BRANCHES HUNG FROM CEILING			•									
	VERTICAL STACKS			•									
	HORIZONTAL STACKS			•									
	UNDERGROUND @ BUILDING			•									
	UNDERGROUND @ SITE		•										
	BRANCHES ABOVE FLOOR SLAB			•									
	IN RETURN AIR PLENUM'S									•			•
VENTS	BRANCHES HORIZ. & VERT.			•									
	VERTICAL STACKS			•									
	UNDERGROUND			•									
	IN RETURN AIR PLENUM'S				•								•
WATER	UNDERGROUND MAINS 4" & ABOVE									•			
	UNDERGROUND ALL SIZES BELOW 4"				•								
	ABOVE GROUND ALL SIZES					•							
	THRU CONCRETE SLAB						•						
STORM DRAINS	VERTICAL LEADERS & DOWNSPOUTS	CONCEALED		•									
		EXPOSED			•								
	HUNG FROM CEILING			•									
	UNDERGROUND OUTSIDE BUILDING			•									
	UNDERGROUND INSIDE BUILDING			•									



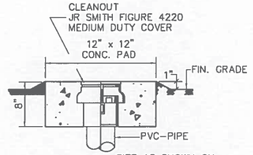
WALL MOUNTED UNIT ISOMETRIC DETAIL

NOT TO SCALE



CONDENSATE DRAIN DETAIL

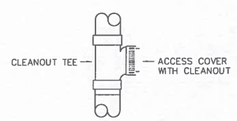
NOT TO SCALE



*AS REGULARY FURNISHED BRASS TOPS.

TYPICAL C.O. F.W.G. DETAIL

NOT TO SCALE



C.O. F.W.W. DETAIL

NOT TO SCALE

GENERAL PLUMBING NOTES:

1. ALL PLUMBING WORK SHALL BE IN STRICT ACCORDANCE WITH THE LOCAL BUILDING CODE, THE NATIONAL PLUMBING CODE (A.S.A. A 40.8-1955) AND THE SPECIFICATIONS ISSUED FOR THIS PROJECT. ALL PIPING SHALL BE FITTED WITH EARTHQUAKE RESTRAINTS AS PER UBC & IPC, LATEST VERSION.

2. THE PLUMBING CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF EXISTING WATER SERVICE PIPE AND CONNECT TO IT WITH PROPER SIZE AS SHOWN IN THE DRAWING.

3. ALL VALVES NOT EXPOSED SHALL BE PROVIDED WITH ACCESS IN THE WALL OR FLOOR FOR OPERATION AND MAINTENANCE.

4. LONG SWEEP BENDS OR LONG SWEEP FITTINGS SHALL BE PROVIDED AT THE BASE OF ALL STACKS.

5. ALL HORIZONTAL PORTIONS OF SOIL, WASTE STACKS & BRANCHES SHALL SLOPE 1/8" PER FOOT, EXCEPT FOR SIZES 3" & SMALLER THAT SHALL BE 1/4" PER FOOT.

6. ALL PIPES SHALL BE ADEQUATELY SUPPORTED ON HANGERS OR CARRIERS AS REQUIRED. HANGERS SHALL BE PLACED 8 FT. APART FOR SIZES UP TO 4" AND 10 FT. APART ON SIZES LARGER THAN 4", EXCEPT THAT CAST IRON SOIL PIPE SHALL BE SUPPORTED AT EACH LEGHT. VERTICAL RISERS AND STACKS SHALL BE SUPPORTED AT EACH FLOOR LEVEL WITH RISER CLAMPS, EXCEPT AS OTHERWISE NOTED.

7. CLEANOUTS SHALL BE OF THE SAME NOMINAL SIZE AS PIPES UP TO 4" DIAM. NOT LESS THAN 4" FOR LARGER PIPES.

8. THE CONTRACTOR SHALL FURNISH AND SET IN PLACE BEFORE CONCRETE POURING, ALL NECESSARY SLEEVES FOR WASTE OR SOIL, AND COLD WATER LINES. THESE SLEEVES SHALL BE AS SPECIFIED.

9. THE PLUMBING CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF PIPING TO AVOID ANY INTERFERENCE WITH PIPING AND/OR EQUIPMENT BEING INSTALLED BY OTHER CONTRACTORS.

10. THESE NOTES AS WELL AS THE LEGEND AND DETAILS APPLY TO ALL PLUMBING WORK FOR THE PROJECT.

11. ALL SOLVENT CEMENT SHALL BE IN ACCORDANCE WITH PIPE MANUFACTURERS, ASTM AND NSF RECOMMENDATIONS.

12. ALL PVC DWV PIPES AND FITTINGS SHALL BE SCHEDULE 40.

13. CONTRACTOR SHALL INSTALL A COMPLETE PLUMBING SYSTEM AS SHOWN IN DRAWINGS AND CALLED FOR IN THE SPECIFICATIONS.

14. SUBMIT FOR ENGINEER'S APPROVAL LITERATURE OF PIPES MATERIAL, VALVES, FLOOR DRAINS, FIXTURES, ETC BEFORE ORDERING.

15. SPECIAL ATTENTION IS CALLED TO THE INTERPRETATION OF THE CODE'S REQUIREMENTS DESCRIBED AND ILLUSTRATED IN THE NATIONAL PLUMBING CODE HANDBOOK ASA-40.8-1955 EDITED BY VINCENT J. MANAS AND PUBLISHED BY McGRAW HILL BOOK CORPORATION INC. AND MADE PART OF THE REQUIREMENTS OF THIS CONTRACT.

16. THE DRAWINGS ARE GENERALLY DIAGRAMATIC AND ARE INTENDED TO CONVEY THE SCOPE OF THE WORK AND INDICATE GENERAL ARRANGEMENT OF EQUIPMENT, PIPING AND FIXTURES.

17. THE LOCATIONS OF ALL ITEMS SHOWN ON THE DRAWINGS ARE NOT DEFINITELY FIXED BY DIMENSIONS AND ARE APPROXIMATE ONLY. THE EXACT LOCATIONS NECESSARY TO SECURE THE BEST CONDITIONS AND RESULTS MUST BE DETERMINED BY THE CONTRACTOR AT THE PROJECT AND SHALL BE ILLUSTRATED IN THE REQUIRED SHOP DRAWINGS FOR THE ARCHITECTS APPROVAL BEFORE ACTUAL INSTALLATION.

18. THE SPECIFICATIONS AND DRAWINGS CALL FOR FINISHED WORK, TESTED AND READY FOR OPERATION ANY APPARATUS, MATERIAL OR WORK NOT SHOWN ON THE DRAWINGS OR SPECIFICATIONS BUT NECESSARY TO MAKE THE PLUMBING WORK COMPLETE SHALL BE PROVIDED BY CONTRACTOR AS IF SPECIFICALLY CALLED FOR BY THESE CONTRACT DOCUMENTS.

19. THE CONTRACTOR MUST INSPECT PROJECT SITE AND MUST COORDINATE HIS WORK WITH THAT OF OTHER TRADES PRIOR TO SUBMITTING HIS PROPOSAL FOR THIS WORK. AFTER CONTRACT IS AWARDED, NO EXTRAS WILL BE ALLOWED FOR COORDINATIONS OR LESS PROJECT SITE CONDITIONS.

20. ALL CUTTING REQUIRED TO PERFORM THE WORK UNDER THIS CONTRACT WILL BE DONE BY MECHANICAL CONTRACTOR, ANY CUTTING OF STRUCTURE MUST BE APPROVED BY STRUCTURAL ENGINEER PRIOR TO WORK COMMENCEMENT. — NPS

21. ALL PIPING WELDS/SOLDER SHALL BE OF PHOSPHORUS FREE TYPE

22. CONTRACTOR SHALL INCLUDE APPROPIATE TRAPS AS PER CODE REQUIREMENTS, NO EQUIPMENTS SHALL BE INSTALLED WITHOUT TRAPS (EXCEPT WASHING MACHINE).

23. CONTRACTOR SHALL PERFORM PLUMBING RELATED INSTALLATIONS UNDER THE DIRECT SUPERVISION OF A "MASTER PLUMBER" AS A MEASURE TO GUARANTEE COMPLIANCE WITH APPLICABLE CODES AND INSTALLATION STANDARDS.

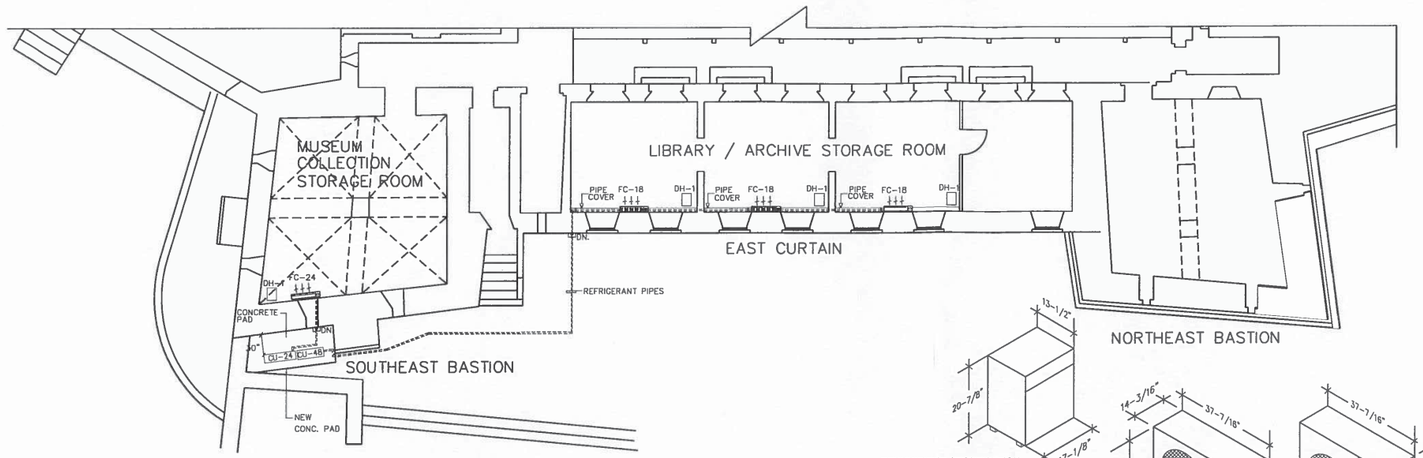
24. CONTRACTOR SHALL SEEK THE CERTIFICATION OF A "MASTER PLUMBER" AS PER LAW # 38 OF FEBRUARY 2002. THIS CERTIFICATION SHALL ASCERTAIN THE CORRECTNESS OF THE INSTALLATION OF ALL PLUMBING FOR THE PROJECT.

24' 18' 12' 6' 0' 12' 24'
12' 9' 6' 3' 0' 6' 12'
SCALE OF FEET

DESIGNED: PJMV	SUB SHEET NO. P1	TITLE OF SHEET: GROUND FLOOR HVAC DRAIN LAYOUT PLAN FORT CHRISTIANSVAERN CHRISTIANSTED NATIONAL HISTORIC SITE	DRAWING NO. 399 80,057
DRAWN: AS			PMIS/PKG NO. CHRI 136136
TECH. REVIEW: ASR			SHEET 2 OF 3
DATE: 08/24/10			

PRELIMINARY DRAWING
NOT FOR CONSTRUCTION AND REVIEW
DATE: AUGUST 10, 2010

8/24/10 09:13 23127 R18 F:\AVIATION\PRODATA\10001536_LAS NPS ST CROIX SERVICES\FORT CHRI HVAC DESIGN SERV\MCOMMING\PEDRO MEDINA\2010 08 23\P1.DWG



GROUND FLOOR HVAC LAYOUT PLAN

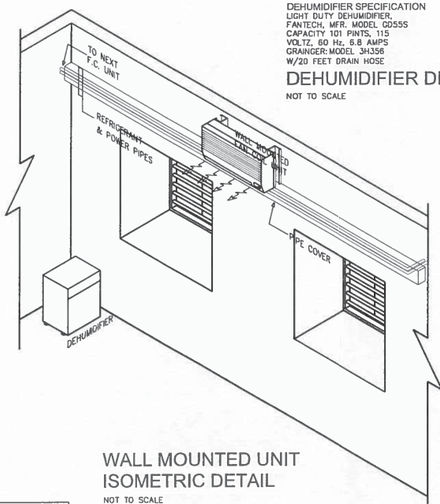
SCALE: 1/8"=1'-0"

REFRIGERANT PIPING NOTES:

1. ALL PIPING SHALL BE TYPE L, COPPER, HARD DRAWN. USE SILVER SOLDER FOR JOINTS AND A FLOW OF DRY NITROGEN THROUGH THE PIPING SYSTEM WHILE SOLDERING TO PREVENT FORMATION OF COPPER OXIDE.
2. ALL ELBOWS SHALL BE OF THE LONG RADIUS TYPE.
3. UNIT MANUFACTURER WILL SUPPLY THERMOSTATIC EXPANSION VALVES AND ONE LIQUID LINE SOLENOID VALVE FOR FIELD INSTALLATION.
4. AIR CONDITIONING CONTRACTOR SHALL SUPPLY AND INSTALL SIGHTGLASS–MOISTURE INDICATORS AND FILTER DRYERS OF LINE SIZE SOLDERED CONNECTIONS.
5. INSULATE SUCTION LINE w/JOHNS–MANVILLE "AEROTUBE", 3/4" THICK. WHERE EXPOSED TO THE WEATHER FINISH w/0.016"ALUMINUM" JACKET.

LEGEND:

==========	REFRIGERANT PIPES
————	COVER PIPE
FC–#	FAN COIL UNIT
CU–#	CONDENSATE UNIT
DH–1	DEHUMIDIFIER
⟵	PIPE DOWN



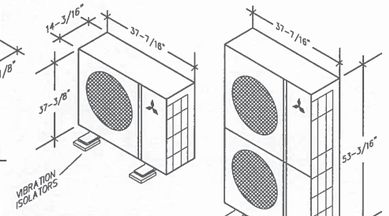
WALL MOUNTED UNIT ISOMETRIC DETAIL

NOT TO SCALE

DEHUMIDIFIER SPECIFICATION
LIGHT DUTY DEHUMIDIFIER,
FANTECH, MFR. MODEL GD55S
CAPACITY 101 PINTS, 115
VOLTZ, 60 Hz, 6.8 AMPS
GRAINGER: MODEL 3HJ56
W/20 FEET DRAIN HOSE

DEHUMIDIFIER DETAIL

NOT TO SCALE

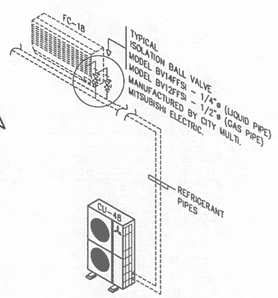


PUY-A24NHA3-BS

NOT TO SCALE

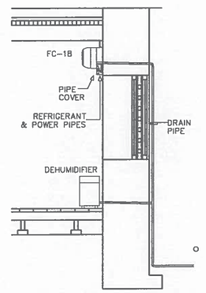
PUMY-P48NHMU-BS

NOT TO SCALE



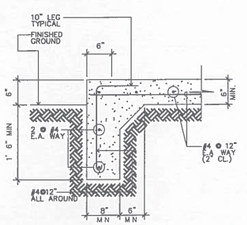
CONNECTION DIAGRAM

NOT TO SCALE



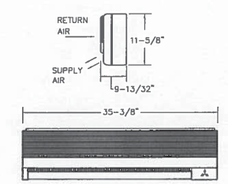
PARTIAL SECTION

NOT TO SCALE



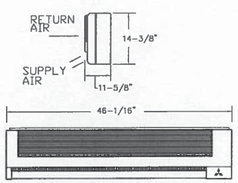
CONC. PAD DETAIL

NOT TO SCALE



PKFY-P18NHMU-E

SCALE: NOT TO SCALE



PKA-A24KAL

SCALE: NOT TO SCALE

INDOOR UNITS	
TAG	FC–1B
MODEL	PKFY–P18NHMU–E
COOLING CAPACITY (BTU/HR)	18,000
FAN MOTOR OUTPUT (W)	30
AIR FLOW RATE (CFM)	320–425
DRIVE	DIRECT DRIVE
PIPING CONNECTIONS (LIQUID)	1/4"
PIPING CONNECTIONS (GAS)	1/2"
ELECTRIC UNIT	208/60/1
POWER CONSUMPTION (W)	30
CURRENT (A)	0.3
MACHINE WEIGHT (LB)	29
MANUFACTURED BY CITY MULTI, VRFZ TECH. MITSUBISHI ELECTRIC.	

OUTDOOR UNIT	
TAG	CU–4B
MODEL	PUMY–P48NHMU–BS
COOLING CAPACITY (BTU/HR)	48,000
COMPRESSOR TYPE	INVERTER – DRIVEN SCROLL
COMPRESSOR MOTOR OUTPUT (kW)	2.4
POWER INPUT (kW)	4.97
CURRENT (A)	24.0–21.7
FAN MOTOR POWER (kW)	0.086x2
PIPING CONNECTIONS (LIQUID)	5/8"
PIPING CONNECTIONS (GAS)	3/8"
ELECTRIC UNIT	208/60/1
DIMENSIONS (HxWxD) (IN)	53–3/16"x37–/16"x13"
MACHINE WEIGHT (LB)	287
MANUFACTURED BY CITY MULTI, VRFZ TECH. MITSUBISHI ELECTRIC.	

INDOOR UNIT	
TAG	FC–24
MODEL	PKA–A24KAL
COOLING CAPACITY (BTU/HR)	24,000
MCA (A)	1
F.L.A. (A)	0.35
FAN MOTOR POWER (W)	56
AIRFLOW CFM	635–705–775
ELECTRIC UNIT	208/60/1
DIMENSIONS (HxWxD) (IN)	14–3/8"x46–1/16"x11–5/8"
MACHINE WEIGHT (LB)	46
MANUFACTURED BY CITY MULTI. MITSUBISHI ELECTRIC.	

OUTDOOR UNIT	
TAG	CU–24
MODEL	PUY–A24NHA3–BS
COOLING CAPACITY (BTU/HR)	24,000
COMPRESSOR TYPE	INVERTER – DRIVEN ROTARY
MCA (A)	18
MOCP (A)	30
F.L.A. (A)	0.75
FAN MOTOR POWER (W)	75
COMPRESSOR R.L.A.	12
COMPRESSOR L.R.A.	14
PIPING CONNECTIONS (LIQUID)	5/8"
PIPING CONNECTIONS (GAS)	3/8"
ELECTRIC UNIT	208/60/1
DIMENSIONS (HxWxD) (IN)	37–1/8"x37–3/8"x14–3/16"
MACHINE WEIGHT (LB)	163
MANUFACTURED BY CITY MULTI. MITSUBISHI ELECTRIC.	

A/C NOTES FOR FAN COILS:

1. THE CONTRACTOR SHALL SUPPLY & INSTALL ALL ELECTRICAL WIRING, POWER & CONTROL NOT INDICATED IN THE ELECTRICAL DRAWINGS BUT NECESSARY FOR THE OPERATION OF THE AIR CONDITIONING SYSTEM. HE SHALL SUPPLY & INSTALL ALL ELECTRICAL CONTROLS SAFETY SWITCHES, MAGNETIC STARTERS & THE NECESSARY ACCESSORIES NOT INDICATED IN THE ELECTRICAL DRAWINGS BUT NECESSARY FOR THE OPERATION OF THE AIR CONDITIONING SYSTEM.
2. THE CONTRACTOR SHALL VISIT THE PROJECT & ITS SITE & EXAMINE THE AREAS AFFECTED BY HIS WORK PRIOR TO SUBMITTING BIDS, SO AS TO FAMILIARIZE WITH THE EXISTING CONDITIONS THAT WILL AFFECT THE EXECUTION OF HIS WORK.
3. ALL EQUIPMENT SHALL BE INSTALLED & CONNECTED IN STRICT ACCORDANCE WITH THE MANUFACTURER'S RECOMMENDATION.
4. THE CONTRACTOR SHALL TAKE PROVISIONS TO MINIMIZE &/OR ELIMINATE NOISE OR VIBRATION FROM THE AIR CONDITIONING EQUIPMENT, PIPING OR DUCTS TO THE AIR CONDITIONING SPACE.
5. AIR CONDITIONING EQUIPMENT MUST BE PROVIDED WITH CONTROL VALVES, & THERMOSTATS.
6. THE AIR CONDITIONING INSTALLATION SHALL BE DONE IN STRICT ACCORDANCE WITH THE STANDARDS OF THE AMERICAN SOCIETY OF HEATING, REFRIGERATING & AIR CONDITIONING ENGINEERS, THE AIR CONDITIONING & REFRIGERATION INSTITUTE & BY THE SHEET METAL & AIR CONDITIONING CONTRACTORS NATIONAL.
7. AFTER COMPLETION, THE CONTRACTOR SHALL MAKE ALL NECESSARY TESTS, ADJUSTMENTS & SHALL BALANCE THE AIR DISTRIBUTION SYSTEM. AS PART OF THIS CONTRACT, THE CONTRACTOR SHALL MAKE CHANGES TO BELT, DAMPERS, TO PROVIDE THE REQUIRED BALANCE OF THE AIR DISTRIBUTION. SUBMIT TWO (2) COPIES OF THE BALANCE REPORT.
8. CONTRACTOR IS REQUIRED TO COORDINATE HIS WORK WITH THAT OF THE ELECTRICAL & HUNG CEILING CONTRACTORS SO AS TO PLACE DIFFUSERS, REGISTER & GRILLED AS REQUIRED BY THE DRAWINGS.

Notes on Piping Insulation

1.0 General

Insulation, adhesives, mastics, sealants and coverings shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less as determined by an independent testing laboratory in accordance with NFPA 255 & US 728 as required by ASHRAE 90° and 90B. Coatings and adhesives applied in the filed shall be non–flammable in the wet state. Hangers on chilled water and other cold piping systems shall be installed on the outside of the insulation to prevent hangers from aerating. Supports shall be appropriately installed not to deform or compromise the integrity of the insulation material.

2.0 Insulation Types

2.0.1 Molded Fiberglass Insulation
Insulation shall be sectional molded glass fiber, minimum 3.0lb per cubic foot density, thermal conductivity not greater than 0.24BTU–in./sq.ft./deg.F/Hr. at a mean temperature of 75deg.F and factory applied hacker of white, flame retardant vapor barrier jackets of 0.001" aluminum fil laminated to Kraft paper, reinforced with glass fibers, or all service jacket.
2.0.2 Flexible Foamed Plastic Insulation
Insulation shall be flexible foamed plastic, minimum 5.0 lb. Per cubic foot density, thermal conductivity not greater than 0.28 BTU–in./sq.ft./deg.F/Hr. At a mean temperature difference of 75 deg.F.
2.0.3 Cellular Glass Insulation
Insulation shall be cellular glass, thermal conductivity not greater than 0.40 BTU–in./sq.ft./deg.F/Hr. At a mean temperature difference of 75 deg.F.
2.0.4 Foam Glass
Insulation shall be foamglass, minimum 8.5 lb. Per cubic foot density, thermal conductivity not greater than 0.35 BTU–in./sq.ft./deg.F/Hr. At a mean temperature difference of 75 deg.F.

3.0 Schedule

PIPE INSULATION SCHEDULE

PIPING SYSTEM TYPE	PIPE SIZE DIAMETER	INSULATION THICKNESS PER TYPE*			
		FiberG	FlxFm	FoamG	CelG
AC COND	All	0.5"	0.5"	1.0"	0.75"
Refrig. Suct./Liq.	≤ 1 inch	1.0"	1.5"	2.0"	1.5"
Refrig. Suct./Liq	1¼ to 6 inch	1.5"	2.0"	2.5"	2.5"
Refrig. Suct./Liq.	≥8 inch	2.0"	2.5"	3.5"	3.0"
Refrigerant Hot Gas	All	0.75"	1.0"	1.5"	1.0"

*increase by one inch for exterior applications.
Legend
CHW=CHILLED WATER | AC COND=Air Conditioning Condensate HW=HOTWATER | Refrig. Suct./Liq.=Refrigerant Suction and Liquid piping. FiberG=Fiber Glassinsulation | FlxFm=Flexible Foam Insulation | FoamG=Foam Glass Insulation | CelG=Cellular Glass Insulation | Insulation values given in inches. Listed pipe sizes are inch diameters.

4.0 Technical Application Notes:

4.0.1 For piping exposed to ambient temperatures, either due to external runs or exposed internals due to location, or inevitably adjacent or subject to ambient conditions, contractor shall increase insulation thickness by 1.0 inch.
4.0.2 Unless otherwise specified, insulation shall not required on systems with temperatures between 65 deg.F and 105 deg.F
4.0.3 Interior chilled water piping runs, shall be insulated with fiberglass pipe insulation. Exterior chilled water pipe runs shall be insulated with foamglass and shall also include aluminum jacket.
4.0.4 Unless otherwise specified, heating water system piping, low temperature, shall be insulated with fiberglass pipe insulation.
4.0.5 Unless otherwise specified, steam system piping and steam condensate system piping shall be insulated with fiberglass pipe insulation.
4.0.3 Refrigerant system piping shall be insulated with flexible foamed plastic, or fiberglass pipe insulation. Refrigerant hot gas lines shall always be insulated to prevent the risk of personal injury from contact.

1. GENERAL NOTES:

IT IS THE INTENTION OF THE DRAWINGS TO CALL FOR FINISHED WORK, COMPLETE, TESTED AND READY FOR OPERATION. DETAILS NOT SHOWN OR SPECIFIED, BUT NECESSARY FOR THE PROPER INSTALLATION, FUNCTION AND OPERATION OF THE SYSTEM SHALL FORM PART OF THE WORK TO BE PERFORMED BY THE CONTRACTOR

EQUIPMENT
CONTRACTOR SHALL PROVIDE SUITABLE VIBRATION ISOLATORS FOR THE SYSTEM AS RECOMMENDED BY MANUFACTURER OF EQUIPMENT SPECIFIED OR PROVIDED

NOTES ON MECHANICAL CODE REQUIREMENTS:

1) CONTRACTOR SHALL PERFORM MECHANICAL WORK UNDER THE REQUIREMENTS OF THE UNIFORM MECHANICAL CODE (UMC) AND NFPA PAMPHLETS. FROM NOW ON REFERENCED AS "THE CODES" IN THE FOLLOWING STATEMENTS. THESE SHALL BE CONSIDERED THE "STANDARD PRACTICE" FOR THE WORK TO BE PERFORMED. PROVISIONS OF THE CODES, STANDARDS & REQUIREMENTS SHALL APPLY TO THE ERECTION, INSTALLATION, ADDITION TO, USE OR MAINTENANCE OF MECHANICAL SYSTEMS WITHIN THIS PROJECT, EVEN WHEN NOT SPECIFICALLY CALLED FOR IN THE DRAWINGS. APPLICABILITY OF THE CODES SHALL GOVERN THE INSTALLATION OF ALL MECHANICAL SYSTEMS UNDER THIS CONTRACT. DEFINITIONS SHALL BE AS PER THE CODES. MANDATORY REFERENCED STANDARDS OF THE CODES AS WELL AS THEIR APPENDIXES SHALL BE BINDING.

2) THE DESIGN, DOCUMENTATION, INSPECTION AND APPROVAL OF CHANGES TO THE ENGINEERED DESIGN OF MECHANICAL SYSTEMS SHALL COMPLY WITH THE PROVISIONS OF THE CODES. DESIGN CRITERIA SHALL BE SUBMITTED WITH ALL TECHNICAL DATA, AND CERTIFIED BY A DESIGN PROFESSIONAL.

3) GENERAL REGULATIONS OF THE CODES SHALL INCLUDE, BUT NOT BE LIMITED TO: DEFINITIONS, STATED GENERAL CODE REQUIREMENTS, VENTILATION AIR SUPPLY, EXHAUST SYSTEMS, ENVIRONMENTAL AIR DUCTS AND PRODUCT CONVEYING SYSTEMS, COMMERCIAL HOODS AND KITCHEN VENTILATION; DUCT SYSTEMS, COMBUSTION AIR, CHIMNEYS, VENTS, WARM–AIR HEATING SYSTEMS, MISCELLANEOUS HEAT–PRODUCING APPLIANCES, INCINERATORS, STEAM AND HOT WATER BOILERS, REFRIGERATION SYSTEMS, COOLING TOWERS, HYDRAULICS, STEAM AND WATER PIPING, FUEL GAS PIPING, PROCESS PIPING, AND SOLAR SYSTEMS.

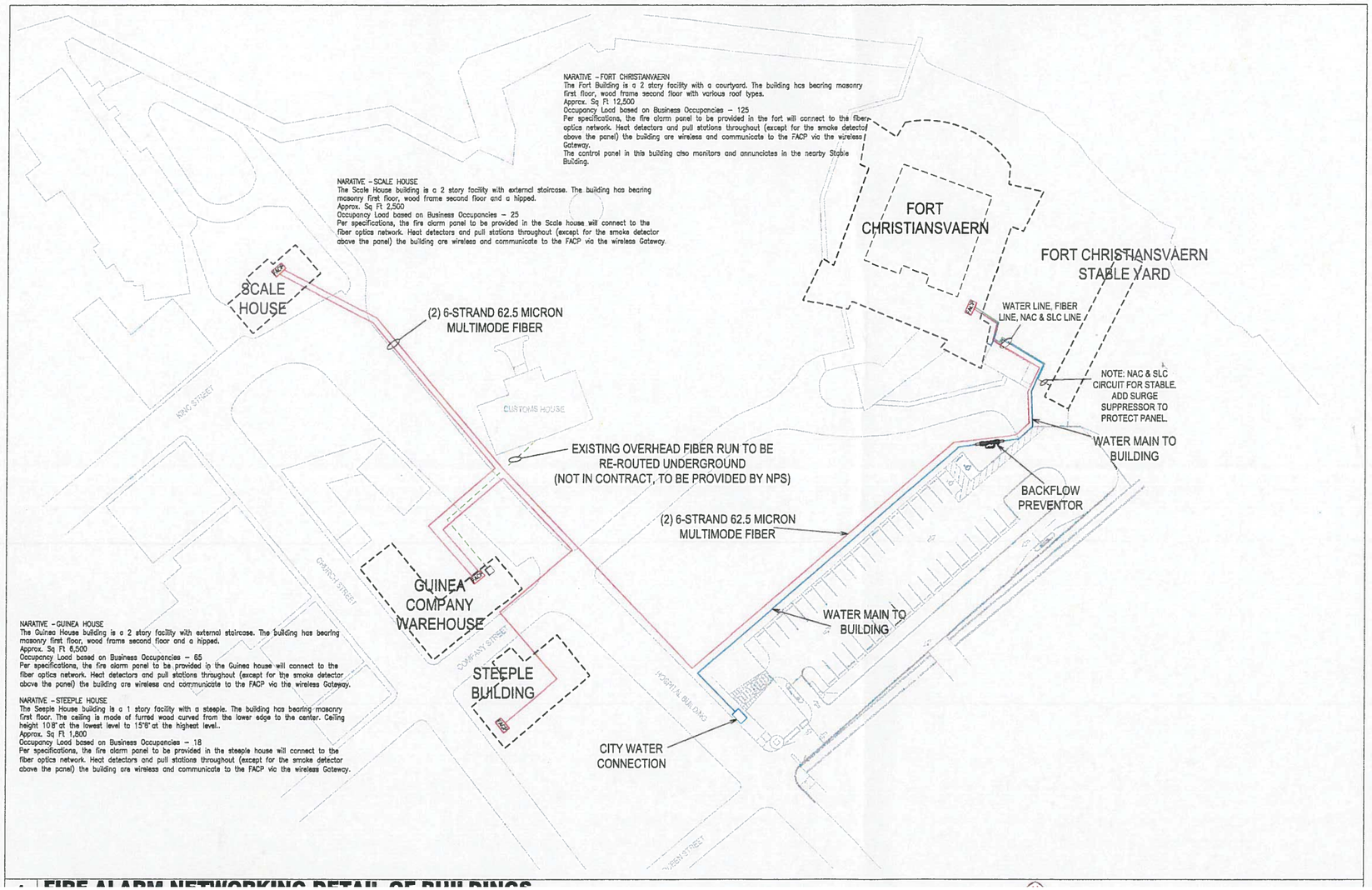
24' 18' 12' 6' 0' 12' 24'
12' 9' 6' 3' 0' 6' 12'
SCALE OF FEET

DESIGNED: PJMV	SUB SHEET N	TITLE OF SHEET: GROUND FLOOR HVAC LAYOUT PLAN AND DETAILS	DRAWING NO. 399 80,057
CADD AS			PMIS/PKG NO. CHRI 136136
TECH. REVIEW: ASR			SHEET
DATE: 08/24/10			

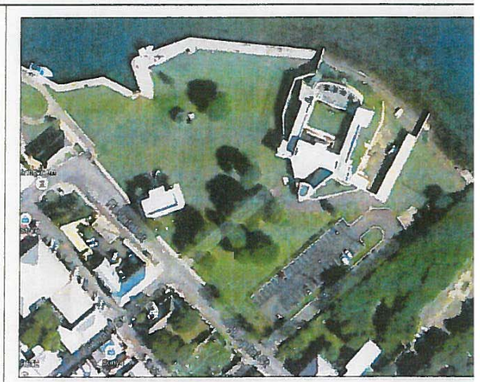
PRELIMINARY DRAWING
ISSUE FOR COORDINATION
DATE: AUGUST 17, 2010.

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NATIONAL PARK SERVICE
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, ST. CROIX, VI
NEW GAMEWELL FCI S-3 FIRE ALARM SYSTEM



1 FIRE ALARM NETWORKING DETAIL OF BUILDINGS



2 SITE KEY PLAN
SCALE: NTS

FA-01 -	1st Floor Fort Christiansvaern Building Fire Alarm Plan.
FA-02 -	2nd Floor Fort Christiansvaern Building Fire Alarm Plan.
FA-03 -	1st & 2nd Floor Scale House Fire Alarm Plans. 1st & 2nd Floor Guinea Building Fire Alarm Plans.
FA-04 -	Steeple and Stable Building Fire Alarm Plans.
FA-05 -	Fire Alarm Riser Diagram.
FA-06 -	Fire Alarm Battery and Voltage Drop Calculations.
FA-07 -	Fire Alarm Specifications and Details.

3 FIRE ALARM SHEETS
SCALE: NTS

Bass United Fire and Security, Inc. (we, us, our) will design, and deliver new Fire Alarm Gamewell FCI S-3 System Control Panel, FCI Initiating and System Sensor Notification Devices as shown herein in order to provide appropriate minimum requirements for performance, selection, use, and location to ensure timely warning for the purposes of life safety and protection.

Our scope of work includes parts, materials, programming, testing, and certification of the system consisting of:
- FCI S-3 Fire Alarm Control Panels
- FCI Initiating Devices
- System Sensor Notification Device.

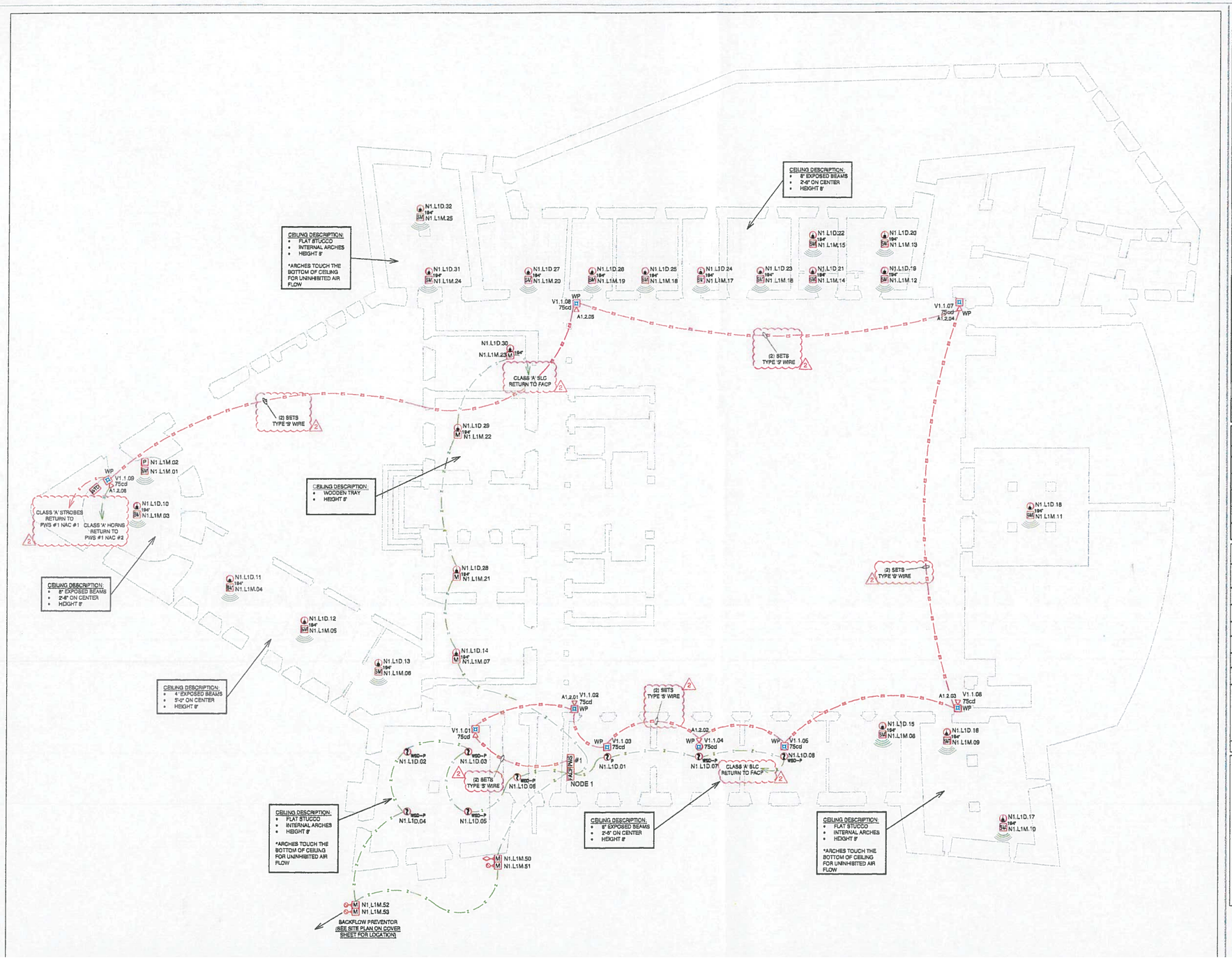
All the work will be done in compliance with:
- NFPA 101 - 2012 ed.
- NFPA 72 - 2013 ed.
- NFPA 70/NEC - 2011 ed.
- NFPA 1 - 2012 ed.
- ALL LOCAL PREVAILING CODES

4 SCOPE OF WORK
SCALE: NTS

NARATIVE - GENERAL
Provide the equipment for a new networked fire alarm system utilizing the Gamewell FCI S73 with SWIFT Wireless mesh components. Bass will also provide the material for the fire sprinkler system to protect the portion of The Fort Christiansvaern Building as contracted.
Fire Alarm Control Panel Networking:
The system consists of four control panels, one located in each of these locations – The Fort Christiansvaern Building, the Scale House, The Guinea House and The Steeple Building. All panels will be interconnected in a peer to peer network utilizing Fiber Optic interface cards and Multi?Mode fiber optics between buildings. The fiber optics cable is to be run in the appropriately rated raceway underground. The panel in The Fort Christiansvaern Building will also monitor and control the devices in the Stable Building.
Initiation:
All panels will monitor the associated wired/wireless smoke detectors, heat detectors, manual pull stations as well as the sprinkler monitoring devices. These devices, otherwise known as initiating devices, will sense abnormal fire or fault conditions and transmit to the fire alarm panel. There the preprogrammed control panel will send the appropriate signals to the occupant notification devices as well as the monitoring station. The initiating devices in the Stable building will report to the main panel in The Fort Christiansvaern Building and will require a physical connection between the two buildings.
Notification:
The system provides two forms of notification, the occupant notification and offsite notification. The occupant notification devices, otherwise known as notification appliances, will alert the occupants by audio visual signals placed throughout the building of the fire condition. The horns will alert occupants by a march time signal at least 15dbs above ambient. The notification devices in the Stable building will be controlled by the main panel in The Fort Christiansvaern Building and will require a physical connection between the two buildings.
Additionally, an alarm will send a signal to the remote monitoring station via two transmission paths via a telephone line and a wireless cellular phone connected to the panel located at The Guinea Building . The signal transmitted can be interpreted by the monitoring station to identify the building with the emergency condition.

5 NARRATIVE OF WORK
SCALE: NTS

BASS UNITED FIRE & SECURITY SYSTEMS, INC.
3000 Parkway Drive
Pompano Beach, FL 33069
TOLL FREE => 1.800.372.2770
24 Hour Emergency Service
FAX => 954.785.7004



SYMBOL LEGEND

SYMBOL	QTY	DESCRIPTION
FACP	4	FCI S-3 FIRE ALARM CONTROL PANEL
FAA	1	FCI LCD-SLP REMOTE FIRE ALARM ANNUNCIATOR (GUINEA BUILDING)
WTD	4	FCI GFANN-60 WIRELESS TROUBLE DISPLAY
WRC	1	HONEYWELL IPGSM-4G WIRELESS RADIO COMMUNICATOR
PWS	1	FIRELITE FCPS-24FS8 8-AMP POWER SUPPLY
P WP	14	FCI MS-7LOB ADDRESSABLE DOUBLE ACTION MANUAL PULL STATION
P	4	FCI ASD-PI4F ADDRESSABLE PHOTCELECTRIC SMOKE DETECTOR
WSD-P	37	FCI-SWIFT WSD-P WIRELESS ADDRESSABLE SMOKE DETECTOR
WTD-RH	14	FCI-SWIFT WTD-RH WIRELESS 135° ADDRESSABLE HEAT DETECTOR
194°	41	SYSTEM SENSOR S622 ADDRESSABLE 194° HEAT DETECTOR
M	14	FCI AMM-2F ADDRESSABLE MONITOR MODULE
SM	55	FCI SWIFT WAM-MM ADDRESSABLE WIRELESS MODULE
G	6	FCI SWIFT VW-GATE WIRELESS GATEWAY
D	6	FCI SWIFT VW-DIS-D WIRELESS DISPLAY DRIVER
H WP	27	SYSTEM SENSOR P4WK WEATERPROOF HORN STROBE MULTICANDELA WALL MOUNTED
H WP	1	SYSTEM SENSOR PC4WK WEATHERPROOF HORN STROBE MULTICANDELA CEILING MOUNTED
WP	5	SYSTEM SENSOR SWK WEATHERPROOF STROBE LIGHT MUTLICANDELA WALL MOUNTED
H WP	2	SYSTEM SENSOR SCWK WEATHERPROOF STROBE LIGHT MUTLICANDELA CEILING MOUNTED
	3	TAMPER SWITCH (BY OTHERS) MONITORED BY FIRE ALARM SYSTEM W/ MODULE AMM-2F
	1	FLOW SWITCH (BY OTHERS) MONITORED BY FIRE ALARM SYSTEM W/ MODULE AMM-2F
WP		DENOTES WEATHERPROOF DEVICE
EOL		END OF THE LINE RESISTOR AT LAST DEVICE ON EACH NAC

LINETYPE LEGEND

LINE TYPE	DESCRIPTION
S	SIGNALING LINE CIRCUIT (SLC)
S	NOTIFICATION APPLIANCE CIRCUIT (NAC)
E	EVACUATION SIGNAL CIRCUIT (EVAC)
P	24 VDC POWER CIRCUIT
D	DATA CIRCUIT

WIRE LEGEND

TYPE	DESCRIPTION	SIZE	# OF CONDUCTORS	NOTES
S	PLENUM (FPLP) * TWISTED/UNSHIELDED	14 AWG	2	NAC
Z	PLENUM (FPLP) * TWISTED/UNSHIELDED	16 AWG	2	SLC
P	PLENUM (FPLP) *	14 AWG	2	24V POWER
E	PLENUM (FPLP)* TWISTED/SHIELDED	16 AWG	2	EVAC
J	THHN *	14 AWG	1	GROUND
N	62.5 MICRON MM FIBER OPTIC	FIBER	2	NETWORK

* ALL WIRING INSTALLATION SHALL BE IN COMPLIANCE WITH NFPA 72, LIFE SAFETY CODE 101, & N.E.C. (CURRENT EDITIONS)

* CONNECTIONS AT DEVICES SHALL BE AS INDICATED ON INSTALLATION DOCUMENTS & AS FURNISHED WITH EQUIPMENT &/OR DEVICES.

* ALL FIRE ALARM WIRING SHALL BE POWER LIMITTED

* CABLE SIZE SHALL COMPLY WITH N.E.C. ARTICLE 760.71

* CONDUIT SHALL BE A MINIMUM OF ¾".

SCOPE OF WORK

Bass United Fire and Security, Inc. (we, us, our) will design, furnish, and deliver new Fire Alarm Gamewell FCI S-3 System Control Panel. FCI Initiating and System Sensor Notification Devices as shown herein in order to provide appropriate minimum requirements for performance, selection, use, and location to ensure timely warning for the purposes of life safety and protection.

Our scope of work includes, parts, materials, programming, testing, and certification of the system consisting of:

- FCI S-3 Fire Alarm Control Panels
- FCI Initiating Devices
- System Sensor Notification Device.

All the work will be done in compliance with:

- NFPA 101 - 2012 ed.
- NFPA 72 - 2013 ed.
- NFPA 70/NEC - 2011 ed.
- NFPA 1 - 2012 ed.
- ALL LOCAL PREVAILING CODES

BASS UNITED FIRE & SECURITY SYSTEMS, INC.
3000 Gateway Drive
Pompano Beach, FL 33069
24 Hour Emergency Service
954.785.7800
www.bassunited.com
PME engineering
robert a. germain, pe
3000 GATEWAY DRIVE
POMPANO BEACH, FL 33069
954.785.7800 FAX 954.785.7801

REVISIONS			
NO	REMARKS	BY	DATE
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1	REVISIONS PER GOVERNMENT	TW	03.10.2016
2	REVISIONS PER GOVERNMENT		

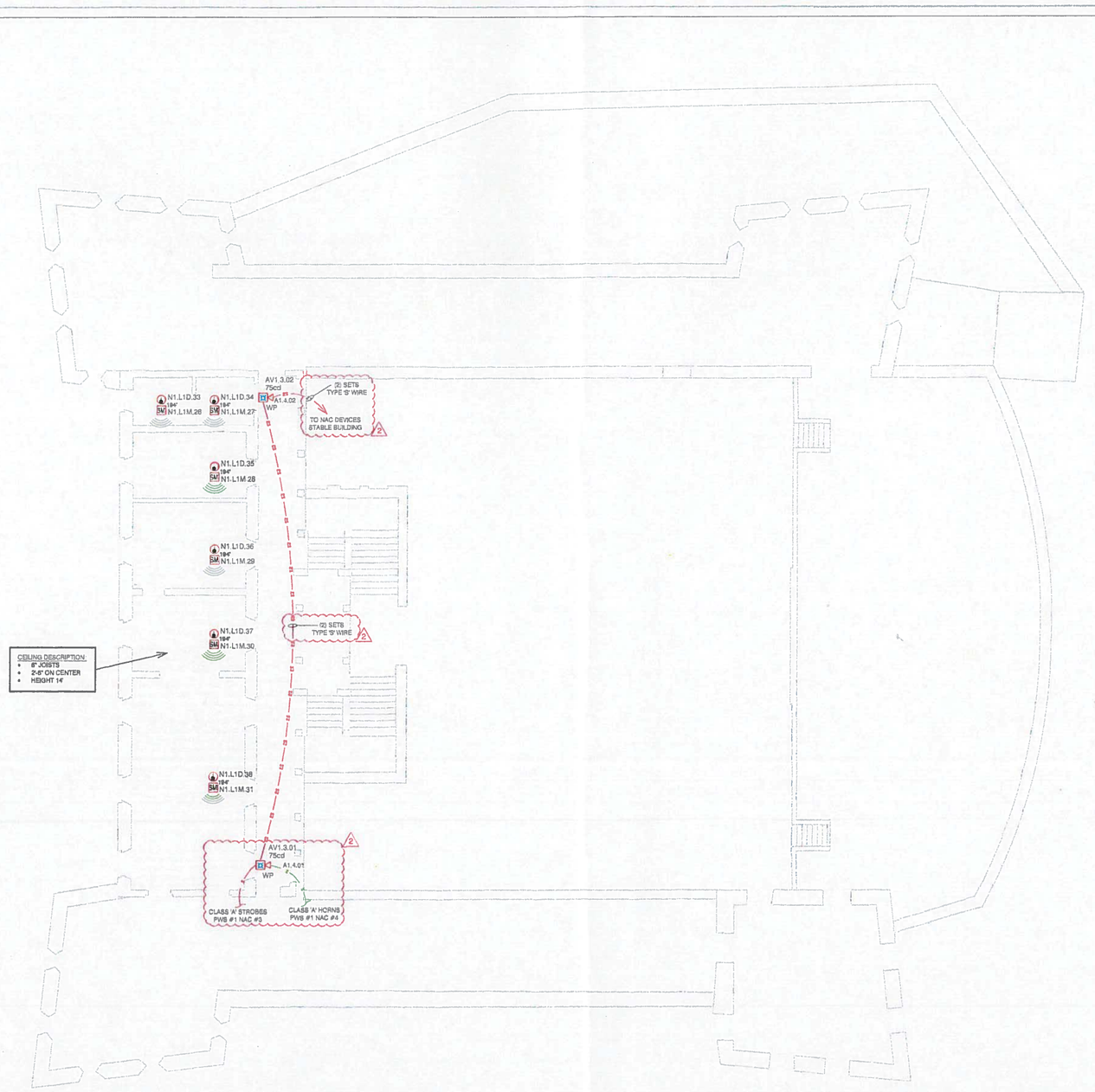
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CHECKED BY: RAM | DATE: 03-10-2016
REVISED: | DATE: AS NOTED

DRAWINGS PREPARED FOR:
BASS UNITED
3000 GATEWAY DRIVE
POMPANO BEACH, FL
FL LIC.# EF 0000994

PROJECT NAME:
NATIONAL PARK SERVICE
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, ST. CROIX, VI
FIRE ALARM SYSTEM

PROJECT NUMBER: 10061

SHEET NUMBER



SYMBOL LEGEND

SYMBOL	QTY	DESCRIPTION
FACP	4	FCI S-3 FIRE ALARM CONTROL PANEL
FAA	1	FCI LCD-SLP REMOTE FIRE ALARM ANNUNCIATOR (GUINEA BUILDING)
ATC	4	FCI GFANN-80 WIRELESS TROUBLE DISPLAY
WRC	1	HONEYWELL IPGSM-4G WIRELESS RADIO COMMUNICATOR
PWS	1	FIRELITE FCPS-24FS8 8-AMP POWER SUPPLY
P WP	14	FCI MS-7LOB ADDRESSABLE DOUBLE ACTION MANUAL PULL STATION
P	4	FCI ASD-PL2F ADDRESSABLE PHOTOELECTRIC SMOKE DETECTOR
WSD-P	37	FCI-SWIFT WSD-P WIRELESS ADDRESSABLE SMOKE DETECTOR
WTD-RH	14	FCI-SWIFT WTD-RH WIRELESS 135° ADDRESSABLE HEAT DETECTOR
194°	41	SYSTEM SENSOR 5822 ADDRESSABLE 194° HEAT DETECTOR
M	14	FCI AMM-2F ADDRESSABLE MONITOR MODULE
SV	58	FCI SWIFT WAM-MM ADDRESSABLE WIRELESS MODULE
G	6	FCI SWIFT VW-GATE WIRELESS GATEWAY
D	8	FCI SWIFT VW-DIS-D WIRELESS DISPLAY DRIVER
H WP	27	SYSTEM SENSOR P4WK WEATHERPROOF HORN STROBE MULTICANDELA WALL MOUNTED
H WP	1	SYSTEM SENSOR PC4WK WEATHERPROOF HORN STROBE MULTICANDELA CEILING MOUNTED
WP	5	SYSTEM SENSOR SWK WEATHERPROOF STROBE LIGHT MUTLICANDELA WALL MOUNTED
WP	2	SYSTEM SENSOR SCWK WEATHERPROOF STROBE LIGHT MUTLICANDELA CEILING MOUNTED
	3	TAMPER SWITCH (BY OTHERS) MONITORED BY FIRE ALARM SYSTEM W/ MODULE AMM-2F
	1	FLOW SWITCH (BY OTHERS) MONITORED BY FIRE ALARM SYSTEM W/ MODULE AMM-2F
WP		DENOTES WEATHERPROOF DEVICE
EOL		END OF THE LINE RESISTOR AT LAST DEVICE ON EACH NAC

LINETYPE LEGEND

LINE TYPE	DESCRIPTION
Z	SIGNALING LINE CIRCUIT (SLC)
S	NOTIFICATION APPLIANCE CIRCUIT (NAC)
E	EVACUATION SIGNAL CIRCUIT (EVAC)
P	24 VDC POWER CIRCUIT
D	DATA CIRCUIT

WIRE LEGEND

TYPE	DESCRIPTION	SIZE	# OF CONDUCTORS	NOTES
S	PLENUM (FPLP) * TWISTED/UNSHIELDED	14 AWG	2	NAC
Z	PLENUM (FPLP) * TWISTED/UNSHIELDED	16 AWG	2	SLC
P	PLENUM (FPLP) *	14 AWG	2	24V POWER
E	PLENUM (FPLP)* TWISTED/SHIELDED	16 AWG	2	EVAC
J	THHN *	14 AWG	1	GROUND
N	62.5 MICRON MM FIBER OPTIC	FIBER	2	NETWORK

* ALL WIRING INSTALLATION SHALL BE IN COMPLIANCE WITH NFPA 72, LIFE SAFETY CODE 101 & N.E.C. (CURRENT EDITIONS)

* CONNECTIONS AT DEVICES SHALL BE AS INDICATED ON INSTALLATION DOCUMENTS & AS FURNISHED WITH EQUIPMENT &/OR DEVICES.

* ALL FIRE ALARM WIRING SHALL BE POWER LIMITTED

* CABLE SIZE SHALL COMPLY WITH N.E.C. ARTICLE 760.71

* CONDUIT SHALL BE A MINIMUM OF ¾"

SCOPE OF WORK

Baas United Fire and Security, Inc. (we, us, our) will design, furnish, and deliver new Fire Alarm Gamewell FCI S-3 System Control Panel. FCI Initiating and System Sensor Notification Devices as shown herein in order to provide appropriate minimum requirements for performance, selection, use, and location to ensure timely warning for the purposes of life safety and protection.

Our scope of work includes, parts, materials, programming, testing, and certification of the system consisting of:

- FCI S-3 Fire Alarm Control Panels
- FCI Initiating Devices
- System Sensor Notification Device.

All the work will be done in compliance with:

- NFPA 101 - 2012 ed.
- NFPA 72 - 2013 ed.
- NFPA 70/NEC - 2011 ed.
- NFPA 1 - 2012 ed.
- ALL LOCAL PREVAILING CODES

BAAS UNITED FIRE & SECURITY SYSTEMS, INC.
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24 Hour Emergency Service
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LIC # FF: 0000884

PME engineering
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9210 stony creek
st. thomas, vi 00802
340.998.4644

REVISIONS			
NO	DESCRIPTION	BY	DATE
0	ORIGINAL SUBMITTAL	TW	11-24-2015
1	REVISIONS PCR1 GOVERNMENT	TW	02-11-2016
2	REVISIONS PCR1 GOVERNMENT	TW	03-15-2016

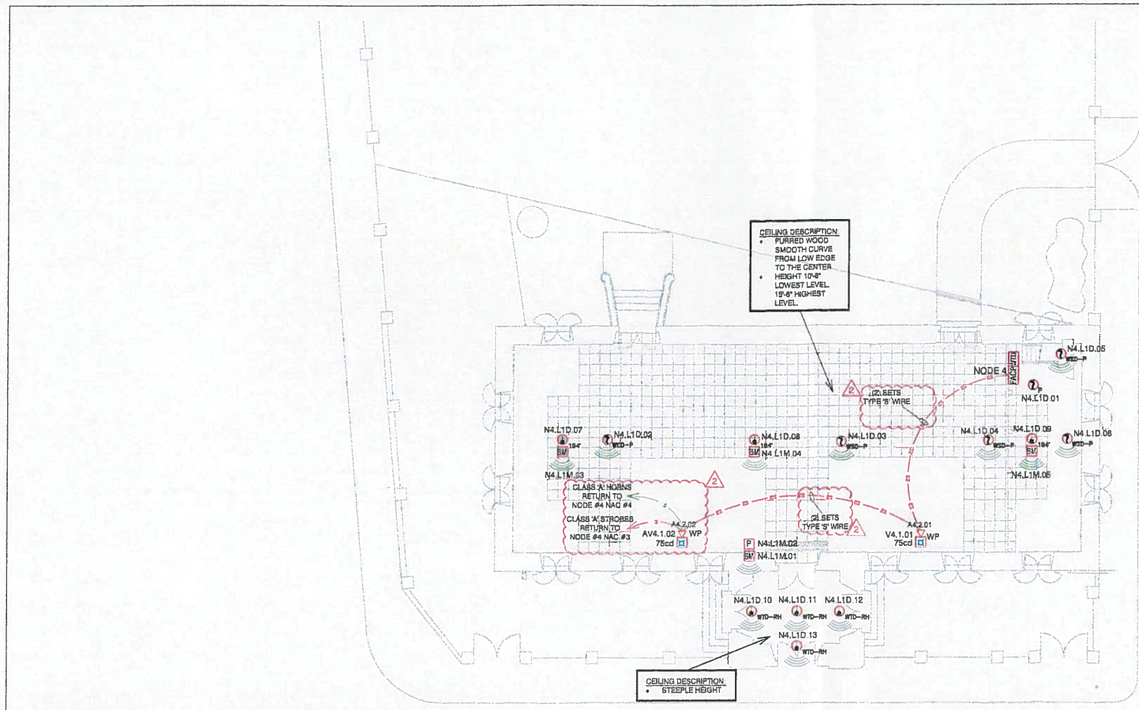
DRAWN BY: TW
DATE: 11-24-2015
CHECKED BY: RKG
DATE: 03-15-2016
FILE NAME:
SCALE: AS NOTED

DRAWINGS PREPARED FOR:
BAAS UNITED
3000 GATEWAY DRIVE
POMPANO BEACH, FL
FL LIC# EF 0000884

PROJECT NAME:
NATIONAL PARK SERVICE
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, ST. CROIX, VI
FIRE ALARM SYSTEM

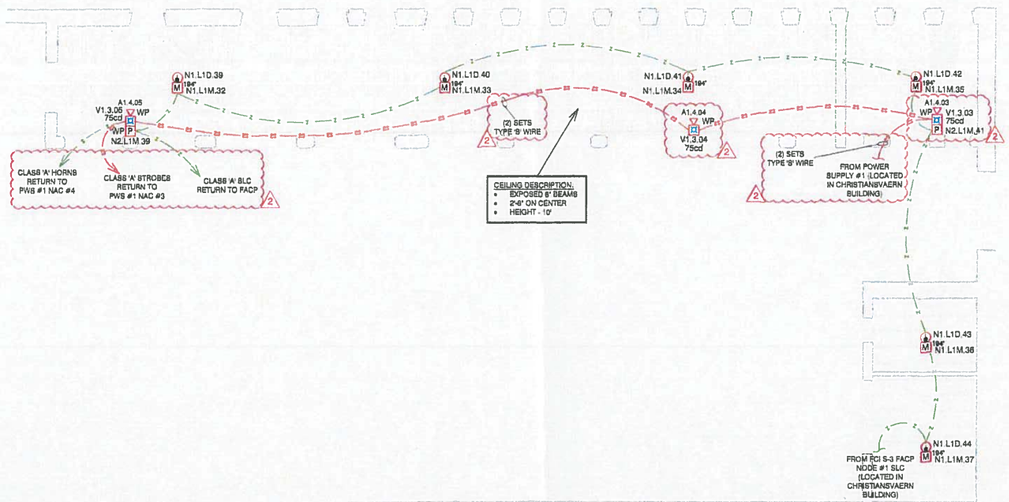
PROJECT NUMBER:
1006.1

SHEET NUMBER:
FA-03



1 STEEPLE BUILDING FIRE ALARM PLAN

SCALE: 1/8" = 1'-0"



SYMBOL LEGEND

SYMBOL	QTY	DESCRIPTION
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SM	56	FCI SWIFT WAM-MM ADDRESSABLE WIRELESS MODULE
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H WP	27	SYSTEM SENSOR P4WK WEATERPROOF HORN STRCBE MULTICANDELA WALL MOUNTED
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WP		DENOTES WEATHERPROOF DEVICE
EOL		END OF THE LINE RESISTOR AT LAST DEVICE ON EACH NAC

LINETYPE LEGEND

LINE TYPE	DESCRIPTION
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S	NOTIFICATION APPLIANCE CIRCUIT (NAC)
E	EVACUATION SIGNAL CIRCUIT (EVAC)
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P	PLENUM (FPLP) *	14 AWG	2	24V POWER
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J	THHN *	14 AWG	1	GROUND
N	62.5 MICRON MM FIBER OPTIC	FIBER	2	NETWORK

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* CABLE SIZE SHALL COMPLY WITH N.E.C. ARTTICLE 760.71

* CONDUIT SHALL BE A MINIMUM OF ¾".

SCOPE OF WORK

Bass United Fire and Security, Inc. (we, us, our) will design, furnish, and deliver new Fire Alarm Gamewell FCI S-3 System Control Panel, FCI Initiating and System Sensor Notification Devices as shown herein in order to provide appropriate minimum requirements for performance, selection, use, and location to ensure timely warning for the purposes of life safety and protection.

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- FCI S-3 Fire Alarm Control Panels
- FCI Initiating Devices
- System Sensor Notification Device.

All the work will be done in compliance with:

- NFPA 101 - 2012 ed.
- NFPA 72 - 2013 ed.
- NFPA 70/NEC - 2011 ed.
- NFPA 1 - 2012 ed.
- ALL LOCAL PREVAILING CODES

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PROFESSIONAL ENGINEER
STATE OF FLORIDA

NO	REVISIONS	BY	DATE
0	ORIGINAL SUBMITTAL	TW	02-24-2015
1	REVISIONS PER GOVERNMENT	TW	02-11-2016
2	REVISIONS PER GOVERNMENT	TW	03-15-2016

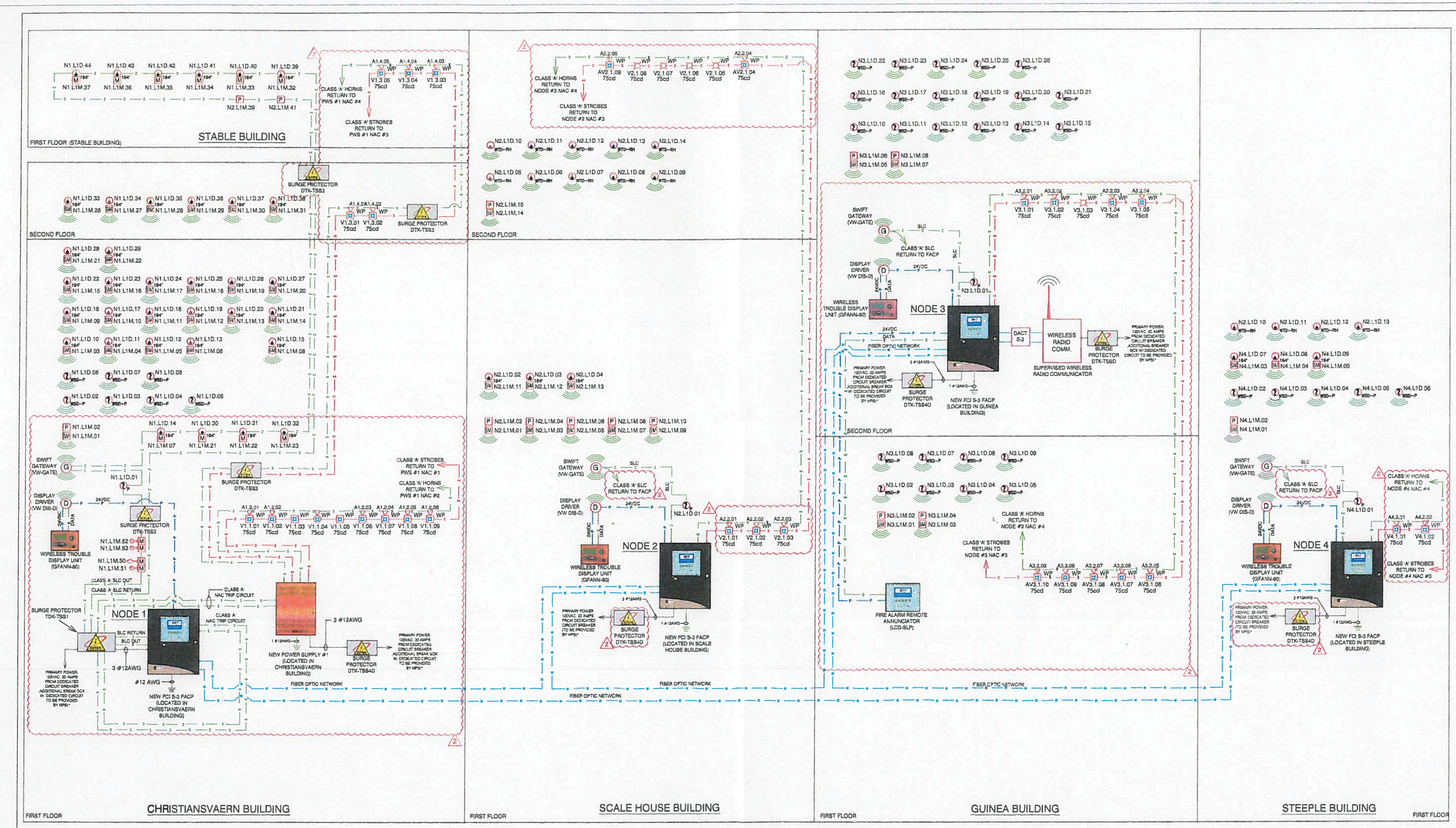
DRAWN BY: TW
DATE: 02-05-2015
CHECKED BY: MH
DATE: 03-15-2016
FILE NAME: SHEET SIZE: AS NOTED

ENGINEER PREPARED FOR:
BASE LIMITED
3000 GATLINWAY DRIVE
FT. LAUDERDALE, FL
FL LIC.# EF 0000084

PROJECT NAME:
NATIONAL PARK SERVICE
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, ST. CROIX, VI
FIRE ALARM SYSTEM

PROJECT NUMBER: 10061

SHEET NUMBER: FA-04



*EXACT CIRCUIT BREAKER NOMINCLATURE TO BE DETERMINED IN THE FIELD AND INCLUDED IN THE AS-BUILT DRAWINGS.

1 FIRE ALARM RISER DIAGRAM - NETWORK OF BUILDINGS
SCALE: N.T.S.

BASS UNITED
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24 Hour Emergency Service: 954.785.7600
www.bassunited.com
FLORIDA LIC # EF 0000684

PME engineering
robert m. german, pe
florida license #56543
certificate of authorization #5582
1 LICENSE: EF 0000684

REVISIONS

NO	DESCRIPTION	BY	DATE
0	ORIGINAL SUBMITTAL	TW	11-25-2015
1	REVISIONS PER GOVERNMENT	TW	02-17-2016
2	REVISIONS PER GOVERNMENT	TW	03-15-2016

DRAWN BY: TW
CHECKED BY: RMG
FILE NAME:
DATE: 03-25-2015
SCALE: AS NOTED

DRAWING PREPARED FOR:
BASS UNITED
3000 GATEWAY DRIVE
POMPANO BEACH, FL
FL LIC# EF 0000684

PROJECT NAME:
NATIONAL PARK SERVICE
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, ST. CROIX, VI
FIRE ALARM SYSTEM

PROJECT NUMBER: 10081

SHEET NUMBER: FA-05

Gamewell FX — System Current Draw — S3 Series Addressable Control Panel — Clear Quantities — Print Sheet

	Total Standby	0.273 A	Total Alarm	0.427 A
	Standby Current		Alarm Current	
Device	Qty	Draw	Standby	Qty	Draw	Alarm
1. System Device						
SLP-E3 Smart Loop Panel Main Board	1	0.10000	0.10000	1	0.18000	0.18000
FLPS-7 - Power Supply	1	0.00000	0.00000	1	0.00000	0.00000
SLC-PM - SLC Expander (System Sensor)	1	0.01400	0.01400	1	0.01400	0.01400
3. S3 Optional Modules						
DACT-E3 - Digital Communicator	1	0.01800		1	0.01800	0.01800
RPT-E3-UTP - ARCNET Repeater	1	0.01600	0.01600	1	0.01700	0.01700
FML-E3 - Fiber-Optic Multi-Mode Board	1	0.05300	0.05300	1	0.05300	0.05300
LCD-SLP - Remote LCD Annunciator	1	0.03000	0.03000	1	0.06500	0.06500
4. Smoke Detectors/Modules						
Pull Station MS-7AF - MS-7LDB	2	0.00010	0.00020	2	0.00300	0.00600
Smoke Detector ASD-PL2F	1	0.00030	0.00030	1	0.00650	0.00650
Monitor Module AMM-2F	14	0.00030	0.00420	14	0.00060	0.00840
Heat Detector 5602 194 degrees	10	0.00010	0.00100	10	0.00050	0.00500
SWIFT Gateway VW-GATE	1	0.02400	0.02400	1	0.02400	0.02400
SWIFT Display Driver VW-DIS-D	1	0.03000	0.03000	1	0.03000	0.03000
5. Notification Appliances						
P2WK75	0	0.00000		0	0.17600	
P2TWK25	0	0.00000		0	0.17600	
SWK25	0	0.00000		0	0.15800	
SCWK25	0	0.00000		0	0.15800	
	Total Standby Load:	0.273 A		Total Alarm Load:	0.427 A

Secondary Load Requirements 7.90 Amp Hours

Total Secondary Load from the calculation table below

Current Draw		Time (hours)	Total (AH)
Secondary Standby Load 0.273 A	x	Required Standby Time 24 hours	6.54
Secondary Alarm Load 0.427 A	x	Required Alarm Time (hours) 0.084 hours	0.04
		Total Secondary Load	6.59
		Derating factor	x 1.20
		Secondary Load Requirements	7.90 AH

Battery Selection 12.00 Amp Hours

Select batteries from the

12 AH Battery (12 volt)

1 NODE 1 - CALCS - CHRISTIANSVAERN/STABLE BLDGS.
SCALE: N.T.S.

Gamewell FX — System Current Draw — S3 Series Addressable Control Panel — Clear Quantities — Print Sheet

	Total Standby	0.267 A	Total Alarm	1.920 A
	Standby Current		Alarm Current	
Device	Qty	Draw	Standby	Qty	Draw	Alarm
1. System Device						
SLP-E3 Smart Loop Panel Main Board	1	0.10000	0.10000	1	0.18000	0.18000
FLPS-7 - Power Supply	1	0.00000	0.00000	1	0.00000	0.00000
SLC-PM - SLC Expander (System Sensor)	1	0.01400	0.01400	1	0.01400	0.01400
3. S3 Optional Modules						
DACT-E3 - Digital Communicator	1	0.01800		1	0.01800	0.01800
RPT-E3-UTP - ARCNET Repeater	1	0.01600	0.01600	1	0.01700	0.01700
FML-E3 - Fiber-Optic Multi-Mode Board	1	0.05300	0.05300	1	0.05300	0.05300
LCD-SLP - Remote LCD Annunciator	1	0.03000	0.03000	1	0.06500	0.06500
4. Smoke Detectors/Modules						
Smoke Detector ASD-PL2F	1	0.00030	0.00030	1	0.00650	0.00650
SWIFT Gateway VW-GATE	1	0.02400	0.02400	1	0.02400	0.02400
SWIFT Display Driver VW-DIS-D	1	0.03000	0.03000	1	0.03000	0.03000
5. Notification Appliances						
P2WK75	5	0.00000	0.00000	5	0.17600	0.88000
P2TWK25	0	0.00000		0	0.17600	
SWK25	4	0.00000	0.00000	4	0.15800	0.63200
SCWK25	0	0.00000		0	0.15800	
	Total Standby Load:	0.267 A		Total Alarm Load:	1.920 A

Secondary Load Requirements 7.89 Amp Hours

Total Secondary Load from the calculation table below

Current Draw		Time (hours)	Total (AH)
Secondary Standby Load 0.267 A	x	Required Standby Time 24 hours	6.42
Secondary Alarm Load 1.920 A	x	Required Alarm Time (hours) 0.084 hours	0.16
		Total Secondary Load	6.58
		Derating factor	x 1.20
		Secondary Load Requirements	7.89 AH

Battery Selection 12.00 Amp Hours

Select batteries from the

12 AH Battery (12 volt)

2 NODE 2 - CALCULATIONS - SCALE HOUSE
SCALE: N.T.S.

Gamewell FX — System Current Draw — S3 Series Addressable Control Panel — Clear Quantities — Print Sheet

	Total Standby	0.267 A	Total Alarm	2.150 A
	Standby Current		Alarm Current	
Device	Qty	Draw	Standby	Qty	Draw	Alarm
1. System Device						
SLP-E3 Smart Loop Panel Main Board	1	0.10000	0.10000	1	0.18000	0.18000
FLPS-7 - Power Supply	1	0.00000	0.00000	1	0.00000	0.00000
SLC-PM - SLC Expander (System Sensor)	1	0.01400	0.01400	1	0.01400	0.01400
3. S3 Optional Modules						
DACT-E3 - Digital Communicator	1	0.01800		1	0.01800	0.01800
RPT-E3-UTP - ARCNET Repeater	1	0.01600	0.01600	1	0.01700	0.01700
FML-E3 - Fiber-Optic Multi-Mode Board	1	0.05300	0.05300	1	0.05300	0.05300
LCD-SLP - Remote LCD Annunciator	1	0.03000	0.03000	1	0.06500	0.06500
4. Smoke Detectors/Modules						
Smoke Detector ASD-PL2F	1	0.00030	0.00030	1	0.00650	0.00650
SWIFT Gateway VW-GATE	1	0.02400	0.02400	1	0.02400	0.02400
SWIFT Display Driver VW-DIS-D	1	0.03000	0.03000	1	0.03000	0.03000
5. Notification Appliances						
P2WK75	9	0.00000	0.00000	9	0.17600	1.58400
P2TWK25	0	0.00000		0	0.17600	
SWK25	1	0.00000	0.00000	1	0.15800	0.15800
SCWK25	0	0.00000		0	0.15800	
	Total Standby Load:	0.267 A		Total Alarm Load:	2.150 A

Secondary Load Requirements 7.91 Amp Hours

Total Secondary Load from the calculation table below

Current Draw		Time (hours)	Total (AH)
Secondary Standby Load 0.267 A	x	Required Standby Time 24 hours	6.42
Secondary Alarm Load 2.150 A	x	Required Alarm Time (hours) 0.084 hours	0.18
		Total Secondary Load	6.60
		Derating factor	x 1.20
		Secondary Load Requirements	7.91 AH

Battery Selection 12.00 Amp Hours

Select batteries from the

12 AH Battery (12 volt)

3 NODE 3 - CALCULATIONS - GUINEA BUILDING
SCALE: N.T.S.

Gamewell FX — System Current Draw — S3 Series Addressable Control Panel — Clear Quantities — Print Sheet

	Total Standby	0.760 A	Total Alarm	0.760 A
	Standby Current		Alarm Current	
Device	Qty	Draw	Standby	Qty	Draw	Alarm
1. System Device						
SLP-E3 Smart Loop Panel Main Board	1	0.10000	0.10000	1	0.18000	0.18000
FLPS-7 - Power Supply	1	0.00000	0.00000	1	0.00000	0.00000
SLC-PM - SLC Expander (System Sensor)	1	0.01400	0.01400	1	0.01400	0.01400
3. S3 Optional Modules						
DACT-E3 - Digital Communicator	1	0.01800		1	0.01800	0.01800
RPT-E3-UTP - ARCNET Repeater	1	0.01600	0.01600	1	0.01700	0.01700
FML-E3 - Fiber-Optic Multi-Mode Board	1	0.05300	0.05300	1	0.05300	0.05300
LCD-SLP - Remote LCD Annunciator	1	0.03000	0.03000	1	0.06500	0.06500
4. Smoke Detectors/Modules						
Smoke Detector ASD-PL2F	1	0.00030	0.00030	1	0.00650	0.00650
SWIFT Gateway VW-GATE	1	0.02400	0.02400	1	0.02400	0.02400
SWIFT Display Driver VW-DIS-D	1	0.03000	0.03000	1	0.03000	0.03000
5. Notification Appliances						
P2WK75	2	0.00000	0.00000	2	0.17800	0.35200
P2TWK25	0	0.00000		0	0.17600	
SWK25	0	0.00000		0	0.15800	
SCWK25	0	0.00000		0	0.15800	
	Total Standby Load:	0.267 A		Total Alarm Load:	0.760 A

Secondary Load Requirements 7.77 Amp Hours

Total Secondary Load from the calculation table below

Current Draw		Time (hours)	Total (AH)
Secondary Standby Load 0.267 A	x	Required Standby Time 24 hours	6.42
Secondary Alarm Load 0.760 A	x	Required Alarm Time (hours) 0.084 hours	0.05
		Total Secondary Load	6.48
		Derating factor	x 1.20
		Secondary Load Requirements	7.77 AH

Battery Selection 12.00 Amp Hours

Select batteries from the

12 AH Battery (12 volt)

4 NODE 4 - CALCULATIONS - SCALE HOUSE

VOLTAGE DROP CALCULATIONS

VD = 2 x L x R x I / 1000

OPERATING RANGE FOR DEVICES ARE BETWEEN 16VDC AND 33VDC

OHMS PER THOUSAND	
18 AWG	7.77
16 AWG	4.89
14 AWG	3.07
12 AWG	1.93
10 AWG	1.21

VD = VOLTAGE DROP
L = ONE-WAY LENGTH OF CIRCUIT
R = CONDUCTOR RESISTANCE IN OHMS PER THOUSAND FEET
I = LOAD CURRENT

FIRE-LITE FCPS-24FS8 POWER SUPPLY 1

DESCRIPTION	STANDBY CURRENT PER UNIT (AMPS)	QTY	TOTAL STANDBY CURRENT PER ITEM (AMPS)	ALARM CURRENT PER UNIT (AMPS)	QTY	TOTAL ALARM CURRENT (AMPS)
FCPS-24FS8	0.091	x 1 =	0.091	0.240	x 1 =	0.240
CIRCUIT #1				1.422	x 1 =	1.422
CIRCUIT #2				0.483	x 1 =	0.483
CIRCUIT #3				0.790	x 1 =	0.790
CIRCUIT #4				0.345	x 1 =	0.345
	TOTAL SYSTEM STANDBY (AMPS):		0.091	TOTAL SYSTEM ALARM (AMPS):		3.280

REQUIRED OPERATION TIME FROM NFPA 72 4.4.1.5.1 (1) & 4.4.1.5.3.1

STANDBY: 24 HOURS — ALARM: 15 MINUTES X 1.60 = 0.25 HOURS

REQUIRED STANDBY TIME (HOURS)		TOTAL STANDBY CURRENT (AMPS)		REQUIRED STANDBY CAPACITY (AMP-HR)		REQUIRED ALARM TIME (HOURS)		TOTAL ALARM CURRENT (AMPS)		REQUIRED ALARM CAPACITY (AMP-HR)
24	x	0.091	=	2.184		0.25	x	3.280	=	0.820

REQUIRED STANDBY CAPACITY (AMP-HR)		REQUIRED ALARM CAPACITY (AMP-HR)		REQUIRED AMP HOUR BATTERY		DERATING FACTOR 1.2		MINIMUM AMP-HOUR BATTERY REQUIRED		MINIMUM AMP-HOUR BATTERY REQUIRED
2.184	+	0.820	=	3.004	x	1.2	=	3.605		7

TOTALS FOR CIRCUIT #1

QTY	NOTIFICATION TYPE	AMPS	TOTAL
6	SYS. SEN. P/WK STR. 75cd	0.158	0.948
0	SYS. SEN. P/WK HORN	0.069	0.000
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
2	SYS. SEN. SCWK STR. 75cd	0.158	0.316
0	-	0.000	0.000
0	-	0.000	0.000
9		TOTAL AMPS:	1.422

TOTALS FOR CIRCUIT #2

QTY	NOTIFICATION TYPE	AMPS	TOTAL
5	SYS. SEN. P/WK STR. 75cd	0.158	0.790
0	SYS. SEN. P/WK HORN	0.069	0.000
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
5	SYS. SEN. SCWK STR. 75cd	0.158	0.790
0	-	0.000	0.000
0	-	0.000	0.000
5		TOTAL AMPS:	1.580

TOTALS FOR CIRCUIT #3

QTY	NOTIFICATION TYPE	AMPS	TOTAL
7	SYS. SEN. P/WK STR. 75cd	0.158	0.948
0	SYS. SEN. P/WK HORN	0.069	0.414
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
1	SYS. SEN. P/CWK HORN	0.069	0.069
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
8		TOTAL AMPS:	0.483

TOTALS FOR CIRCUIT #4

QTY	NOTIFICATION TYPE	AMPS	TOTAL
0	SYS. SEN. P/WK STR. 75cd	0.158	0.000
5	SYS. SEN. P/WK HORN	0.069	0.345
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
5		TOTAL AMPS:	0.345

VOLTAGE DROP CALCULATIONS

CIRCUIT NUMBER	WIRE RUN ONE WAY (FEET) (W.C.S.)	OHMS PER WIRE SIZE OHMS	AWG	TOTAL CIRCUIT DRAW	VOLTAGE DROP	POWER SUPPLY VOLTAGE	VOLTAGE READING AT LAST DEVICE	VOLTAGE DROP AT END	ACCEPTABLE VOLTAGE DROP
CIRCUIT #1	369	3.07	14	1.422	3.366	20.4	17.00	17%	YES
CIRCUIT #2	339	3.07	14	0.483	1.154	20.4	19.25	6%	YES
CIRCUIT #3	234	3.07	14	0.790	1.138	20.4	19.26	6%	YES
CIRCUIT #4	234	3.07	14	0.345	0.499	20.4	19.90	2%	YES

5 POWER SUPPLY #1 VOLTAGE DROP CALCULATIONS

TOTALS FOR CIRCUIT #1

QTY	NOTIFICATION TYPE	AMPS	TOTAL
5	SYS. SEN. P/WK STR. 75cd	0.158	0.790
0	SYS. SEN. P/WK HORN	0.069	0.000
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
5		TOTAL AMPS:	0.790

TOTALS FOR CIRCUIT #2

QTY	NOTIFICATION TYPE	AMPS	TOTAL
9	SYS. SEN. P/WK STR. 75cd	0.158	1.422
0	SYS. SEN. P/WK HORN	0.069	0.000
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
9		TOTAL AMPS:	1.422

VOLTAGE DROP CALCULATIONS

CIRCUIT NUMBER	WIRE RUN ONE WAY (FEET) (W.C.S.)	OHMS PER WIRE SIZE OHMS	AWG	TOTAL CIRCUIT DRAW	VOLTAGE DROP	POWER SUPPLY VOLTAGE	VOLTAGE READING AT LAST DEVICE	VOLTAGE DROP AT END	ACCEPTABLE VOLTAGE DROP
CIRCUIT #1	168	3.07	14	1.422	1.487	20.4	18.93	7%	YES
CIRCUIT #2	168	3.07	14	0.345	0.358	20.4	20.04	2%	YES
RETURN #1	0	3.07	14	0.000	0.000	20.4	20.40	0%	RETURN #1
RETURN #2	0	3.07	14	0.000	0.000	20.4	20.40	0%	RETURN #2

6 NODE 2 - FACP VOLTAGE DROP CALCULATIONS
SCALE: N.T.S.

TOTALS FOR CIRCUIT #1

QTY	NOTIFICATION TYPE	AMPS	TOTAL
9	SYS. SEN. P/WK STR. 75cd	0.158	1.422
0	SYS. SEN. P/WK HORN	0.069	0.000
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
1	SYS. SEN. SWK STR. 75cd	0.158	0.158
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
10		TOTAL AMPS:	1.580

TOTALS FOR CIRCUIT #2

QTY	NOTIFICATION TYPE	AMPS	TOTAL
9	SYS. SEN. P/WK STR. 75cd	0.158	1.422
0	SYS. SEN. P/WK HORN	0.069	0.621
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
9		TOTAL AMPS:	1.621

VOLTAGE DROP CALCULATIONS

CIRCUIT NUMBER	WIRE RUN ONE WAY (FEET) (W.C.S.)	OHMS PER WIRE SIZE OHMS	AWG	TOTAL CIRCUIT DRAW	VOLTAGE DROP	POWER SUPPLY VOLTAGE	VOLTAGE READING AT LAST DEVICE	VOLTAGE DROP AT END	ACCEPTABLE VOLTAGE DROP
CIRCUIT #1	329	3.07	14	1.580	2.804	20.4	17.60	14%	YES
CIRCUIT #2	295	3.07	14	0.621	1.102	20.4	19.30	5%	YES
RETURN #1	0	3.07	14	0.000	0.000	20.4	20.40	0%	RETURN #1
RETURN #2	0	3.07	14	0.000	0.000	20.4	20.40	0%	RETURN #2

7 NODE 3 - FACP VOLTAGE DROP CALCULATIONS
SCALE: N.T.S.

TOTALS FOR CIRCUIT #1

QTY	NOTIFICATION TYPE	AMPS	TOTAL
2	SYS. SEN. P/WK STR. 75cd	0.158	0.316
0	SYS. SEN. P/WK HORN	0.069	0.000
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
2		TOTAL AMPS:	0.316

TOTALS FOR CIRCUIT #2

QTY	NOTIFICATION TYPE	AMPS	TOTAL
0	SYS. SEN. P/WK STR. 75cd	0.158	0.000
2	SYS. SEN. P/WK HORN	0.069	0.138
0	SYS. SEN. P/CWK STR. 75cd	0.158	0.000
0	SYS. SEN. P/CWK HORN	0.069	0.000
0	SYS. SEN. SWK STR. 75cd	0.158	0.000
0	SYS. SEN. SCWK STR. 75cd	0.158	0.000
0	-	0.000	0.000
0	-	0.000	0.000
2		TOTAL AMPS:	0.138

VOLTAGE DROP CALCULATIONS

CIRCUIT NUMBER	WIRE RUN ONE WAY (FEET) (W.C.S.)	OHMS PER WIRE SIZE OHMS	AWG	TOTAL CIRCUIT DRAW	VOLTAGE DROP	POWER SUPPLY VOLTAGE	VOLTAGE READING AT LAST DEVICE	VOLTAGE DROP AT END	ACCEPTABLE VOLTAGE DROP
CIRCUIT #1	97	3.07	14	0.316	0.189	20.4	20.21	1%	YES
CIRCUIT #2	97	3.07	14	0.138	0.082	20.4	20.32	0%	YES
RETURN #1	0	3.07	14	0.000	0.000	20.4	20.40	0%	RETURN #1
RETURN #2	0	3.07	14	0.000	0.000	20.4	20.40	0%	RETURN #2

8 NODE 4 - FACP VOLTAGE DROP CALCULATIONS

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NO	DATE	BY
2	11-24-2015	TW
1	02-11-2016	TW
0	03-15-2016	TW

DRAWING REVISIONS

NO	DATE	BY
0	ORIGINAL SUBMITTAL	TW
1	REVISIONS PER GOVERNMENT	TW
2	REVISIONS PER GOVERNMENT	TW

DRAWN BY	DATE	BY
TW	10-05-2015	TW
TEREMIAH BRAY	03-15-2016	TW

REVISIONS

NATIONAL PARK SERVICE
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, ST. CROIX, VI
FIRE ALARM SYSTEM

PROJECT NUMBER: 10061

SHEET NUMBER:

PERFORMANCE OF SIGNALING LINE CIRCUITS (SLC)							COMMENT
CLASS	A			X			FIBER RUNS SHALL RETURN IN THE SAME RACEWAY PER NPS COMMENTS
	ALM	TRBL	ARC	ALM	TRBL	ARC	
ABNORMAL CONDITIONS	4	5	6	7	8	9	
SINGLE OPEN	-	X	R	-	X	R	
SINGLE GROUND	-	X	R	-	X	R	
WIRE-TO-WIRE SHORT	-	X	-	-	X	R	
WIRE-TO-WIRE SHORT & OPEN	-	X	-	-	X	-	
WIRE-TO-WIRE SHORT & GROUND	-	X	-	-	X	-	
OPEN & GROUND	-	X	R	-	X	R	
LOSS OF CARRIER (IF USED) CHANNEL INTERFACE	-	X	-	-	X	-	

FUNCTION:
ALM = ALARM
TRBL = TROUBLE
ARC = ALARM RECEIPT CAPABILITY DURING ABNORMAL CONDITION

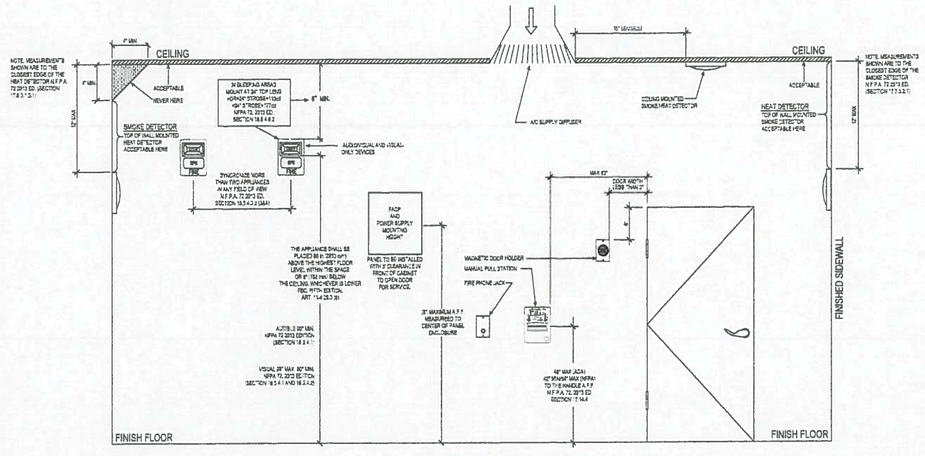
ABNORMAL CONDITION
R = REQUIRED CAPACITY
X = INDICATION REQUIRED AT PROTECTED PREMISES AND AS REQUIRED BY NFPA 72, CHAPTER 26
(PERFORMANCE OF SLC AS PER NFPA-72 (ED. 2013) ARTICLE 12.3*)

NOTIFICATION APPLIANCE CIRCUITS (NAC)			COMMENT
CLASS	A		
ABNORMAL CONDITIONS	TROUBLE INDICATION AT PROTECTED PREMISES	ALARM CAPABILITY DURING ABNORMAL CONDITIONS	
SINGLE OPEN	X	R	
SINGLE GROUND	X	R	
WIRE-TO-WIRE SHORT	X	-	

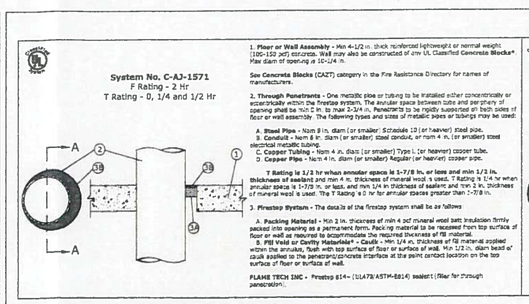
ABNORMAL CONDITION:
X = INDICATION REQUIRED AT PROTECTED PREMISES
R = REQUIRED CAPABILITY
(PERFORMANCE OF NOTIFICATION APPLIANCE CIRCUITS (NACs), AS PER NFPA 72 (ED. 2013) ARTICLE 12.3*)

- ALL CIRCUITS SHALL BE IN CONDUIT (NFB 3.6 A - J)
- OUTGOING AND RETURN CIRCUITS SHALL RUN IN TWO SEPARATE CONDUITS.
- AQUASEAL WIRE BETWEEN PORT AND STABLE BLDG.
- EQUIPMENT, EQUIPMENT GROUNDING CONDUCTORS, AND CABLE SHIELDS SHALL BE GROUNDED ACCORDING TO THE MANFACTURERS RECOMMENDATIONS AND NFPA 70, NATIONAL ELECTRICAL CODE. SHIELDED TYPE FPL CABLE SHALL HAVE SHIELDS OR DRAIN WIRE TIED THROUGH DEVICES AND JUNCTION BOXES. ISOLATED (INSULATED) FROM GROUND EXCEPT AT THE FACP.
- GROUNDING SHALL COMPLY WITH ARTICLE 250 OF NFPA 70, NATIONAL ELECTRICAL CODE.

1 CIRCUIT SPECIFICATION
SCALE: NTS



2 MOUNTING DETAILS
SCALE: NTS



1. **Floor or Wall Assembly** - Min 4-1/2 in. thick reinforced lightweight or normal weight (100-150 pcf) concrete. Wall may also be constructed of any UL Classified **Concrete Blocks*** Max diam of opening is 10-1/4 in.

See **Concrete Blocks** (CAZT) category in the Fire Resistance Directory for names of manufacturers.

2. **Through Penetrants** - One metallic pipe or tubing to be installed either concentrically or eccentrically within the firestop system. The annular space between tube and periphery of opening shall be 1in C in. to max 2-3/4 in. Penetrants to be rigidly supported on both sides of floor or wall assembly. The following types and sizes of metallic pipes or tubings may be used:

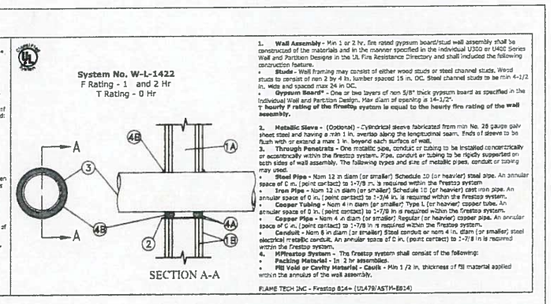
A. **Steel Pipe** - Nom 8 in. diam (or smaller) Schedule 10 (or heavier) steel pipe.
B. **Conduit** - Nom 6 in. diam (or smaller) steel conduit, or nom 4 in. (or smaller) steel electrical metallic tubing.
C. **Copper Tubing** - Nom 4 in. diam (or smaller) Type L (or heavier) copper tube.
D. **Copper Pipe** - Nom 4 in. diam (or smaller) Regular (or heavier) copper pipe.

T Rating is 2/3 hr when annular space is 1-7/8 in. or less and min 1/2 in. thickness of sealant and min 4 in. thickness of mineral wool is used. T Rating is 1/4 hr when annular space is 1-7/8 in. or less, and min 1/4 in thickness of sealant and min 2 in. thickness of mineral wool is used. The T Rating is 0 hr for annular spaces greater than 1-7/8 in.

3. **Firestop System** - The details of the firestop system shall be as follows:

A. **Packing Material** - Min 2 in. thickness of min 4 pcf mineral wool batt insulation firmly packed into opening as a permanent form. Packing material to be recessed from top surface of floor or wall as required to accommodate the required thickness of fill material.
B. **Fill Void or Cavity Materials* - Caulk** - Min 1/4 in. thickness of fill material applied within the annulus, flush with top surface of floor or surface of wall. Min 1/2 in. diam bead of caulk applied to the penetrant/concrete interface at the point contact location on the top surface of floor or surface of wall.

FLAME TECH INC - Firestop 814+ (UL479/ASTM-E814) sealant (fiber for through penetration).



1. **Wall Assembly** - Min 1 or 2 hr, fire rated gypsum board/stud wall assembly shall be constructed of the materials and in the manner specified in the individual U305 or U400 Series Wall and Partition Designs in the UL Fire Resistance Directory and shall included the following construction features:
   - **Studs** - Wall framing may consist of either wood studs or steel channel studs. Wood studs to consist of nom 2 by 4 in. lumber spaced 16 in. OC. Steel channel studs to be min 4-1/2 in. wide and spaced max 24 in OC.
   - **Gypsum Board*** - One or two layers of nom 5/8" thick gypsum board as specified in the individual Wall and Partition Design. Max diam of opening is 14-1/2".

T hourly F rating of the firestop system is equal to the hourly fire rating of the wall assembly.

2. **Metallic Sleve** - (Optional) - Cylindrical sleeve fabricated from min No. 26 gauge galv sheet steel and having a min 1 in. overlap along the longitudinal seam. Ends of sleeve to be flush with or extend a max 1 in. beyond each surface of wall.
3. **Through Penetrants** - One metallic pipe, conduit or tubing to be installed concentrically or eccentrically within the firestop system. Pipe, conduit or tubing to be rigidly supported on both sides of wall assembly. The following types and size of metallic pipes, conduit or tubing may used:
   - **Steel Pipe** - Nom 12 in diam (or smaller) Schedule 10 (or heavier) steel pipe. An annular space of 0 in. (point contact) to 1-7/8 in. is required within the firestop system
   - **Iron Pipe** - Nom 12 in diam (or smaller) Schedule 10 (or heavier) cast iron pipe. An annular space of 0 in. (point contact) to 1-3/4 in. is required within the firestop system.
   - **Copper Tubing** - Nom 4 in diam (or smaller) Type L (or heavier) copper tube. An annular space of 0 in. (point contact) to 1-7/8 in is required within the firestop system.
   - **Copper Pipe** - Nom 4 in diam (or smaller) Regular (or heavier) copper pipe. An annular space of 0 in. (point contact) to 1-7/8 in is required within the firestop system.
   - **Conduit** - Nom 6 in diam (or smaller) Steel conduit or nom 4 in. diam (or smaller) steel electrical metallic conduit. An annular space of 0 in. (point contact) to 1-7/8 in is required within the firestop system.
4. **Firestop System** - The firestop system shall consist of the following:
   - **Packing Material** - In 2 hr assemblies.
   - **Fill Void or Cavity Material* - Caulk** - Min 1 / 2 in. thickness of fill material applied within the annulus of the wall assembly.

FLAME TECH INC - Firestop 814+ (UL479/ASTM-E814)

3 GENERAL PENETRATION DETAIL
SCALE: NTS

1.0.1 CONTROL PANEL

A. THE FIRE ALARM AND DETECTION SYSTEM SHALL BE MICROPROCESSOR BASED, POWER-LIMITED, SUPERVISED 24 VDC, NON-CODED SYSTEM. THE SYSTEM SHALL BE CAPABLE OF PROVIDING THE FOLLOWING FUNCTIONS:
1. REAL-TIME CLOCK/CALENDAR WITH DAYLIGHT SAVING TIME CONTROL
2. ALARM VERIFICATION SELECTION PER DETECTOR POINT
3. SELECTABLE STROBE SYNCHRONIZATION PER NAC
4. BUILT-IN PROGRAMMER
5. WALK TEST, SILENT OR AUDIBLE
6. 80 CHARACTER ALPHANUMERIC LCD DISPLAY
7. PAS (POSITIVE ALARM SEQUENCE) OPERATION.

1.0.2 SUPERVISION

A. SUPERVISED AND POWER LIMITED COMMUNICATION LOOP, STYLE 4 (CLASS A) SUPERVISION OF ALL INITIATION DEVICES IS REQUIRED. NOTIFICATION APPLIANCE WIRING SHALL ALSO BE STYLE Y (CLASS A).

1.0.3 POWER SUPPLY

- AT LEAST TWO INDEPENDENT AND RELIABLE POWER SUPPLIES SHALL PROVIDED, ONE PRIMARY AND ONE SECONDARY, EACH OF WHICH SHALL BE ADEQUATE CAPACITY FOR THE APPLICATION.
- PRIMARY POWER SHALL CONSIST OF A TWO-WIRE 120 VAC, MAXIMUM 20 AMPERES AND THE CONNECTION MUST BE FROM A BRANCH CIRCUIT DEDICATED TO THE FIRE ALARM SYSTEM. THE CIRCUIT AND CONNECTION MUST BE MECHANICALLY PROTECTED. THE CIRCUIT DISCONNECTING MEANS MUST HAVE A RED MARKING AS "FIRE ALARM CIRCUIT". INSIDE THE FIRE ALARM SYSTEM CONTROL UNIT, THE PRIMARY POWER IS SUPPLIED BY A CONNECTION FROM UTILITY-GENERATED ELECTRIC POWER (COMMERCIAL POWER).
- THE SYSTEM MUST HAVE 24 HR. OF STANDBY POWER, FOLLOWED BY 5 MINUTES OF ALARM (15 MINUTES FOR A VOICE SYSTEM).

1.0.4 SECONDARY POWER SUPPLY

(THE SECONDARY POWER SUPPLY SHALL CONSIST OF A STORAGE BATTERY DEDICATED TO THE FIRE ALARM SYSTEM.
THE SECONDARY POWER SOURCE OF THE FIRE ALARM CONTROL PANEL SHALL HAVE SUFFICIENT CAPACITY TO OPERATE THE FIRE ALARM SYSTEM UNDER QUIESCENT LOAD (SYSTEM OPERATING IN A NON ALARM CONDITION) FOR A MINIMUM OF 24 HOURS, AND AT THE END OF THAT PERIOD SHALL BE CAPABLE OF OPERATING ALL ALARM NOTIFICATION APPLIANCE USED FOR EVACUATION AT 10 DIRECT AID TO THE LOCATION OF AN EMERGENCY FOR 15 MINUTES. AS PER NFPA 72 ARTICLE 10.6.8.3.1.

1.0.5 VOLTAGE DROP CALCULATION:

- UL 864 INDICATE A MINIMUM VALUE OF 20.4V (END OF USEFUL BATTERY LIFE) AS PER NFPA 72 ARTICLE 18.3.2.3. (THIS VALUE THEN BECOMES THE STARTING POINT FOR THE VOLTAGE DROP CALCULATION).
- FOR OLDER APPLIANCES THAN DON'T COMPLY WITH PUBLISHED TEST STANDARD DATE MAY 1, 2004. THE MINIMUM OPERATING VOLTAGE SHALL BE 17.7 VOLTS.
- FOR (NEW) APPLIANCES THAT COMPLY WITH PUBLISHED TEST STANDARD DATE MAY 1, 2004 THE MINIMUM OPERATING VOLTAGE SHALL BE 16 VOLTS.
- TO CALCULATE THE VOLTAGE DROP CALCULATION WE ARE USING THE SIMPLEST METHOD. TO LUMP SUM ALL APPLIANCE LOAD AT THE END OF THE CIRCUIT.

1.0.6 CIRCUIT

FIRE ALARM SYSTEM HAVE THREE BASIC TYPE CIRCUITS

1. INITIATING DEVICES CIRCUIT (IDC) - TWO-WIRE CIRCUIT AN END-OF-LINE RESISTOR
2. NOTIFICATION APPLIANCE CIRCUITS (NAC) - TWO-WIRE CIRCUIT AND END-OF-LINE RESISTOR
3. SIGNALING LINE CIRCUIT (SLC) - TWO WIRE CIRCUIT AND END-OF-LINE CIRCUIT.

ALL FIRE ALARM SYSTEM CABLE AND WIRING INSTALLATION SHALL BE IN ACCORDANCE WITH LOCAL, STATE AND NFPA 72, AND SPECIFICALLY WITH ARTICLE 760 OF NFPA 70 (NEC) FOR POWER-LIMITED FIRE PROTECTION SIGNAL CIRCUIT, AND THE ADDITIONAL REQUIREMENTS OF NFPA 72.

WIRING FOR 24-VOLTS DC CONTROL, ALARM NOTIFICATION, EMERGENCY COMMUNICATION AND SIMILAR POWER LIMITED AUXILIARY FUNCTIONS MAY BE RUN IN THE SAME CONDUIT AS INITIATING AND SIGNALING LINE CIRCUITS.

THE ALARM CURRENT DRAW OF THE ENTIRE FIRE ALARM SYSTEM SHALL NOT EXCEED 80 PERCENT OF THE POWER-SUPPLY MODULE RATING.

WIRE AND CABLE SIZE SHALL COMPLY WITH NEC 760.27, AND AS RECOMMENDED BY THE MANUFACTURE OF FIRE ALARM SYSTEM. NUMBER AND SIZE OF CONDUCTORS SHALL BE AS RECOMMENDED BY THE FIRE ALARM MANUFACTURER, BUT NOT LESS THAN 16 AWG (#16 AWG FPLP, SOLID COPPER CONDUCTOR) FOR INITIATING DEVICE CIRCUITS, 16 AWG (#16 TWISTED PAIR, SOLID COPPER UNSHIELDED) FOR NOTIFICATION APPLIANCE CIRCUIT, AND 18 AWG (#18 AWG FPLP SOLID UNSHIELDED FOR SIGNALING LINE CIRCUIT. AS PER NEC.

ALL FIRE ALARM SYSTEM WIRING SHALL BE MEW, COLOR CODE MAY NOT APPLY TO EXISTING WIRE. (LABEL ALL EXISTING WIRE ACCORDINGLY).

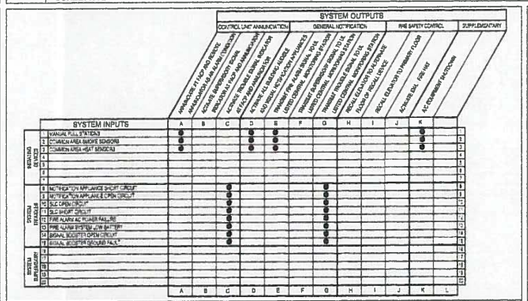
ALL WIRE AND CABLE SHALL BE LISTED AND/OR APPROVED BY A RECOGNIZED TESTING AGENCY FOR USE WITH A PROTECTIVE SIGNALING SYSTEM.

FIRE ALARM CIRCUITS SHALL BE IDENTIFIED AT TERMINALS AND JUNCTION LOCATION TO COMPLY WITH NEC ARTICLE 760.13

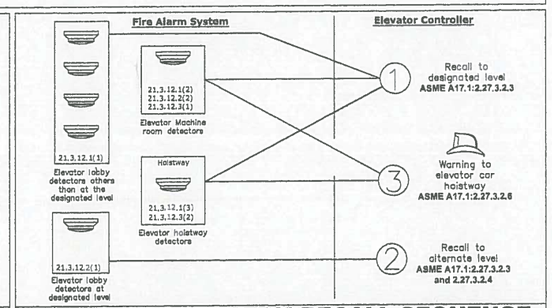
WIRE AND CABLES NOT INSTALLED IN CONDUIT SHALL HAVE A FIRE RESISTANCE RATING SUITABLE FOR INSTALLATION AS INDICATED IN NEC 760

ALL FIELD WIRING SHALL BE COMPLETELY SUPERVISED. IN THE EVENT OF A PRIMARY POWER FAILURE, DISCONNECTED STANDBY BATTERY, REMOVAL OF ANY INTERNAL MODULES OR ANY OPEN CIRCUITS IN THE FIELD WIRING. A TROUBLE SIGNAL WILL BE ACTIVATED UNTIL THE SYSTEM AND ITS ASSOCIATED FIELD WIRING ARE RESTORED TO NORMAL CONDITION.

4 GENERAL NOTES
SCALE: NTS



5 SEQUENCE OF OPERATION MATRIX
SCALE: NTS



6 ELEVATOR SYSTEM RECALL SEQUENCE
SCALE: NTS

BUILDING SPECIFICATIONS

PROJECT NAME	BUILDING						FIRE ALARM SYSTEM									METHOD OF COMMUNICATION TO THE MONITORING STATION		FIRE DETECTION SYSTEM			COMMENT
			OCCUPANCY				CIRCUITS	MONITORED OFF-SITE			NOT MONITORED OFF-SITE										
	EXISTING	NEW	BUSINESS	SCHOOL	ASSEMBLY	NUMBER OF STORIES	POWER LIMITED	NON-POWER LIMITED	UL LISTED CENTRAL STATION F.A. SYSTEM	FIRE ALARM SERVICE - LOCAL F.A. SYSTEM	PROPRIETARY SUPERVISING STATION F.A. SYSTEM	LOCAL F.A. SYSTEM	PROPRIETARY SUPERVISING STATION F.A. SYSTEM			DACT - TWO TELEPH LINES	WIRELESS RADIO TRANSMITTER	ELEVATOR RECALL	F.A. SYSTEM	VOICE	FIRE FIGHTER PHONES	
NATIONAL PARK SERVICE	●		●			1-2	●			●							●		●			

7 BUILDING SPECIFICATIONS
SCALE: NTS

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CERT. No. 47727
EXPIRES: 2/28/2017

REVISIONS

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Appendix E:
Structural Investigation Report by 1200AE

MCC 1200
ARCHITECTURAL ENGINEERS PLLC

Fort Christiansvaern and Stable Building

Historic Structure Report



1200AE PROJECT NO. 20-131

July 19, 2023

Prepared For:

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Introduction

1200 Architectural Engineers (1200AE) was contracted to assist with preparing a Historic Structures Report (HSR) for Fort Christiansvaern in Christiansted, St. Croix, U.S. Virgin Islands. The scope of the HSR includes Fort Christiansvaern (1738) and its Stable Building (1836) and the associated Stableyard, Gate, and Walls. This HSR is intended to update a previous HSR produced in 1960, including a review of research and documentation of historic treatment and restoration efforts undertaken since that time. In addition, it will provide recommendations for future maintenance, preservation, and use of the structures.



Figure 1: Aerial View of Fort Christiansvaern (Google Maps).

Fort Christiansvaern is located on the shoreline of Christiansted Harbor and is sited on the earthworks of the earlier French fortification. Construction of the fort was begun in 1738 during the Danish occupation and largely completed by 1749, with the last major additions dating from 1835-1841. After 1878, the fort was used as a police station and courthouse. In 1952, the U.S. Secretary of the Interior, through a Memorandum of Agreement with the Governor of the Virgin Islands, established Virgin Islands National Historic Site, which in 1960 was renamed Christiansted National Historic Site.

The structure measures approximately 132 feet by 144 feet and is built around a central rectangular courtyard. It has vaulted masonry corner bastions built at salient angles and a ravelin on the landward (south) side to protect the two-story south curtain and sally port. The south curtain houses a second-floor gallery which overlooks the central courtyard. The bastions are connected on the east and west elevations by one-story curtains which support terrepleins and on the north side by a water battery. A stableyard, carriage house and stables are located to the east of the fort at a lower elevation.

The fort structure consists of brick and rubble masonry load-bearing walls. Framed floors and roofs are built with one of three systems depending on location: brick vaults support the bastion floor and roof structure and the water battery, timber framing with wood planks support the south curtain second floor, and timber framing supports the flat or low-slope brick roofs. In isolated locations within the west curtain, earlier timber construction was replaced with reinforced concrete structure. The yellow brick used

throughout the fort is said to have been brought from Denmark in sailing vessels as ballast.

As part of the current efforts, 1200AE conducted a detailed site investigation of the Fort on May 28 through May 30, 2021, documenting via field notes and photographs the existing conditions of the structures and localized structural geometry, including typical framing member dimensions and floor and roof system assemblies and dimensions. A follow up site visit was performed on February 14 through February 15, 2022, to perform a more detailed assessment of the deteriorated timber girder at the Commandant's Gallery. These field observations along with a review of various existing drawings and documents are used as the basis for a preliminary structural analysis of isolated structural elements to evaluate historic and current load patterns on the structure, including areas of potential structural concern noted by 1200AE on site. This review is then followed by a discussion of the analysis results and prioritized recommendations for future structural preservation work.

Review of Existing Documents

The following existing drawings and documents were provided by the National Park Service and are referenced for this report:

Drawings:

1. "Main floor plan and stable yard plan," April 1953 (NHS-VI-250).
2. "Plan of second floor & gun decks," April 1953 (NHS-VI-251).
3. "Sections thru flat brick roofs," April 1953 (NHS-VI-252).
4. Historic American Building Survey, December 1959, Sheets 1-26.

Reports and other documents:

5. Condition Report of Historic Buildings, Virgin Islands National Historic Site, Christiansted, St. Croix, Virgin Islands: Christiansvaern Fort by Frederik C. Gjessing, Architect, May 1956.
6. Historic Structure Report (HSRs) for Fort Christiansvaern (H-3, LCS 188) and Stable Building (H-9, LCS 91554), located within Christiansted National Historic Site St. Croix, U. S. Virgin Islands, Herbert Olsen, 1960.
7. General Management Plan / Environmental Assessment, Christiansted National Historic Site, National Park Service, June 1986.
8. Historic Structure Treatment Record, Emergency Stabilization of the Christiansted NHS Gallery Floor by the Historic Preservation Training Center, February 2015.

Past Structural Investigations and Preservation Efforts

Based on information provided to 1200AE and noted above, past structural investigations or structural preservation efforts conducted at Fort Christiansvaern are extensive. Those which have been completed are primarily in response to noted areas of deterioration and past extreme weather events. Known past investigations and recommendations relating to the existing structure as well as previous repair campaigns are discussed in more detail in the architectural section of this report but include the following:

1. 1956 Condition Report of Historic Buildings: This report was written after the fort became part of the Virgin Islands National Historic Site in 1952. The following observations and recommendations were made as part of this report:
   - Replace the second-floor roofs.
   - The 1st floor roofs supporting the gun decks were noted to be in poor condition, especially in the southwest and southeast bastions.
   - At the southwest bastion and adjoining rooms, the beam supports had rotted out and required replacement.
   - At the ravelin immediately east of the sally port, the vault and roof needed restoration. A similar condition existed at the roof of the stables.
   - The brick paving had extensive vegetation growing in it and required restoration.
   - At the south curtain second story porch, the parapet wall was noted to be cracked.

2. Major repair/restoration work is understood to have been undertaken by the NPS in the early 1980s, including reconstruction of both terreplein (gun decks). Extensive masonry repairs consisted of pointing in areas of mortar deterioration, grouting of cracks, and replacement of bricks and stones to match existing construction where needed. Replacement and repair of wood framing elements was also documented, including a preservation treatment of the wood.

3. Post-hurricane repairs are understood to have taken place and are described in more detail in the architectural section of this report. Hurricane Hugo (Category 4; September 17, 1989) inflicted significant damage to the fort and caused it to be closed temporarily. Post-hurricane repairs included reconstruction of the latrine roof, which had had been torn off; replacement of the flagpole in the Northwest bastion; and repair or replacement of numerous doors and windows. The west and east site wingwalls were partially destroyed by impact from large yachts thrown by the storm and were later reconstructed.

Later hurricanes include Hurricanes Marilyn (Strong Category 2; September 15,1995), Omar (Category 3; October 15, 2008), and Irma / Maria (Category 5; September 6 and 20, 2017). Following Hurricane Marilyn, repairs included localized roof repairs and repairs to windows, doors, and shutters. Hurricane Omar caused more significant damage and required more extensive repairs, including repairs to severe cracking in the fort's masonry walls, replacement of roofs and repair of the flagpole at the northwest bastion.

4. 2015 Historic Structure Treatment Record by HPTC:
    - The Historic Structure Treatment Record (HSTR) is a statement of the Emergency Stabilization of the Christiansted NHS Gallery Floor completed by personnel of the National Park Service, Historic Preservation Training Center (HPTC) from January 19th through February 26th, 2015. The Final Project Agreement, dated November 2014, included as an appendix in the HSTR, indicated two primary areas of work: the second floor Gallery and the exhibit area in the south curtain and southwest bastion. This document appears to have been revised in December 2014 to eliminate the scope for the exhibit areas and therefore it is assumed that this work has not been completed.
      <u>Second Floor Gallery</u>
        - The floor area located on the second floor Gallery of the fort, located between the two staircases over the breezeway was noted to be sagging. The timber beams and wooden boards supporting the floor were damaged by long term moisture exposure and termite activity. In the two most seriously deteriorated areas, the cribbing was sagging and ready to fall. Temporary shoring was installed to stabilize the ceiling until a repair could be devised.
        - The floor construction was dismantled to facilitate replacement and repair of deteriorated members. Floor composition was noted to consist of masonry tile set on 6" fill supported by modern 3/4"x5-1/4" tongue and groove wood planking on 6"x7" timber beams spaced at 34" on center. The historic planking found in the gallery hallways was measured to be 1-1/2" thick and random width. The 3/4" tongue and groove boards were noted to have been installed as part of repair work performed in the 1980s and 1990s.
        - As part of the repair work, the 3/4" tongue and groove boards were replaced with 1-1/2" thick random width mahogany to match the historic configuration. Deteriorated beams were replaced with mahogany beams to match the existing. Approximately 70% of the planking and beams were noted to have been replaced. Pressure treated plywood (3/4") was installed above the boards and a

waterproofing membrane (Grace Bituthene System 4000) installed over top of the plywood. The existing fill was replaced with crushed stone dust and then the salvaged tiles were reinstalled using a traditional lime-based mortar. Two coats of a waterproofing substance (WaterBan) were applied to the entire gallery floor and the joints between the pavers were filled with an impermeable grout.

Exhibit Areas, South Curtain and Southwest Bastion

- In the exhibit areas of the slave quarters, soldiers' barracks and brick kitchen & oven located in the south curtain and southwest bastion at the parade ground level, the walls were noted to contain embedded iron components that were rusting and causing displacement of structural elements. The anticipated scope of work in these areas, which appears not to have been executed, was summarized in the November 2014 Final Project Agreement and is noted in more detail below.
- Soldiers' barracks: This is a trapezoidal room with four embrasure openings, each containing six iron bars 1-1/4" square which are embedded in a wooden header beam and into a masonry sill. The rusting bars caused spalling and deterioration of the masonry sills. Proposed scope of work consisted of removal of rusting iron bars, replacement of bars with non-ferrous components, reconstruction of masonry sills, repairs of wood headers, and stucco repairs to sills and groin vaults.
- Slave quarters: Two openings to the courtyard had extensive damage to the wooden header and masonry sill as well as the stucco due to rust jacking. Reconstruction was recommended, although the exact tasks were not identified.
- Brick Kitchen and Oven: Two openings in the oven were framed with steel / iron frames, both of which were corroding and causing damage to the surrounding masonry. The main oven chamber was noted to have partially collapsed. Careful dismantling and reconstruction were recommended.

5. Successive campaigns of termite damage assessments and treatments were performed throughout the decades. These included a report on termite activity prepared by the park biological technician in October 1987, termite monitoring and baiting in 1991, removal of tree roots in the Ravelin Yard in 1992 to help mitigate subterranean termite infestations, among other reasons, and a 1995 prototype termite treatment developed by University of Florida entomologists.

Existing Structural Systems and History of Structural Modifications

As observed on site and through historic documentation, the existing structure of Fort Christiansvaern consists of a combination of masonry and timber construction. Structural systems are described below, starting at the Ravelin Yard, continuing with the south curtain, moving counterclockwise from that location around the interior courtyard, and finishing with the Stableyard and Site Structures. For room numbers and names, refer to Drawings 1 through 6 in Appendix C. Structural framing plans and select sections and details are provided in Drawings E-1 through E-11 in Appendix E.1.

Ravelin Yard

The Ravelin Yard was built as part of the original construction between 1738 and 1749 and is located at the southern end of the fort and is triangular in shape (Fig. 2). The west side of the triangle is defined by a masonry site wall. The east side is defined by the Ravelin (Rm. 27) with the Guard House at the southern tip (Rm. 28).


Figure 2: Ravelin Yard as Seen from SE Bastion.

The Ravelin is constructed of exterior masonry walls supporting a shed roof that slopes down towards the Ravelin Yard (Fig. 3). The wall facing the East is thicker, approximately 2'-4" thick based on the HABS drawings, and the wall facing the Ravelin Yard is thinner. Wood rafters 3" wide by 5-1/2" deep are spaced at 3'-10" (+/-) on center and support wood roof boards and a corrugated metal roof (Fig. 4). The rafters are notched over wood sill plate over top the exterior masonry walls. Some temporary shoring of the roof is in place in the rear storage area, which is depicted and discussed in the conditions and treatment recommendations section below.


Figure 3: Looking East at Ravelin West Façade.

The Guard House has significantly thicker masonry walls, approximately 4'-0" thick at their thinnest points (Fig. 5). The roof is framed with roof joists measured to be 4"

wide by 7-1/2" deep spaced at 18" on center (Fig. 6).

Per the 1960 HSR, in 1826 the vaulted roof on the former magazine at the salient angle of the ravelin was replaced with a wood-framed roof and flat brick roofing since the vaults were severely cracked.



Figure 4: Looking North within Ravelin Interior (27).



Figure 5: Guard House Façade at Yard.



Figure 6: Guard House Roof Framing (28).

South Curtain

Current Existing Construction

The south curtain stands at the transition from the Ravelin to the Interior Courtyard. The south façade presents the central arched entrance with a series of rectangular window openings on two levels (Fig. 7). The stucco-covered wall is constructed of brick masonry and is approximately 2'-2" thick.

The north façade presents three distinct switchback stairways from the first to second floor levels, jutting out in plan into the Interior Courtyard (Fig. 8). The stair construction consists of brick masonry walls and lower-level vaulting, stuccoed on the vertical surfaces. The second level presents a continuous arcade along the full length of the façade. The typical piers are approximately 18" to 20" in width, while the piers at the east and west ends are wider, measuring approximately 2'4" in width. The increased width reflects the need for thrust resistance at the ends of the arcade.

The center hall at the lower level is spanned in the southern portion by a series of groin vaults (Fig. 9). The traditional masonry vaulted form takes advantage of masonry's strength in compression and its geometry directs these forces to discrete locations along the supporting walls. This allows for the creation of openings in the masonry walls in lesser loaded areas. The northern portion of the center hall is spanned with wood framing.



Figure 7: South Curtain South Facade at Ravelin Yard.



Figure 8: South Curtain North Façade at Interior Courtyard.



Figure 9: South Curtain Entrance Corridor.

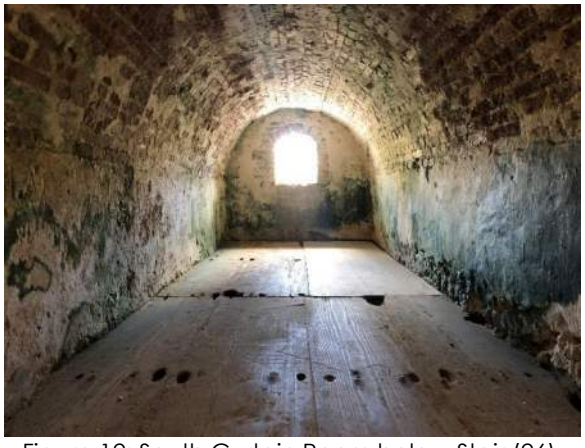
At the lower level, in Room 26, some deterioration of finishes helps to expose the structural systems within (Fig. 10). The floor consists of wood boards on wood sleepers, laid directly onto the ground surface. The brick masonry walls show remnants of arches on both the south and west walls, indicating a likely change in wall openings at some point in its history. The masonry openings are typically spanned with wood lintels. The framing above at the second-floor level consists of two primary wood beams spanning north-south and dividing the space in thirds east-west. The beams are approximately 7" wide by 8" deep. Floorboards span east to west between the beams.

The main east-west corridor at the lower level is sided by an approximately 2-foot-thick wall to the south that defines the rooms of the south curtain, and a series of piers and arched openings to the north providing access to the Interior Courtyard and the vaulted spaces below the stairs (Fig. 11). The Gallery floor above is supported with wood joists spanning north-south, with sizes varying from 5 ½" square to 6" x 7" and spaced from 2'-6" to 3'-0" on center. Wood boards span east-west between the joists.

Per the 2015 Historic Structure Treatment Record by HPTC, much of this floor was rebuilt by HPTC in 2015. The floor construction was dismantled to facilitate replacement and repair of deteriorated members. Floor composition was noted to consist of masonry tile set on 6" fill supported by modern 3/4"x5-1/4" tongue and groove wood planking on the timber beams. The historic planking found in the gallery hallways was measured to be 1-1/2" thick and random width. The 3/4" tongue and groove boards were noted to have been installed as part of repair work performed in the 1980s and 1990s.


Figure 10: South Curtain Room below Stair (26).


Figure 11: South Curtain Corridor below Gallery.


Figure 12: South Curtain Room below Stair (26).

As part of the 2015 repair work, the 3/4" tongue and groove boards were replaced with 1-1/2" thick random width mahogany to match the historic configuration. Deteriorated beams were replaced with mahogany beams to match the existing. Approximately 70% of the planking and beams were noted to have been replaced. Pressure treated plywood (3/4") was installed above the boards and a waterproofing membrane installed over top of the plywood. The existing fill was replaced with crushed stone dust and then a combination of salvaged and new tiles was reinstalled using a traditional lime-based mortar. A waterproofing substance was applied to the entire gallery floor and the joints between the pavers were filled with an impermeable grout.

The spaces below the stairs are generally spanned with barrel vaults (Fig. 12). The semicircular geometry of the coursed brick ceiling delivers the weight of the heavy masonry fill materials and floor above to the robust masonry side walls as a uniform load. Small arched openings offer some light to these confined spaces.

At the second-floor level the robust masonry walls define a series of rooms on the south side (the Commandant's Quarters) and the arcaded Gallery to the north. Masonry wall openings are spanned with either wood lintels or shallow masonry arches, covered with exterior stucco and interior plaster (Fig. 13). The roof framing consists of 3-1/2" x 11" wood joists spaced at 16" on center, which in turn support regularly spaced wood sleepers and the flat brick roofing system (Fig. 14).

The North Gallery is sided by the masonry walls of the Commandant's Quarters to the south and the exterior brick masonry arcade to the north. The arched


Figure 13: South Curtain Second Floor (G).


Figure 14: South Curtain Roof Framing.


Figure 15: South Curtain North Gallery.

openings are currently open for the most part with remnants of wood window jambs and their iron anchorages around the perimeter (Fig. 15). The roof above is spanned from north to south with 3 ¾" x 10 ¼" wood joists spaced at 17" on center typically within the narrow halls east and west. Wood sleepers and the flat brick roofing system again bear atop the joists.

The center landing at the North Gallery is spanned with 4" x 10" joists over a 14" wide by 12" to 16" deep tapered girder, set below the joists which run continuously overtop north to south. Again, the same wood sleeper and brick roofing system are over top. As depicted in Fig. 16, the low girder is heavily deteriorated and has been the subject of more detailed evaluation, included as an appendix to this report.

At the east side of the south curtain a wood-framed shed roof provides a sheltered transition to the North Gallery (Fig. 17). The framing is depicted on drawing 1/E-7. The light wood framing consists of 3" x 3-3/8" rafters spaced at 2'-11" on center, supported by a 3-3/8" x 4-7/8" primary wood member spanning over the east line of wood posts. The posts are 3-1/4" square with chamfered edges (Fig. 18).

A single scarf joint is located approximately 2 feet north of the southernmost bay, and in this case seems likely part of the original construction and a means of lapping the edge framing for two shorter members rather than finding a single, slender member that would be more than 25 feet long (Figure19). The joint appears pegged with 3/4" diameter dowels. See detail 3/E-8.

At the corners, the framing members are lapped overtop the posts (Fig. 20). The



Figure 16: South Curtain North Gallery.



Figure 17: South Curtain Shed, Looking South.



Figure 18: South Curtain Shed, Underside of Roof Framing.

full nature of the connections is somewhat hidden; however, it consists of a combination of metal fasteners and traditional timber-frame joinery. Lapping side plates with nail and screw fasteners provide the current level of tie-down of the roof framing to the posts. The anchorage of the side panels to the masonry wall of the south curtain may represent the primary tie-down, as the full nature of the connections of the posts to the roof deck below is unclear.

History of Structural Modifications / Repairs

Per the 1960 HSR, the original flat brick roof of the southern portion of the south curtain was replaced with a mansard roof between 1755 and 1767. This roof was damaged and largely blew off during a hurricane on August 31 – September 1, 1772. After the hurricane, between 1774 and 1777, a flat brick roof was constructed in place of the mansard roof again.

In 1839 a new masonry stair was added on the west side of the double stair up to the Commandant's quarters. These stairs were supported on eight piers.

In 2005, the Commandant Gallery floor was repaired due to extensive termite damage and water damage from Hurricane Jeanne. It appears that water drainage issues were not resolved, and as noted above, this floor was again disassembled and rebuilt in 2015 by HPTC, with 70 percent of the wood elements replaced.



Figure 19: South Curtain Shed, Scarf Joist in Edge Beam.



Figure 20: South Curtain Shed, Corner Half-lapped Connection.



Figure 21: Southwest Bastion, Exterior View.

Southwest Bastion

Current Existing Construction

The Southwest Bastion consists of heavy brick masonry exterior walls and brick masonry groin vaults supporting both the first floor and roof levels (observed from the basement and first floors respectively). As depicted in Fig. 21, two large masonry buttresses are battered in profile, widening toward the base, and are set near the middle of the walls at the south and west faces. A plan of the two levels of the bastion is shown on drawing E-1 with a section through the vaulting shown on drawing E-9.

From the interior, the groin vaulting is seen to be coated with plaster. The vaults are formed from brick masonry. At the lower level, the groins integrate seamlessly with the surrounding walls and central pier (Fig. 22). At the upper level the center pier transitions to a more slender section above its base, and the load path to that pier is articulated with ribbed arches in the two cardinal directions (Fig. 23). Crack monitors and active cracking is apparent from this image and discussed in more detail below.

At the roof level the surface rises up higher than the adjacent roof areas to the north (Fig. 24). The walls are typically on the order of 20" minimum thickness and the piers were measured to be on the order of 4 feet wide (out-of-plane from the line of wall) at the top.

History of Structural Modifications / Repairs

Per the 1960 HSR, the roof of the Southwest Bastion was originally built as a flat brick roof supported on timber joists. This roof was replaced between 1774 and



Figure 22: Southwest Bastion, Lower Level.



Figure 23: Southwest Bastion, Upper Level.



Figure 24: Southwest Bastion Roof, Looking South.

1777 with the current vaulted brick construction.

West Curtain

Current Existing Construction

The exterior wall to the west is approximately 2'-2" thick brick masonry, while the interior east wall that defines this side of the Interior Courtyard is approximately 1'-7" thick. The floor is on grade while the roof is framed with a mix of framing approaches. A site wall provides an additional line of the defense further to the west (Figs. 25 and 26).

Rooms within the west curtain are separated by walls of varying thickness, some of which show intact half-timbered construction (Fig. 27). This approach has a long history dating back to medieval construction. The integration of wood with a masonry wall has the structural benefit of adding stronger tension-resisting elements into the masonry assemblies, which in general are strong in compression but weak in tension. This is particularly valuable in areas with significant lateral loading requirements, such as wind and seismic.

Roof framing is indicated on drawings E-1 and E-2 and consists typically of a low north-south running girder that supports regularly spaced joists overtop. The girders are generally on the order of 8" x 10" and the joists typically 6" x 7 ½" spaced at 18" to 20" on center.



Figure 25: West Curtain, East Façade.



Figure 26: West Curtain, West Façade. Note West Site Wall and Northwest Bastion in Distance.



Figure 27: West Curtain, Interior Half-timbered Wall, Room 14/15. Note Timber Roof Framing with Low Girder and Joists above.

A number of joists and girders have apparently been repaired, with visible scarf joints at some locations (Fig. 28). A sample of these are noted in plan and depicted in drawing E-8.

The Kitchen area presents an interesting change in roof construction, with the use of brick masonry vaulting within the western extension (Room 15) (Fig. 29).

At the northern end of the west curtain the roof framing has been changed to reinforced concrete (Fig. 30), perhaps in response to more historic deterioration of wood framing.

History of Structural Modifications / Repairs

Per the 1960 HSR, the gun deck of the west curtain was shored in several places in 1824 due to rotten bearing ends of roof joists.

In the early 1980's significant repairs to the terreplein surfaces and to the wood framing below were implemented.

In 2016-2017, HPTC rebuilt portions of the brick oven in the kitchen, whose inner arch had almost completely collapsed.



Figure 28: West Curtain, Scarf Joint at Roof Joist.



Figure 29: West Curtain, Kitchen.



Figure 30: West Curtain, Reinforced Concrete Framing above Room 21.

Northwest Bastion and Latrine

Current Existing Construction

The Northwest Bastion is constructed of brick masonry vaulting. The construction is depicted in plan on drawing E-2 and in section on E-10. An overarching barrel vault spans from north to south within the bastion and is then divided at its midspan by a wall with arched openings (Fig. 31). This interior wall is approximately 2 feet thick while the exterior walls range from approximately 3'-7" to 4'-10".


Figure 31: Northwest Bastion, Room 22/23.

At the roof level, the northwest corner is thickened to provide the structural base for the flagpole (Fig. 32).


Figure 32: North Bastion Roof, Note Flagpole.

Extending north from the bastion is the latrine, with lower, buttressed, masonry walls that define the space as the land descends toward the shoreline (Fig. 33). The roof is wood-framed and surfaced with corrugated metal.

As depicted in Fig. 34, the framing is light but well built, with inverted joist hangers tying down the metal roof and flatwise sleepers to the main rafters. The lightweight structure and immediate exposure to the shoreline render this roof susceptible to strong uplift forces from the wind.


Figure 33: Latrine Roof.

History of Structural Modifications / Repairs

The flagpole in the North Bastion roof was repaired or replaced several times, once in 1991 after Hurricane Hugo and again in 2010 after Hurricane Omar.

The Latrine Roof was replaced several times. It was reported in 1953 that portions of the roof were missing, and the 1959 HABS drawings showed the roof to

be entirely missing. The roof was replaced in 1983 and again in 1990 after Hurricane Hugo.



Figure 34: Latrine, Underside of Roof Framing above Room 24C.

Water Battery

Current Existing Construction

The Water Battery along the north side of the fort is a robust, heavy mass masonry construction mostly construction (Fig. 35). A group of nine groin vaults at the center, constructed of brick masonry, provides a strong support for the upper platform (Fig. 36). With short spans, robust piers, and ample mass and thickness above and to all sides, the structure was likely conceived with resistance to both heavy dead loads and potential artillery impacts.



Figure 35: Water Battery, Looking Northwest.



Figure 36: Water Battery, Vaulting at Room 25.

Typical of most areas at the top of the fort, the roof surface is covered with a cementitious parging over brick masonry pavers (Fig. 37).

History of Structural Modifications / Repairs

In 2020, HPTC removed vegetation from the Water Battery parapet.



Figure 37: Water Battery, Brick Paving at Roof, Looking South towards Courtyard.

Northeast Bastion

Current Existing Construction

Like the Northwest Bastion, the Northeast Bastion is spanned by a north-south barrel vault that is divided midspan by an interior wall with arched openings (Figure 38).



Figure 38: Northeast Bastion, First Floor Level (Room 1) with Vaulted Roof.

A raised extension creates a second-floor space that has an innovative approach to roof framing for the non-rectangular space. A kinked timber girder spans north-south, set below 4" x 10" rafters spaced approximately at 17" on center. The framing is shown in plan on drawing E-4 with details of the kinked beam on E-7 (Fig. 39).



Figure 39: Northeast Bastion, Room N at Second Floor with Wood-framed Roof. Note Kinked Beam.

History of Structural Modifications / Repairs

Per the 1960 HSR, the Bastion was extended vertically in 1836 to create a "Common Room." The new flat brick roof was supported on timber framing.

After Hurricane Marilyn, it was noted in 1995 that the Common Room's roof framing required modifications to address

wind uplift; however, it is unclear whether any repairs were made.

East Curtain

Current Existing Construction

The exterior wall to the east is approximately 2'-4" thick brick masonry, while the interior east wall that defines this side of the Interior Courtyard is approximately 1'-8" thick. The floor is on grade. A site wall provides an additional line of the defense further to the east (Figs. 40 and 41).

Roof framing is indicated on drawings E-1 and E-2 and consists of regularly spaced joists spanning in the east-west direction. The joists are typically 5 ½" x 7" spaced at 18" on center. These joists support 3"-wide by 2"-thick sleepers spaced at 4 ½" on center spanning in the perpendicular direction. These sleepers support roof boards which, in turn, support the flat brick roof. A similar construction exists in Room 7. In this area, previous repairs in the form of scarf joints were made (Fig. 42).

At the west side of the east curtain a wood-framed shed roof provides a sheltered transition from the Courtyard (Fig. 40). The framing is depicted on drawing 1/E-7 and Figure 43. The light wood framing consists of 1-1/2" x 3" rafters spaced at 3'-4" on center, supported by a 2-3/8" x 2-5/8" primary wood member spanning over the west line of wood posts. The posts are 2-3/8" square and spaced at 8'-0" to 8'-6" on center.

The full nature of the connections is somewhat hidden; however, it consists of a combination of metal fasteners and traditional timber-frame joinery. Roof joists have birdsmouth connections over



Figure 40: East Curtain, West Façade facing Courtyard.



Figure 41: East Curtain, East Façade Facing Stableyard.



Figure 42: East Curtain Room 7, Existing Scarf Joint in Timber Roof Framing.

the edge beams with blocking between joists to provide lateral stability (Fig. 44). West edge beams are connected to the posts below with pegged, mortise and tenon connections (Fig. 45), providing resistance against uplift. The east edge beam against the building wall is tied down to the wall with a metal connector (Fig. 46).

History of Structural Modifications / Repairs

Per the 1960 HSR, in 1817-1818 rotted wood roof joists supporting the gun deck were replaced and the brick was relaid. In 1822, additional reconstruction of the east curtain was performed, including replacing the original half-timbered west wall with a thicker masonry wall. In 1826 the roof of the east curtain was covered with a layer of cement to mitigate the on-going leaks. In 1843, the gun deck was torn out and the timber roof joists were replaced due to rot. The gun deck was then relaid.

In 1836 the zinc-covered shed on the courtyard side of the east curtain was constructed supported by eight hardwood posts. The floor below the shed consisted of bricks laid flat.

In the early 1980's significant repairs to the terreplein surfaces and to the wood framing below were implemented.



Figure 43: East Curtain Shed, Underside of Roof.



Figure 44: East Curtain Shed, Edge Detail.



Figure 45: East Curtain Shed, Beam to Post Connection.



Figure 46: East Curtain Shed, Hold-Down Detail.



Figure 47: Southeast Bastion, Room 8, Brick Vaulting Supporting Roof.

Southeast Bastion

Current Existing Construction

The Southeast Bastion consists of heavy brick masonry exterior walls and brick masonry groin vaults supporting the roof level, as observed from the first floor. Similar to the Southwest Bastion, two large masonry buttresses are battered in profile, widening toward the base, and are set near the middle of the walls at the south and east faces. A Plan representation of the bastion is shown on drawing E-1.

From the interior, the groin vaulting is seen to be coated with plaster. The vaults are formed from brick masonry. At the lower level, the groins integrate seamlessly with the surrounding walls and central pier. The load path to that pier is articulated with ribbed arches in the two cardinal directions (Fig. 47). Cracking is apparent from this image, similar but less severe than that observed at the Southwest Bastion. This is described in more detail below.

History of Structural Modifications / Repairs

Per the 1960 HSR, the roof of the Southeast Bastion was originally built as a flat brick roof supported on timber joists, per the 1960 HSR. This roof was replaced in between 1781 and 1782 with the current vaulted brick construction.

In 1836 a wood shingle-covered shed was installed on the roof of the Southeast Bastion connected to the east wall of the south curtain.

Stables

Current Existing Construction

The Stable is a long, narrow one-story brick masonry building approximately 123 feet long by 17.5 feet wide (Fig. 48). Its west wall is approximately 1'-8" thick with a series of large, arched openings (Fig. 48 and 49). The east wall is approximately 2'-3" thick and punctured with small windows (Fig. 50). The south and north wall are approximately 2'-0" thick. Neither one has any openings currently, although the north wall has a previous arched opening which has been infilled (Fig. 49).

The roof is a flat brick roof supported on wood sleepers and wood joists (Fig. 50). The roof joists were measured to be 5-1/2" square and spaced at 13" to 18" on center. A roof framing plan is provided on drawing E-5.

History of Structural Modifications / Repairs

Per the 1960 HSR, the original stable was built between 1836 and 1837 and was 74' long with six arched openings on the west façade. It had a flat brick roof supported on timber framing. The floor was paved with bricks, some of which were replaced with stone in 1839.



Figure 48: Stable and Stableyard, Looking East at West Façade.



Figure 49: Stable, Looking South at North Façade.



Figure 50: Stable, Looking East at Interior Face of East Wall. Note Wood Roof Framing.

In 1840 the stable was extended 25' towards the north to accommodate laundry functions. In 1844, another addition approximately 21' long was built at the north end of the stable for a second carriage house. The southern portion of the stable was also partitioned for a granary at that time.

By 1978, large portions of the stable roof were missing or damaged and the roof was replaced in 1978-79. The new roof consisted of two layers of thin Danish brick and a rigid underlayment sandwiched between, all supported on wood framing.

By 2013 the roof was determined to have "critical structural failure," presumably due to considerable termite and water damage. The roof was once again replaced, this time in two phases. During Phase 1 in 2015-2017, the previous roof was removed in its entirety and all wood framing was replaced with green, pressure treated pine. Framing was attached to a top plate which was anchored into the masonry walls below. A temporary plywood roof was then installed over top of the framing. During the course of the work, it was discovered that the masonry walls and rafter pockets were damaged and these were rebuilt.

Phase 2 was performed in 2015 and consisted of replacing the temporary roof with a new roof consisting of one layer of brick adhered to concrete roof panels with epoxy. The added weight of this system required modifications of the roof framing.



Figure 51: Carriage House, Looking South.

Carriage House

Current Existing Construction

The Carriage House was built with brick masonry exterior load-bearing walls. The

south wall is approximately 2' thick while the other three walls are thinner, measuring approximately 1'-6". The west side of the structure connects to the Ravelin as well as the East Site Wall.

The roof is a flat brick roof supported on wood sleepers and wood roof joists. The joists were measured to be 2-3/4" wide by 5-3/4" deep spaced at 15" on center. A roof framing plan is provided on drawing E-5.

History of Structural Modifications / Repairs

Per the 1960 HSR, the combined watchman's room – carriage house was built between 1836 and 1837. It had a flat brick roof supported on timber framing. The Carriage House was reroofed in 1977 using salvaged bricks.

Site Structures

Current Existing Construction

Site structures consist of the West and East Site Walls which flank the west and east curtains, described above. These walls, in addition to several other site structures, extend towards and even into the water on the north side of the site (Fig. 53 & 54).

History of Structural Modifications / Repairs

Per the 1960 HSR, the stone retaining wall on the west side of the stable yard was built between 1840 and 1841.

In 1992, portions of the west and east wing walls were reconstructed after damage inflicted by Hurricane Hugo. Historic stone was salvaged for reuse in future projects and the wall was rebuilt with concrete block to differentiate the new from the earlier construction.



Figure 52: Carriage House, Looking South within Interior. Note Wood Roof Framing.



Figure 53: View of North Side of Site Facing Water. Note Various Site Structures.



Figure 54: Looking East at West Site Wall. Note Continuation of Site Wall into Water.

Existing Conditions

Existing conditions observed during 1200AE's site visits on May 28 through May 30, 2021, and February 14 through February 15, 2022, are summarized below and follow the same order as the descriptions of the structural systems in the previous section. Observations start at the Ravelin Yard, continue with the south curtain, move counterclockwise from that location around the interior courtyard, and finish with the Stableyard and Site Structures. For room numbers and names, refer to Drawings 1 through 6 in Appendix C. Structural framing plans with annotated conditions and select sections and details are provided in Drawings E-1 through E-11 in Appendix E.1. All photographs are by 1200AE unless noted otherwise.

Ravelin

Shoring has been installed in the artillery shed (Room 27) to support deteriorated roof boards (Fig. 55). This deterioration is likely due to water infiltration through the roof. It appears that the leak has been repaired.

Recommendation: Replace the roof boards for one bay. Sister or replace the rafter up against the wall. This will also require some roofing / flashing repair or replacement.

The roof framing above Room 27 is of small dimensions and is spaced far apart, at approximately 3'-10" on center. Preliminary analysis of these rafters (using assumed material properties in the absence of wood identification and grading) indicates that the live load capacity of these rafters is on the order of only 8 pounds per square foot. This is not sufficient to meet current load requirements. In addition, it is unclear whether the rafter ends are adequately tied down to resist wind uplift loads (Fig. 56).

Recommendation: Install one or two intermediate rafters in each rafter bay, pending further analysis. Install tie-downs at rafter ends.



Figure 55: Ravelin Artillery Shed (Room 27), Deteriorated and Shored Roof Boards (JKOA).



Figure 56: Ravelin Room 27, Rafter Bearing Condition at Low End.

South Curtain – First Floor Spaces and Second Floor Framing

The rooms below the exterior stairs on the north side of the south curtain are built with barrel vaults supporting the stairs above. The brick masonry and mortar in these vaults are showing signs of deterioration, likely due to long-term water infiltration through the stairs above (Fig. 57).

Recommendation: The vaults appear structurally stable; however, surface deterioration of brick units and mortar can accelerate over time and lead to future structural weakening. The transmission of water through the stairs above should be minimized where possible, through localized joint treatments or potential resloping of surfaces to assure water can run off and is not trapped. At the intrados of the vaults, repointing is recommended at deteriorated areas and consideration of applying a parge coat to help minimize further losses of brick units.



Figure 57: South Curtain First Floor, Deteriorated Masonry in Room 26 below Stairs.

The wood floor and supporting joists/ sleepers at the south-facing rooms in the south curtain are heavily deteriorated (Fig. 58). They are in direct contact with the ground, which dramatically increases the moisture contact of the wood, a condition favorable to wood rot and termites.

Recommendation: Wood in direct contact with earth is subject to accelerated deterioration from both moisture and easy access for termites and other insects. If public access is to be allowed, lift wood boards and salvage intact material for reuse. Install a reinforced concrete slab on grade at an elevation deep enough to allow room for application of wood sleepers and finish



Figure 58: South Curtain First Floor, Deteriorated Wood Floor in Room 12.

wood flooring at the current elevation. Reinforcement in the slab on grade should be corrosion resistant, with consideration of both galvanized and stainless-steel wire mesh. If public access is not to be allowed, then the existing condition can remain as is.

The second-floor framing above Room 12 was found to have evidence of termite damage (Fig. 59). Field documentation of exposed areas estimated the amount of loss to the 7" x 8" beams to be on the order of 1" from the top surface, for the southern third of the span. The floorboards were previously replaced and are currently supported on wood sleepers set on top of the beams. The sleepers are intermittently attached to the beams and some gaps in their support are likely causing flexibility in the floor surface above.

Recommendation: Termite treatments should be updated at regular intervals to assure that infestations are not active. Preliminary calculations based upon the observed dead load and a 60 psf live load find the magnitude of loss to warrant reinforcement of the framing. Refinement of these findings is warranted, given the limited access, and the need for reinforcement may be limited to a portion of the beam span. It is assumed that reinforcement would be in the form of sistering new timber alongside the existing framing. As the current floorboard support is inconsistent, sistering the beams could also provide a more continuous and direct support of the floorboards, thereby providing both added beam capacity and continuous board support.



Figure 59: South Curtain Second Floor Framing above Room 12. Note Termite Damage and Sleeper Discontinuity.



Figure 60: South Curtain Second Floor, Termite Trails on Wall Leading up to Roof Framing.

South Curtain – Second Floor Spaces and Roof Framing

Termite trails were noted on wall surfaces in the Commandant's Gallery at several locations (Fig. 60). These trails lead up the walls towards the roof framing.

Recommendation: Termite treatments should be updated at regular intervals to assure that infestations are not active.

Evidence of water infiltration through the roof and resulting deterioration of wood framing was noted in several locations within the Commandant's Gallery. One such location is at the northwest corner of Room M and the adjacent space at the west end of the corridor (Fig. 62 and 63). At this location, there is a scupper to drain the rainwater from the roof. It is likely that the scupper does not drain adequately and has caused water to back up and enter the building through the exterior wall and / or roof.

Recommendation: Roofing and drainage systems should be reviewed to ensure that the roof is watertight and the scupper is functioning as intended. After any necessary roofing repairs have been made, deteriorated wood members should be replaced in kind, either full length or partial length with an engineered scarf joint.

Commandant's Gallery Roof

Severe deterioration of the low timber girder in the center bay of the Commandant's Gallery was noted during 1200AE's initial site visit (Fig. 63). Deterioration was found to be particularly severe at the east end of the girder. The root cause of this deterioration is likely water ingress from the roof associated at least in part with problems of the flashing



Figure 61: South Curtain Roof Framing with Water Damage, Room M.



Figure 62: South Curtain Roof Framing with Water Damage, Corridor Adjacent to Room M.



Figure 63: South Curtain Gallery, Heavily Deteriorated Roof Girder.

around the flagpole immediately above. The flagpole no longer projects above the roof and the roofing appears to have been repaired such that water is no longer penetrating the roof at this location.

1200AE recommended that temporary shoring be installed to provide safe access to the Gallery and adjacent spaces for staff and the public and provided engineered drawings for this shoring. Subsequently, 1200AE visited the site again to perform probing of the girder and its bearings to assess the remaining intact portions of wood and recommend options for repair or replacement of the girder.

The girder was found to be built up with four separate members connected to each other with ferrous elements (Fig. 64). In the areas of heavy deterioration of the wood, the connectors were also noted to be heavily corroded. Wood testing indicated that the existing girder species is Southern Pine. A more detailed report of the girder assessment is provided in Appendix E.2.

Recommendation: Based on the findings of the girder assessment, the southern ply of the girder should be replaced in kind. Connectors between plies will require replacement and reinforcement. A small area of the lower plies at the west end will require wood consolidation. Final design of the repairs was issued on January 23, 2023.

South Curtain – Embedded Ferrous Elements

Rusting of iron embedments in masonry, including window bars as well as window and door framing anchorages was prevalent. In some areas the deterioration of the iron was coincident



Figure 64: South Curtain Gallery, Heavily Deteriorated Roof. Note Corroded Connectors.



Figure 65: South Curtain, Embedded Corroded Ferrous Element.



Figure 66: South Curtain, Embedded Corroded Ferrous Element.

with significant wood deterioration, or complete loss of wood components (Fig 65 & 66). Other areas were clearly in an earlier phase of deterioration, with iron fasteners beginning to rust and starting to cause damage to surrounding materials (Fig. 67). As iron or steel rust in the presence of water and oxygen, the chemical process results in the volumetric expansive production of iron oxide. This expansive process can exert large forces on the surrounding materials. Figure 68 shows an apparent case of rusting embedded anchors that is damaging the surrounding wood and masonry, with incipient failures in both.

Recommendation: Iron or steel anchorages should be replaced with structurally equivalent stainless steel to assure proper durability in the marine environment. Given the proximity of salt water, stainless steel Type 316 is recommended. Embedded iron or steel that is not deteriorating actively may be susceptible to future deterioration; however, replacement may be deferred, and the areas visually monitored over time to assure conditions do not change.



Figure 67: South Curtain, Embedded Corroded Ferrous Element in Wood Frame.



Figure 68: South Curtain Gallery, Embedded Steel with Adjacent Incipient Spall in Masonry.

South Curtain – Shed Roof

The second-floor porch on the east side of the south curtain has a wood-framed, corrugated metal covered shed roof. As opposed to the heavy flat brick roofs in other areas, where the weight of the brick resists wind uplift during heavy wind events, this shed roof is of much lighter construction. Wind uplift is resisted by roof connections down to the wood rafters and tie-downs of the roof rafters to the wood beams and posts below.



Figure 69: South Curtain Shed, Post Crack at Beam to Post Connection.

Edge beam to wood post connections are assumed to consist of pegged mortise and tenon connections, possibly with ferrous connectors in lieu of wood

pegs. Some cracking was observed in the wood at these connections (Fig. 69), possibly indicating either corrosion of the ferrous connector or overstress in the wood. In addition, at the south end of the roof, the edge beam was observed to be pulling away from the south curtain wall (Fig. 70). This behavior is consistent with roof shifting or uplift due to high wind loads.

Recommendation: Tie-downs and connections should be evaluated, although they currently appear to have performed relatively well over time. As the severity of storms and, as a result, wind loads are predicted to increase with the warming climate, this evaluation should take into account these anticipated changes. It is likely that connections will require some reinforcement in the form of added fasteners or connector plates. Added materials should be selected for the marine environment, with stainless steel typical for metal fasteners and connectors.

Southwest Bastion

The windows of the basement rooms are protected with steel or iron bars embedded in the surrounding masonry. These bars are corroding (Fig. 71). As noted above, when ferrous elements corrode in the presence of moisture and oxygen, they expand volumetrically, exerting large pressures against the surrounding materials. This typically causes cracking, crushing and/or displacement of these materials.

Recommendation: The bars are likely still needed for both safety and historical reasons. As such, we recommend replacing the bars in kind with stainless steel and repairing surrounding masonry. If these elements are deemed to no



Figure 70: South Curtain Shed, Separation of South Edge Beam from Wall.



Figure 71: Southwest Bastion, Basement Window, Corroding Bars and Spalling Masonry.



Figure 72: Southwest Bastion, First Floor. Note Cracking at Pier (Red Arrows).

longer be needed, remove bars from walls and repair masonry in kind with appropriate mortar.

Extensive cracking in the masonry vaulting in the Southwest Bastion was observed from within the first-floor spaces, at the underside of the roof. Crack patterns are indicative of outward movement in masonry walls and piers, and corresponding flattening of the arches and vaults, associated with the horizontal thrust imposed by the primary arches and groin vaults (Fig. 72 & 73). In broad terms, as vertical load is applied to vaults and arches these structures carry that weight through compression along the lines of their raised profiles. For these structures, the rise of the vaults and arches provide the geometric stiffness to accommodate the large weights. These compressive forces must then be resisted at the base of the vaults and arches, both vertically and horizontally. When insufficient resistance to these forces is present, the vaults and arches will spread or settle, generally resulting in cracking.

Crack gauges were installed prior to the current survey as a means to monitor and measure any movements after the installation of the gauges. Assuming that the gauges were all installed to be with the standard zero setting, movement has been observed at several locations (Fig. 74). Several of the gauges indicated no movement, remaining at the zero-movement mark.

In one area, plaster was noted to have fallen from a line of cracking in a primary arch (Fig. 75) with plaster dust and fragments observed on the beds below (Fig. 76). This provided a clear sign of recent, on-going movement.

Based on the 1960 HSR, the roof of the Southwest Bastion was originally built as a



Figure 73: Southwest Bastion Exterior Cracking at Base of Wall, SW Corner.



Figure 74: Southwest Bastion, Crack Gauge Indicating Movement (Rotation).



Figure 75: Southwest Bastion, Recent Plaster Loss at Crack.

brick flat roof supported on timber framing. This framing system would not have imposed horizontal thrust on the walls below, only vertical loads; however, the wood framing would have been more susceptible to rot and termite damage in the presence of moisture over time. The brick roof and wood framing were replaced with brick groin vaults, which likely provided better protection against water infiltration but did exert a horizontal thrust on the walls below.

Recommendation: Since movement has been documented to be active and the observed conditions clearly support that data, a more detailed structural investigation and the design of repairs is warranted. Given the presence of the large exterior piers, the overall mass of the walls and vaulting, and the long history of the vaults remaining in place, an imminent structural failure does not seem likely. It is more likely that movements will advance slowly over time. As such, having this space continue to operate with the public having partial access near the entrance is deemed acceptable while further evaluation and likely strengthening is pursued. Structural analysis should provide a quantified assessment of the vault loads and thrust on the perimeter walls. The exterior masonry piers should be evaluated to resist these forces. Strengthening may consist of grouted anchorage of the exterior wall and piers to the roof and second-floor diaphragms, with potential vertical reinforcement of the exterior piers. Grouted anchorage may be in the form of extended stainless-steel anchors set in a grouted sock, with the grout engaging and keying into irregularities and/or voids in the masonry.



Figure 76: Southwest Bastion, Recent Plaster Loss at Crack.

West Curtain

Some of the wood framing has suffered from both water and insect damage historically, with residual evidence of deterioration as well as areas of both full member replacement and repairs with traditional scarf joints for partial member replacement (Fig. 77).

Recommendation: Address any active areas of water penetration to reduce potential for ongoing accelerated deterioration of wood framing.



Figure 77: West Curtain, Scarf Joint in Framing Member to Address Previous Deterioration.

Cracking was observed at the underside of the reinforced concrete roof framing just south of the Northwest Bastion (Fig. 78). This is likely due to long-term water infiltration causing corrosion of the steel reinforcing at the bottom of the concrete beams. As noted previously, like steel or iron embedded in masonry, when steel reinforcement in concrete corrodes in the presence of moisture and oxygen, it expands volumetrically, exerting large pressures against the surrounding materials. This typically causes cracking, crushing and/or displacement of these materials. The observed cracking will likely continue and eventually result in spalling of the concrete below the reinforcing bars. At this point, the concrete below the bars would eventually break off and fall to the floor. Although this would not likely coincide with a catastrophic failure of the roof structure since the bars typically would remain in place, the falling concrete itself could represent a risk to visitors.



Figure 78: West Curtain, Cracked Concrete Beam.

Recommendation: Remove loose concrete. Expose corroded reinforcing bars, clean of all corrosion and coat with a rust-inhibiting coating. Patch concrete with a trowel-on patching mortar.

Northwest Bastion

Directly to the south of the latrine, in the Northwest Bastion, embedded ferrous elements have caused deterioration in the masonry walls (Fig. 79). As noted above, when ferrous elements rust in the presence of moisture and oxygen, they expand volumetrically, exerting large pressures on the surrounding materials. This has caused spalling of these materials. These elements do not appear to serve a structural function and appear to be abandoned and no longer needed.

Recommendation: Remove ferrous elements from walls and repair masonry in kind with appropriate mortar.



Figure 79: Northwest Bastion, Corroded Elements.

The vaulting of the Northwest Bastion generally appears in good structural condition. A line of cracking was noted, running parallel to the span of the main north-south barrel vault (Fig. 80). That this crack is running parallel to the span, as opposed to being transverse, leaves the vault form and original load path structurally intact without indication of movement relating to horizontal thrust. The crack may relate to some past movement of the exterior wall or localized discontinuity in the construction; however, it does not impede proper structural functioning of the vault.

Recommendation: Localized repointing of crack and repair of finishes. If crack re-emerges then some form of long-term monitoring may be warranted, similar in nature to what has been done at the Southwest Bastion.



Figure 80: Northwest Bastion, Crack in Vault.

Latrine

The latrine window has embedded ferrous bars that have caused damage to the masonry wall (Fig. 81). When ferrous elements rust in the presence of moisture and oxygen, they expand volumetrically, exerting large pressures on the surrounding materials. This has caused localized damage of the surrounding materials and represents an ongoing mechanism of deterioration that will continue to worsen.

Recommendation: The bars are likely still needed for both safety and historical reasons. As such, we recommend replacing the bars in kind with stainless steel and repairing surrounding masonry.


Figure 81: Latrine, Corroded Bars.

The latrine roof is a light corrugated metal roof supported on wood framing. While there are no visible signs of distress, this type of roof is vulnerable to high wind uplift forces during severe weather events.

Recommendation: Tie-downs and connections should be evaluated, although they currently appear to have performed relatively well over time. As the severity of storms and, as a result, wind loads are predicted to increase with the warming climate, this evaluation should take into account these anticipated changes. Some connection reinforcement with stainless steel fasteners or connectors is likely, pending a detailed structural analysis.


Figure 82: Latrine, Underside of Roof.

Water Battery

The structure of the Water Battery was found to appear in good condition where accessible. No structural treatments are required.

Northeast Bastion

The masonry structure of the Northeast Bastion was found to appear in good condition. No structural treatments are required.

The roof framing appears to have suffered some damage historically, with some rafters being repaired with bolted half-lapped joints. The bolt heads are covered with wood plugs and the repairs appear to be functioning well over time. Surface rusting of iron anchors at the kinked center beam was observed (Fig 83 & 84). The rusting does not appear to be compromising the structural functioning of the framing.

Recommendation: Scrape the iron of paint and loose materials, and recoat with an appropriate coating for the marine environment, in-keeping with the historic appearance.



Figure 83: Northeast Bastion, Kinked Roof Beam.



Figure 84: Northeast Bastion, Corroded Connectors at Kinked Roof Beam.

East Curtain

The first-floor porch on the courtyard side of the east curtain has a wood-framed, corrugated metal covered shed roof (Fig. 85). As opposed to the heavy flat brick roofs in other areas, where the weight of the brick resists wind uplift during heavy wind events, this shed roof is of much lighter construction. Wind uplift is resisted by roof connections down to the wood rafters and tie-downs of the roof rafters to the wood beams and posts below.

Edge beam to wood post connections are observed to consist of pegged mortise and tenon connections, possibly with the addition of ferrous connectors in lieu of wood pegs in some areas.

Recommendation: Similar to the shed roof at the south curtain second floor, tie-downs and connections should be



Figure 85: East Curtain Shed, View of Framing.

evaluated, although they currently appear to have performed relatively well over time. As the severity of storms and, as a result, wind loads are predicted to increase with the warming climate, this evaluation should take into account these anticipated changes. It is likely that connections will require some reinforcement in the form of added fasteners or connector plates. Added materials should be selected for the marine environment, with stainless steel typical for metal fasteners and connectors.

In Room 7, some of the wood roof framing has suffered from both water and insect damage historically, with residual evidence of deterioration as well as areas of both full member replacement and repairs with traditional scarf joints for partial member replacement. Some deterioration was still present in the roof boards (Fig. 86).

Recommendation: Address any active areas of water penetration to reduce potential for ongoing accelerated deterioration of wood framing.



Figure 86: East Curtain Room 7, Split in Previous Scarf Joint Repair.

Southeast Bastion

Similar to the observations at the Southwest Bastion, extensive cracking in the masonry vaulting was observed from within the first-floor spaces, at the underside of the roof. Crack patterns are indicative of outward movement in masonry walls and piers, and corresponding flattening of the arches and vaults, associated with the horizontal thrust imposed by the primary arches and groin vaults (Fig. 87).



Figure 87: Southeast Bastion, Crack in Vault.

The observations described for the Southwest Bastion are also applicable here, with a similar history of timber roof

replacement with a heavier and thrust-inducing vaulted masonry roof system.

Recommendation: The observed cracking again appears to be active, with areas of delaminating plaster and/or masonry, particularly at the primary arches. This area is not currently accessible to the public and should remain that way until further analysis and repairs, similar to that recommended for the Southwest Bastion are performed. Like the Southwest Bastion, further deterioration would appear to most likely develop in a slow progression in the form of localized material loss, as opposed to catastrophic collapse. As such, occasional access by staff would be acceptable and temporary shoring is not currently recommended.

Stable

At the northern end of the Stable, there is visible outward displacement of the northwest corner at the spring point of the arches on the west façade (Fig. 88). Related to this outward movement, there is cracking visible at the interior face of that corner and of the north wall (Fig. 89).

This cracking and movement is likely caused by the lateral thrust at the arch spring point and insufficient stiffness at the corner pier to resist this thrust.

Recommendation: Further analysis of the arch system along the west wall of the Stable should be performed to support the development of some form of strengthening and stiffening of the northernmost bay. Given that this bay does not currently have a door opening and has some shelving on the interior, there is opportunity to infill the opening in a discrete manner that still expresses the arched profile on the exterior, and perhaps even keeps the wood lattice



Figure 88: Stable West Elevation, Note Inflection Point at Northwest Corner (Red Arrow).



Figure 89: Stable Interior View of Northwest Corner. Note Cracking (Red Arrow).

finish. An infill might consist of reinforced concrete block with a potential new footing at the existing threshold of the opening, depending on existing conditions below grade. An external augmentation of the pier in the form of a buttress is also a possible solution; however, it will have greater visual impact and likely require more complicated foundations given the slope of the grade and the proximity of the shoreline.

The windows in the east façade of the stable have embedded, corroding ferrous bars that have caused damage to the masonry wall (Fig. 90). As noted previously, when ferrous elements rust in the presence of moisture and oxygen, they expand volumetrically, exerting large pressures on the surrounding materials. This can cause crushing, cracking, or spalling of these materials, while also representing a loss of integrity to the metal itself.

Recommendation: The bars are likely still needed for both safety and historical reasons. As such, we recommend replacing the bars in kind with stainless steel and repairing surrounding masonry. If these elements are deemed to no longer be needed, remove bars from walls and repair masonry in kind with appropriate mortar.



Figure 90: Stable, Corroding Embedded Iron Bar at East Side Window.

Carriage House

Some deterioration of wood framing was observed in areas of more recent water penetration at the Carriage House roof, east end. This correlates to open joints and vegetation observed in the flat brick roof above (Fig. 91), likely allowing water to penetrate into the building and cause the deterioration of the wood.



Figure 91: Carriage House Roof, NE Corner. Note Crack and Vegetation.



Figure 92: Carriage House, Sill, and Roof Joist Deterioration at SE Corner.

The sill and roof framing at the southeast corner of the building showed signs of rot (Fig. 92), as did the west bearing end of the lintel above the door opening (Fig. 93).

Recommendation: Remove vegetation and repair brick roof to provide waterproof enclosure. After any necessary roofing repairs have been made, deteriorated wood members should be replaced in kind. Roof joists may be replaced full length or possibly partial length with an engineered scarf joint. A lapped joint should be provided for the sill replacement. Replacement wood should be suitable to the marine environment and contact with masonry for durability, although these members should not be subjected to extensive amounts of direct, sustained moisture.



Figure 93: Carriage House, Lintel Bearing Deterioration.

Site Structures

The north side of the Fort and its site elements face the water and are more vulnerable to high wind, water, and flooding events. There is a history of strong hurricanes that have damaged the fort and its various site elements.

Scour was observed at the base of the east (Fig. 94) and west seawalls. Erosion has exposed the base of the side walls of the site stair leading down to the water at the north end of the site (Fig. 95). The ground below the end of the east fort wall has also been eroded away, undermining the decorative masonry element (Fig. 96).

Recommendation: Designs for localized underpinning of these projecting walls should be developed in coordination with a geotechnical investigation at the waterline. Underpinning may be in the form of surface-level concrete in combination with deeper pile



Figure 94: East Seawall, Note Scour at Base.



Figure 95: Site Stair, Note Scour / Soil Erosion (Red Arrow).

foundations, depending upon geotechnical findings. Projections of more intense weather events and rising sea levels should be taken into account in the design of the underpinning.	 Figure 96: Undermined Site Element at End of East Fort Wall.

Preliminary Structural Analysis

As part of the review of the existing structure, 1200AE performed a preliminary structural analysis at locations of concern to understand possible sources of the existing distress observed in the field. This analysis was accomplished primarily with hand calculations using the following reference standards:

- 2018 International Building Code (IBC), and referenced codes and standards including:
  - 2018 International Existing Building Code (IEBC)
  - Minimum Design Loads for Buildings and Other Structures (ASCE 7-16)
  - Flood Resistant Design and Construction (ASCE 24-14)
  - 2018 National Design Specification for Wood Construction (NDS)

Given the nature of the structure and its location in a hurricane-prone zone by the sea, wind and flood loads are considered to be contributing to the ongoing mechanisms of deterioration. The following sources were consulted in regard to these types of extreme weather events:

- Climate-Resilient Infrastructure: Adaptive Design and Risk Management, ASCE Manuals and Reports on Engineering Practice No. 140, edited by Bilal M. Ayyub, 2018.
- The Secretary of Interior's Standards for Rehabilitation & Guidelines for Flood Adaptation for Rehabilitating Historic Buildings, U.S. Department of the Interior, National Park Service, Technical Preservation Services, 2021.
- FEMA Advisory Flood Hazard Resources Map, United States Virgin Islands, St. Croix, Map ID 0072, May 25, 2018.
- U.S. Virgin Islands Mitigation Assessment Team (MAT) Report, FEMA P-2021, *Hurricanes Irma and Maria in the U.S. Virgin Islands.*

Structural Loading and Serviceability

1. Risk Category

   The Risk Category of buildings and other structures for flood, wind, and earthquake loads is based on the building's use or occupancy. Given that the building is currently used as office space for NPS staff and as a museum, the Risk Category based on ASCE-7 is Risk Category II.

2. Uniformly Distributed Live Loading

   The following values are specified by the applicable codes and standards or are higher values selected for use on this project.

Occupancy or Use	Live Loadings	
	Uniform	Concentrated
Assembly Areas and Terraces	100 psf	300 lbs
Offices	50 psf	300 lbs
Exhibit / Museum Spaces	60 psf	300 lbs
Metal Roofs	20 psf	300 lbs
Surcharge for Landscape Features	100 psf	

3. Wind Loading

The ASCE 7 Section on wind loads is used to calculate the design forces. The design base shear is found using the static force procedure with the following factors:

Basic Wind Speed	165 mph	(* See Special Wind Region below)
Surface Roughness	D	(Water surfaces)
Wind Exposure	D	
Importance Factor (Iw)	1.0	

Fort Christiansted is in a wind-borne debris region.

ASCE 7 requires that wind speed-up effects at hills, ridges, and escarpments be included in the determination of the wind loads by using the Topographic Factor (Section 26.8 ASCE 7-16). The wind speed-up from topographic effects can produce significantly higher wind pressures than those calculated using the base design wind speed values. However, ASCE 7 topographic procedures are complex, and application is typically inconsistent.

In response to 2017 Hurricanes Irma and Maria and in an attempt to provide a simplified alternative to determining the wind speedup effects, the Federal Emergency Management Agency (FEMA) in collaboration with the U.S. Virgin Islands Department of Planning and Natural Resources (DPNR) developed a set of new basic wind speed maps that include topography related speed-up effects referred to as the U.S. Virgin Island Special Wind Region. Special Wind Region Maps provide design wind speeds at one height above ground level (32.8 feet) and one terrain roughness exposure (Open terrain, Exposure C).

Per the U.S. Virgin Islands Special Wind Region Maps (2019), the Basic Wind Speed including topographic effects is 172 mph.

It has been proposed that the next edition of the USVI Building Code incorporate revised basic wind speed maps that consider topographic effects as an option for determining wind pressures on buildings and that these revised maps developed for the USVI should be included in the next edition of ASCE 7 (7-22).

4. Seismic Loading

The ASCE 7 Section on earthquake loads is used to calculate the design forces. The design base shear is found using the equivalent lateral force procedure with the following factors:

Short Period Map Value (Ss)	82.0% g
1-Sec Period Map Value (S1)	30.6% g
Site Class (soil factor)	D (assumed, to be verified)
5% Spectral Response Acceleration (SDS)	65.6% g
5% Spectral Response Acceleration (SD1)	36.7% g
Seismic Design Category	D

Basic Structural System	Load-bearing masonry walls
Seismic Resisting System	Ordinary plain masonry shear walls
Response Modification Factor (R)	1.5

5. Flood Loading

Flood maps show how likely it is for an area to flood. Any place with a 1% chance or higher chance of experiencing a flood each year is considered to have a high risk. The excerpt of the FEMA flood map below indicates the flood risk in the area surrounding and including Fort Christiansvaern.

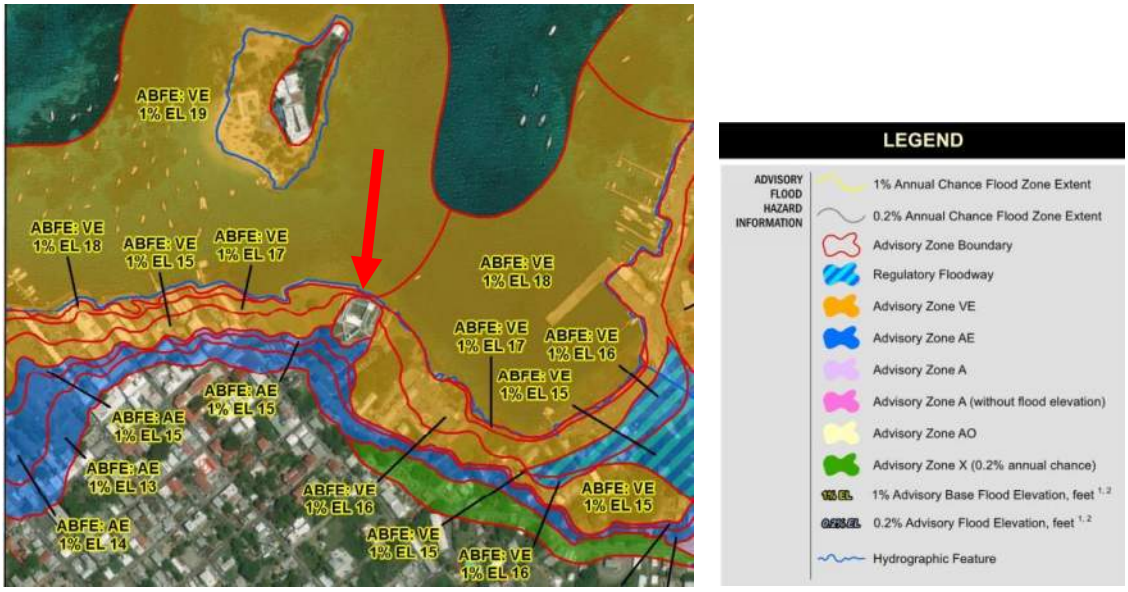


Figure 97: Excerpt from 2018 FEMA Advisory Flood Hazard Resources Map, United States Virgin Islands, St. Croix, Map ID 0072. Red Arrow Points to Fort Christiansvaern.

The areas north, east, and west of the fort are designated as Advisory Zone VE (ABFE: VE 1% EL 16-19), depending on the location. These are shaded in orange. The area south (inland) of the fort is designated as Advisory Zone AE (ABFE: AE 1% EL 15). These zones are shaded in blue. Per the ASCE-7 section on Flood Loads, these zones are defined as follows:

- Coastal V-Zone / High Hazard Area: An area within a Special Flood Hazard Area (SFHA), extending from offshore to the inland limit of a primary frontal dune along an open coast, and any other area that is subject to high-velocity wave action from storms or seismic forces.
- Coastal A-Zone: An area within a special flood hazard area, landward of a V-Zone or landward of an open coast without mapped V-Zones. To be classified as a Coastal A-Zone, the principal source of flooding must be astronomical tides, storm surges, seiches, or tsunamis, not riverine flooding, and the potential for breaking wave heights greater than or equal to 1.5 ft must exist during the flood.

The SFHA is defined as the land area covered by the floodwaters of a base flood. The elevation indicated is the Base Flood Elevation (BFE), which is the computed elevation to which floodwater is anticipated to rise during the base (1-percent-annual-chance) flood event.

The ASCE 7 Section on flood loads defines flood-related design forces, which include the following:

- Hydrostatic loads: loads caused by a depth of water to the level of the Design Flood Elevation (DFE).
- Hydrodynamic loads: loads incorporating the dynamic effects of moving water.
- Wave loads: loads that result from water waves propagating over the water surface and striking a building or other structure.
- Impact loads: loads that result from debris or any object transported by floodwaters striking against buildings or other structures.

ASCE 24 covers the design of structures to resist these flood-related design forces.

Serviceability

1. Floor and Roof Deflections

a) Floor deflection shall not exceed the following:

- For floors supporting wood finishes: the floor live load deflection of wood beams and girders shall not exceed 1/360 of span lengths. Total deflection (dead + live) shall not exceed 1/240 of span lengths.

- For floors supporting tile finishes or plaster ceilings: the floor live load deflection of wood beams and girders shall not exceed 1/480 of span lengths. Total deflection (dead + live) shall not exceed 1/360 of span lengths.

b) Roof deflection shall not exceed the following:

- For flat brick roofs on timber framing: under live or wind load shall not exceed 1/360 of the span length. Total deflection (dead + live) shall not exceed 1/240 of span length.

- For sloped metal roofs on timber framing: under live or wind load shall not exceed 1/240 of the span length. Total deflection (dead + live) shall not exceed 1/180 of span length.

Structural Material Specifications

Existing Timber / Lumber

Wood species identification was performed at the built-up girder supporting the roof at the center of the Commandant's Gallery. This testing was performed by the Forest Service Center for Wood Anatomy Research of the U.S. Department of Agriculture. It was found that the wood is a species of Southern Yellow Pine, Pinus sp. As pine is not native to the Virgin Islands, it appears that this wood was imported.

It was noted in the 2015 HPTC Historic Structure Treatment Record that deteriorated framing members in the south curtain were replaced with Mahogany during that program of repairs.

Given that no additional testing or grading of other wood elements at the Fort was performed as part of this HSR, preliminary analysis of limited areas was based on the assumption of Southern Pine No. 1. For any future detailed analysis, this assumption should be confirmed by testing.

Conclusions and Recommendations

Climatic Effects

There is a history of severe hurricanes damaging elements of Fort Christiansvaern. Post-hurricane structural repairs were undertaken after each of those events and are summarized above. Recent hurricanes resulting in damage include Hurricanes Hugo (Category 4; September 17, 1989), Marilyn (Strong Category 2; September 15,1995), Omar (Category 3; October 15, 2008), and Irma / Maria (Category 5; September 6 and 20, 2017). The intensity and frequency of these hurricanes are anticipated to increase with the warming climate, and building codes are incorporating updated design parameters to reflect these changes.

At Fort Christiansvaern, the implications of these more intense weather events include the following:

- Higher wind loads associated with more intense storms impose larger uplift forces on roofs. This may not affect the heavier brick roofs on site; however, the lighter metal roofs and supporting framing may require additional analysis and more substantial tie-downs to prevent the roofs from being torn off during a heavy storm.

- Flagpoles are also susceptible to wind damage and the flagpoles themselves and/or their attachments may require reinforcement for higher load scenarios.

- Wind-borne debris can impact the building elements with a higher force in more intense storms. Windows are particularly susceptible to damage from wind-borne debris. The heavy masonry walls of the structure are more resistant to these forces but can also sustain damage.

- Site elements near the shoreline are exposed to wave action and may experience higher forces, potentially causing more damage to these elements and their foundations. Scour has affected the foundations for these elements historically and this is anticipated to increase.

Specific recommendations for building elements exposed to these forces are described in more detail below.

Stabilization and Repair

Specific recommendations related to observed structural deficiencies have been described in detail in the Existing Conditions section of this report, including recommendations related to the changing climate. These recommendations are summarized briefly below:

1. **Ravelin, Room 27:** In shored area, replace the roof boards for one bay. Sister or replace the rafter up against the wall. Perform roofing and flashing repair or replacement.

2. **Ravelin, Room 27:** Preliminary analysis of roof framing yielded low load capacities. Install one or two intermediate rafters in each rafter bay, pending further analysis. Install tie-downs at rafter ends.

3. **South Curtain, First Floor:** Deteriorated brick masonry and mortar in barrel vaults below stairs. At stairs above, perform localized joint treatments or potential resloping of surfaces to assure water can run off and is not trapped. Repoint deteriorated areas at the intrados of the vaults and consider applying a parge coat to help minimize further losses of brick units.

4. **South Curtain, First Floor:** Deteriorated wood floor and supporting joists/ sleepers at the south-facing rooms. Wood in direct contact with earth is subject to accelerated deterioration from both moisture and easy access for termites and other insects. If public access is to be allowed, lift wood boards and salvage intact material for reuse. Install a reinforced concrete slab on grade at an elevation deep enough to allow room for application of wood sleepers and finish wood flooring at the current elevation. Reinforcement in the slab on grade should be corrosion resistant, with consideration of both galvanized and stainless-steel wire mesh. If public access is not to be allowed, then the existing condition can remain as is.

5. **South Curtain, second-floor framing above Room 12:** Framing found to have evidence of termite damage with significant section loss and inconsistent support of floorboards. Termite treatments should be updated at regular intervals to assure that infestations are not active. Remove finishes to fully expose extent of deterioration. Reinforce deteriorated beam(s) by sistering new timber alongside the existing framing.

6. **South Curtain – Second Floor Spaces:** Termite trails leading up the wall surfaces towards the roof framing surfaces in the Commandant's Gallery at several

locations. Termite treatments should be updated at regular intervals to assure that infestations are not active.

7. **South Curtain – Second Floor Spaces:** Evidence of water infiltration through the roof and resulting deterioration of wood framing in several locations within the Commandant's Gallery. Roofing and drainage systems should be reviewed to ensure that the roof is watertight and the scupper at west end of corridor is functioning as intended. After any necessary roofing repairs have been made, deteriorated wood members should be replaced in kind, either full length or partial length with an engineered scarf joint.

8. **Commandant's Gallery Roof:** Severe deterioration of the low timber girder in the center bay of the Commandant's Gallery. Temporary shoring should be installed per provided engineered drawings to provide safe access to the Gallery and adjacent spaces. Based on the findings of the girder assessment, the southern ply of the girder should be replaced in kind and connectors between plies replaced and reinforced. A small area of the lower plies at the west end will require wood consolidation. Final design of the repairs was issued on January 23, 2023.

9. **South Curtain**: Corroded ferrous elements embedded in masonry or wood. Replace iron or steel anchorages with structurally equivalent stainless steel (Type 316) to assure proper durability in the marine environment. Embedded iron or steel that is not deteriorating actively may be susceptible to future deterioration; however, replacement may be deferred, and the areas visually monitored over time to assure conditions do not change.

10. **South Curtain – Shed Roof at second-floor porch:** Evidence of behavior consistent with roof shifting or uplift due to high wind loads. Tie-downs and connections should be evaluated, although they currently appear to have performed relatively well over time. As the severity of storms and, as a result, wind loads are predicted to increase with the warming climate, this evaluation should take into account these anticipated changes. It is likely that connections will require some reinforcement in the form of added fasteners or connector plates. Added materials should be selected for the marine environment, with stainless steel typical for metal fasteners and connectors.

11. **Southwest Bastion:** Corroding steel or iron bars embedded in surrounding masonry at basement windows. Replace bars in kind with stainless steel and repair surrounding masonry. If these elements are deemed to no longer be

needed, remove bars from walls and repair masonry in kind with appropriate mortar.

12. **Southwest Bastion Vaulting:** Extensive cracking in masonry vaulting within the first-floor spaces with existing crack gauges installed to facilitate monitoring. Signs of on-going movement are evident, but an imminent structural failure does not seem likely. It is more likely that movements will advance slowly over time. As such, having this space continue to operate with the public having partial access near the entrance is deemed acceptable while further evaluation (structural analysis) and likely strengthening is pursued. Strengthening may consist of grouted anchorage of the exterior wall and piers to the roof and second-floor diaphragms, with potential vertical reinforcement of the exterior piers. Grouted anchorage may be in the form of extended stainless-steel anchors set in a grouted sock, with the grout engaging and keying into irregularities and/or voids in the masonry.

13. **West Curtain:** Some of the wood framing has suffered from both water and insect damage historically. Address any active areas of water penetration to reduce potential for ongoing accelerated deterioration of wood framing.

14. **West Curtain:** Cracking at underside of reinforced concrete roof framing just south of the Northwest Bastion. Remove loose concrete. Expose corroded reinforcing bars, clean of all corrosion and coat with a rust-inhibiting coating. Patch concrete with a trowel-on patching mortar. Address any active areas of water penetration.

15. **Northwest Bastion - directly to the south of the latrine:** Corroded ferrous elements with associated damage in the masonry walls in which they are embedded. Remove ferrous elements from walls and repair masonry in kind with appropriate mortar.

16. **Northwest Bastion vaulting:** Line of cracking running parallel to the span of the main north-south barrel vault. The crack does not impede proper structural functioning of the vault. Localized repointing of crack and repair of finishes. If crack re-emerges then some form of long-term monitoring may be warranted, similar in nature to what has been done at the Southwest Bastion.

17. **Latrine**: Corroded ferrous bars with associated damage in masonry wall in which they are embedded. The bars are likely still needed for both safety and historical reasons. As such, we recommend replacing the bars in kind with stainless steel and repairing surrounding masonry.

18. **Latrine roof:** Light roof construction is vulnerable to high wind uplift forces during severe weather events. Tie-downs and connections should be evaluated, although they currently appear to have performed relatively well over time. As the severity of storms and, as a result, wind loads are predicted to increase with the warming climate, this evaluation should take into account these anticipated changes. Some connection reinforcement with stainless steel fasteners or connectors is likely, pending a detailed structural analysis.

19. **Northeast Bastion Roof:** Surface rusting of iron anchors at the kinked center beam. The rusting does not appear to be compromising the structural functioning of the framing. Scrape the iron of paint and loose materials, and recoat with an appropriate coating for the marine environment, in-keeping with the historic appearance.

20. **East Curtain - first-floor porch roof on the courtyard side:** Light roof construction is vulnerable to high wind uplift forces during severe weather events. Tie-downs and connections should be evaluated, although they currently appear to have performed relatively well over time. As the severity of storms and, as a result, wind loads are predicted to increase with the warming climate, this evaluation should take into account these anticipated changes. It is likely that connections will require some reinforcement in the form of added fasteners or connector plates. Added materials should be selected for the marine environment, with stainless steel typical for metal fasteners and connectors.

21. **East Curtain, Room 7:** Some of the wood roof framing has suffered from both water and insect damage historically. Address any active areas of water penetration to reduce potential for ongoing accelerated deterioration of wood framing.

22. **Southeast Bastion Vaulting:** Extensive cracking in masonry vaulting within the first-floor spaces. Signs of on-going movement are evident, but an imminent structural failure does not seem likely. It is more likely that movements will advance slowly over time. This area is not currently accessible to the public and should remain that way until further analysis and repairs are performed. Occasional access by staff would be acceptable and temporary shoring is not currently recommended. Strengthening may consist of grouted anchorage of the exterior wall and piers to the roof and 2nd floor diaphragms, with potential vertical reinforcement of the exterior piers. Grouted anchorage may be in the form of extended stainless-steel anchors set in a grouted sock, with the grout engaging and keying into irregularities and voids in the masonry.

23. **Stable – northern end:** Outward displacement of northwest corner at the spring point of the arches on the west façade and related cracking at interior face of wall. Further analysis of the arch system along the west wall should be performed to support the development of a strengthening design. A potential solution is to infill the northernmost opening in a discrete manner that still expresses the arched profile on the exterior. Infill might consist of reinforced concrete block and a potential new footing at the existing threshold of the opening, depending on existing conditions below grade. An external augmentation of the pier, in the form of a buttress, is also possible; however, it will have greater visual impact and likely require more complicated foundations.

24. **Stable – east facade:** Corroded ferrous bars with associated damage in masonry wall in which they are embedded. The bars are likely still needed for both safety and historical reasons. As such, we recommend replacing the bars in kind with stainless steel and repairing surrounding masonry. If these elements are deemed to no longer be needed, remove bars from walls and repair masonry in kind with appropriate mortar.

25. **Carriage House – Roof framing:** Areas of water penetration at east end of roof with associated deterioration of framing, including sill and roof framing at southeast corner and west bearing end of the lintel above the door opening. Open joints and vegetation in flat brick roof above. Remove vegetation and repair brick roof to provide waterproof enclosure. After roofing repairs, replace deteriorated wood members in kind. Roof joists may be replaced full length or possibly partial length with an engineered scarf joint. A lapped joint should be provided for the sill replacement. Replacement wood should be suitable to the marine environment and contact with masonry for durability.

26. **Site Structures:** Scour and erosion at bases of seawalls and at site stair side walls and decorative masonry element. The north side of the Fort and its site elements face the water and are more vulnerable to high wind, water, and flooding events. There is a history of strong hurricanes that have damaged the fort and its various site elements. Designs for localized underpinning of these projecting walls should be developed in coordination with a geotechnical investigation at the waterline. Underpinning may be in the form of surface-level concrete in combination with deeper pile foundations, depending upon geotechnical findings. Projections of more intense weather events and rising sea levels should be taken into account in the design of the underpinning.

Appendix E.1: Drawings

E-1: Second Floor Framing on First Floor Plan – South

E-2: Second Floor Framing on First Floor Plan – North

E-3: Roof Framing on Second Floor Plan – South

E-4: Roof Framing on Second Floor Plan - North

E-5: Stable / Carriage House Roof Framing on Floor Plan

E-6: Section Through First Floor Porch

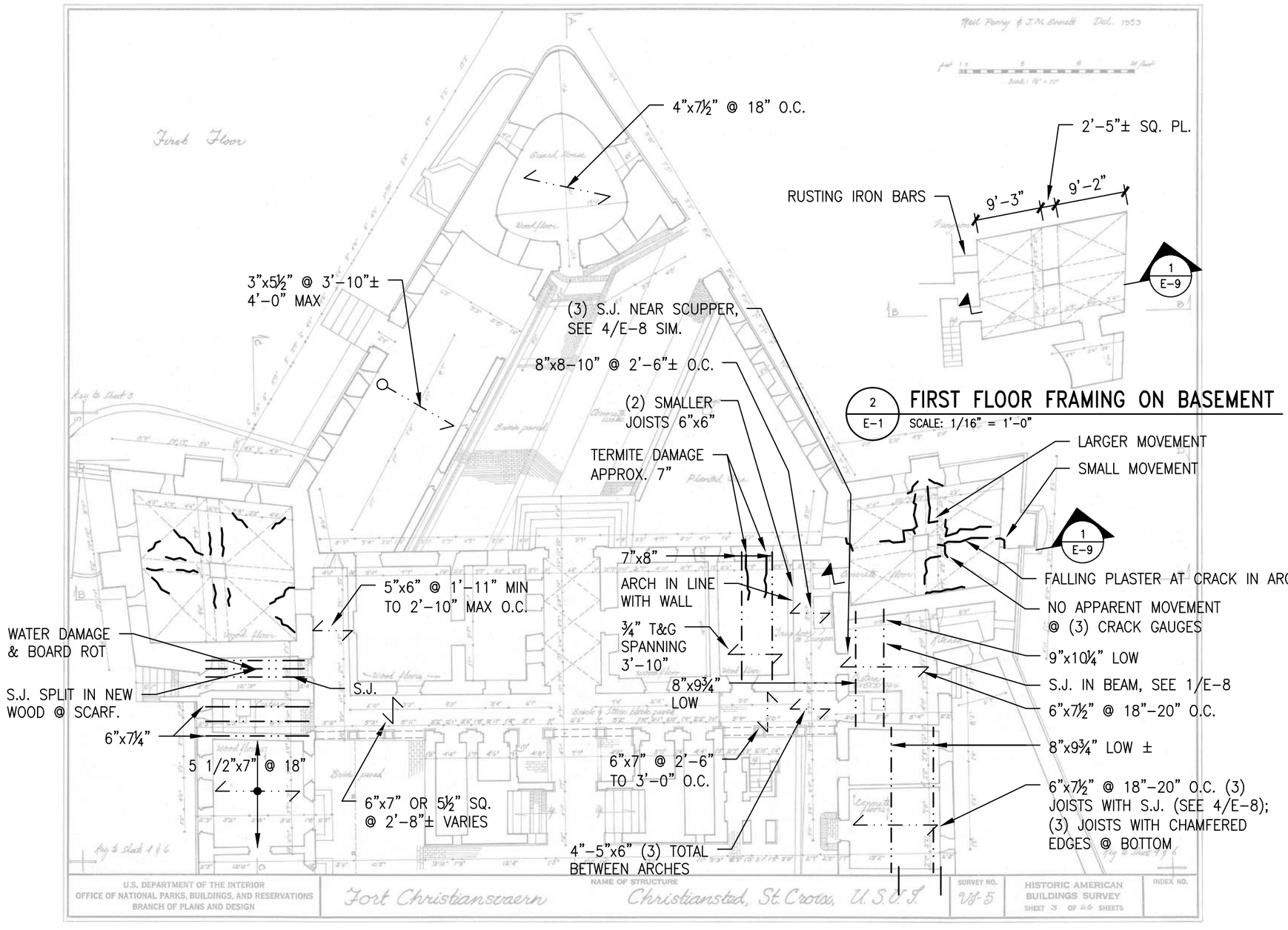
E-7: Section Through Second Floor Porch and Kinked Beam Details

E-8: Scarf Joint Details

E-9: E-W Section Through Southwest Bastion – Looking South

E-10: Partial Building Sections Through West Curtain

E-11: Partial Building Sections Through Stable



2 / E-1 **FIRST FLOOR FRAMING ON BASEMENT**
SCALE: 1/16" = 1'-0"

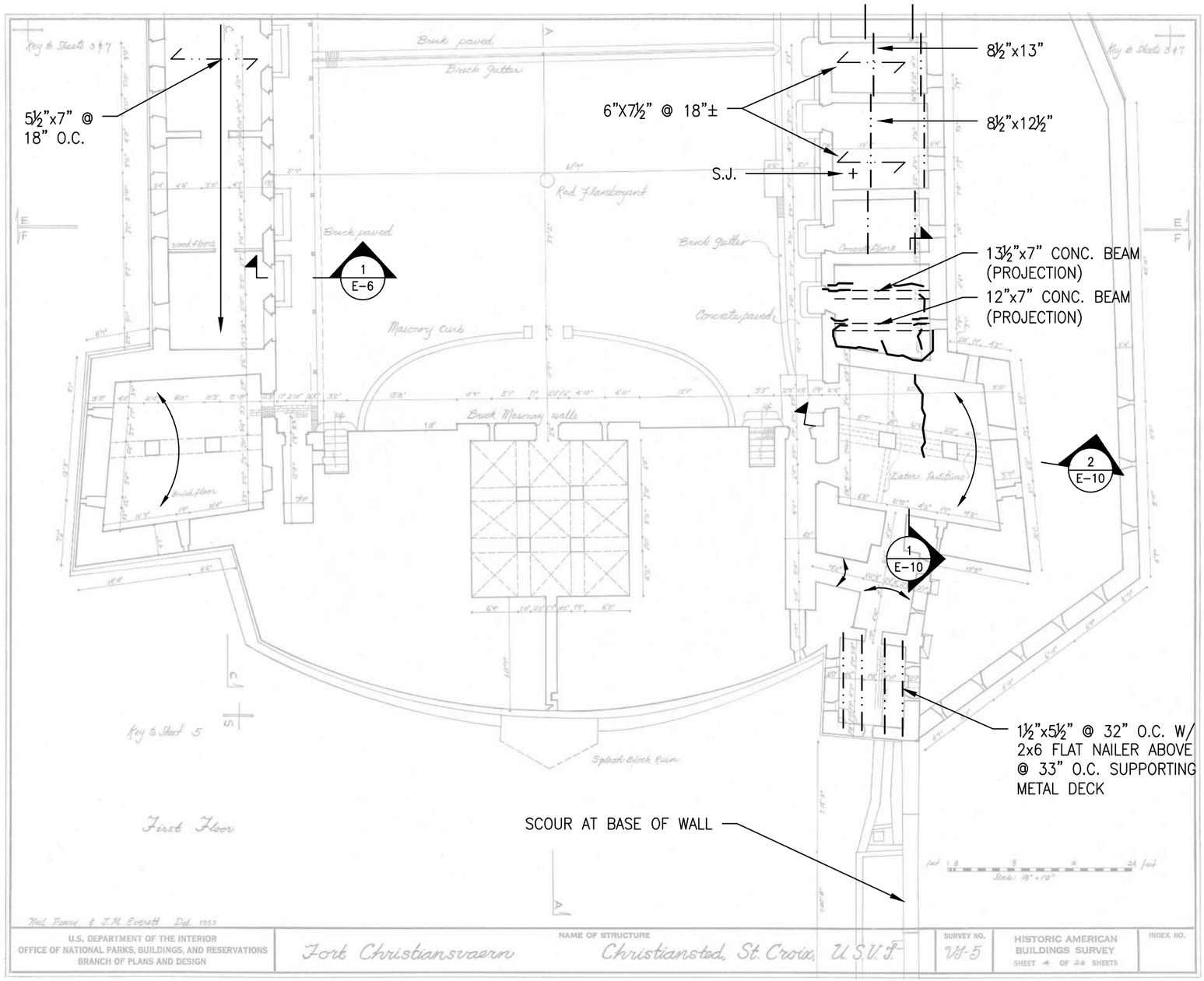
1 / E-1 **SECOND FLOOR FRAMING ON FIRST FLOOR PLAN – SOUTH**
SCALE: 1/16" = 1'-0"

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1 / E-2 SECOND FLOOR FRAMING ON FIRST FLOOR PLAN – NORTH

SCALE: 1/16" = 1'-0"

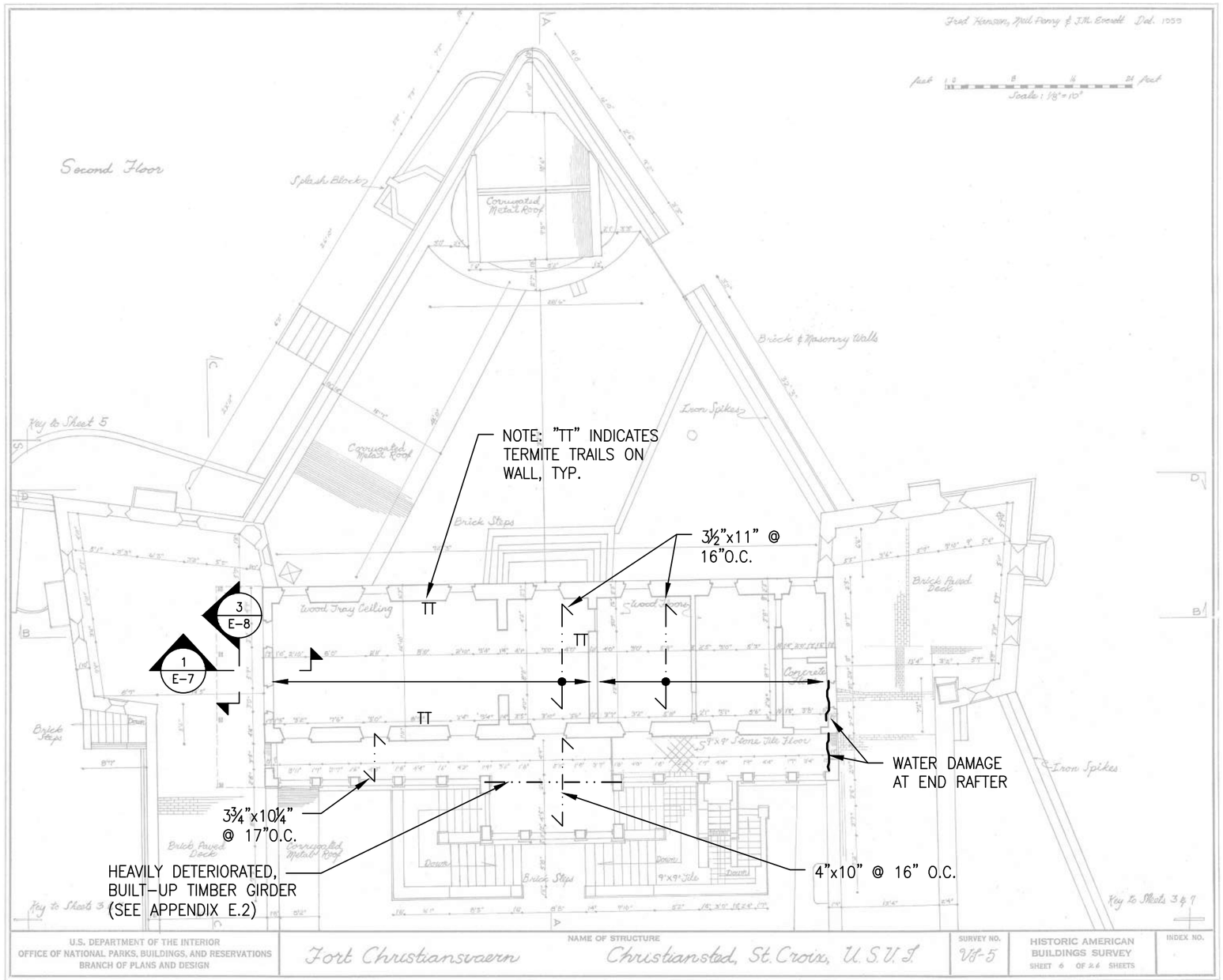
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1 / E-3 ROOF FRAMING ON SECOND FLOOR PLAN – SOUTH

SCALE: 1/16" = 1'-0"

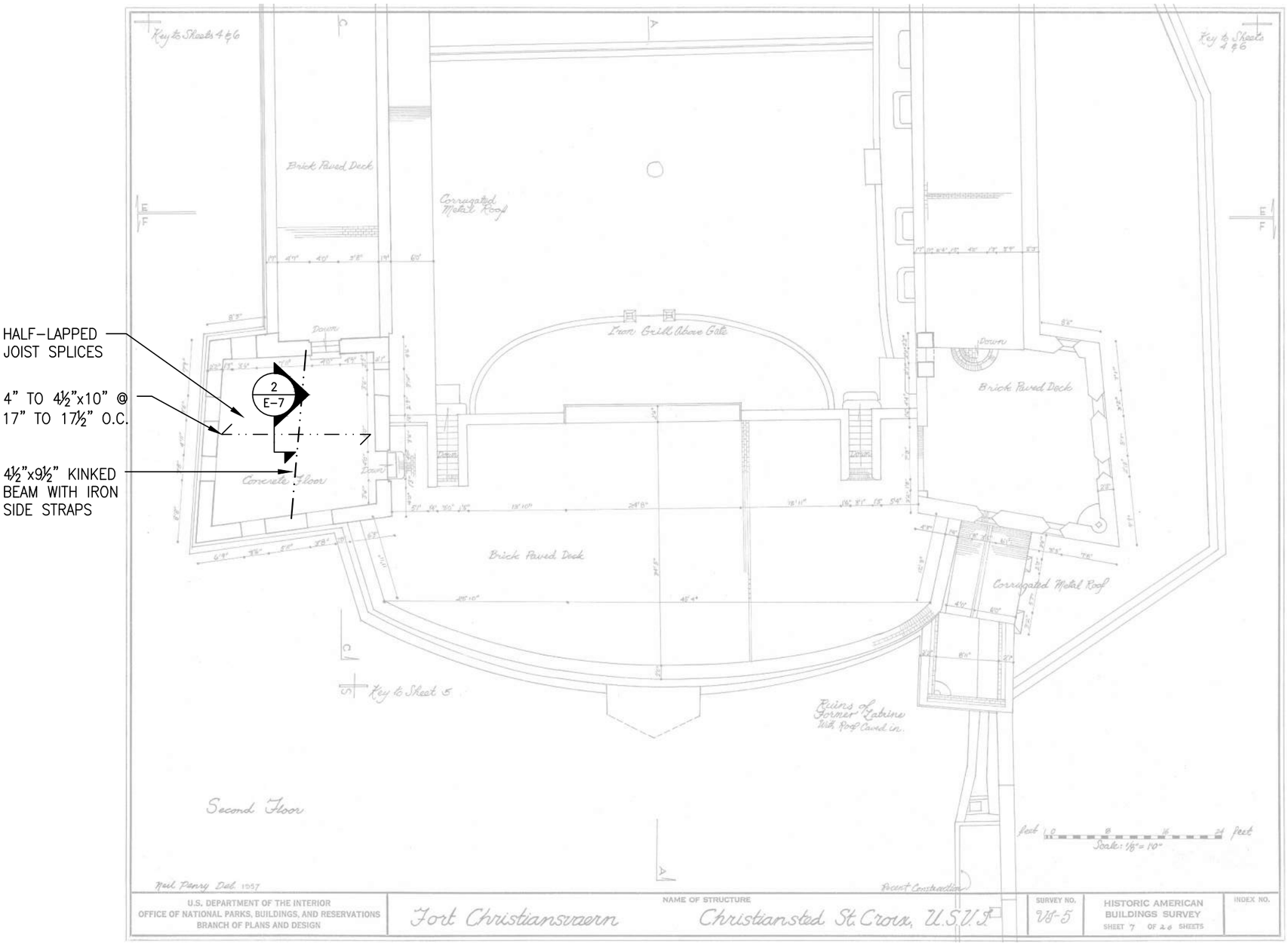
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HALF–LAPPED JOIST SPLICES

4" TO 4½"x10" @ 17" TO 17½" O.C.

4½"x9½" KINKED BEAM WITH IRON SIDE STRAPS

2 / E–7

1 / E–4 ROOF FRAMING ON SECOND FLOOR PLAN – NORTH

SCALE: 1/16" = 1'–0"

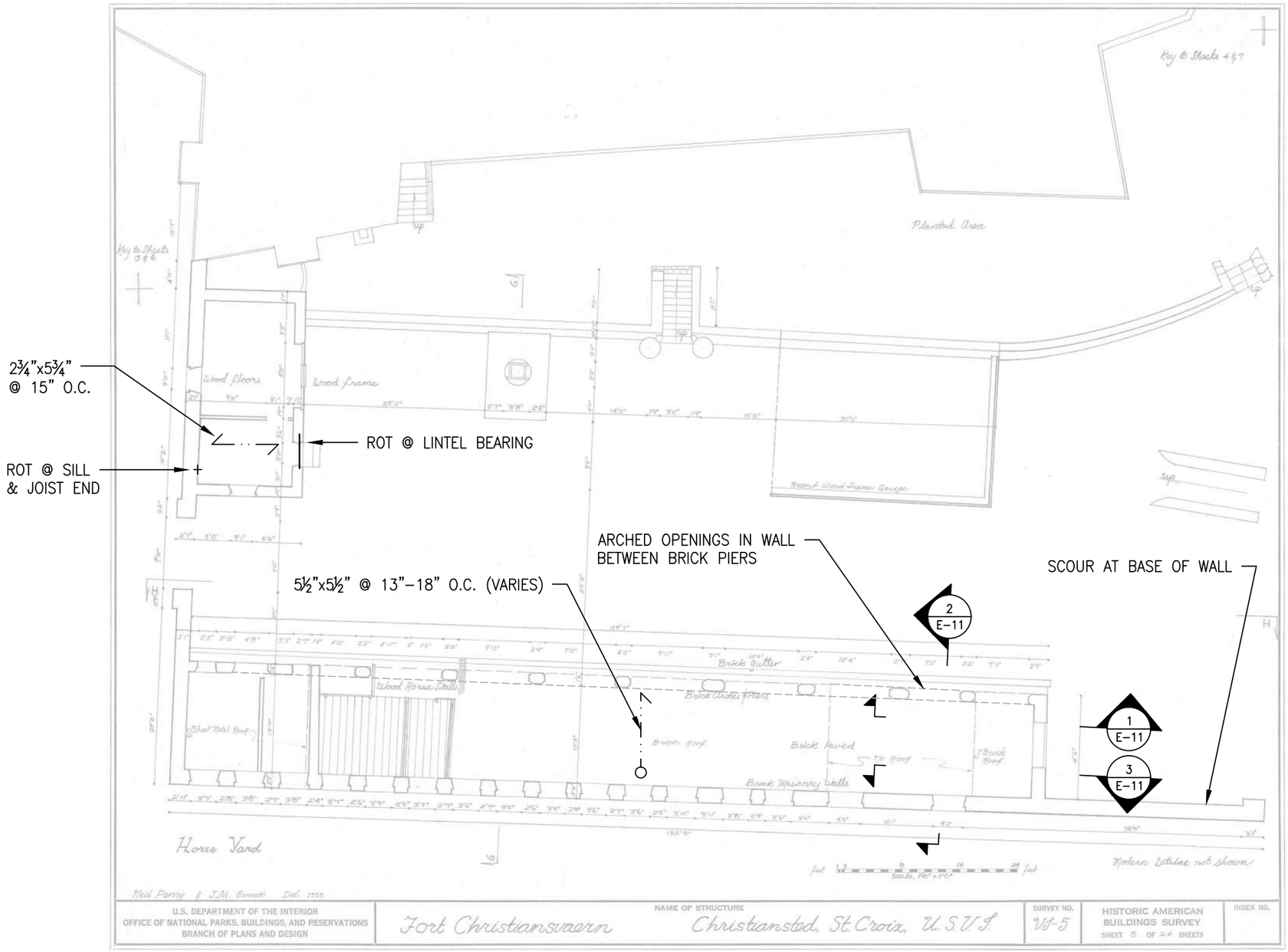
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1 / E–5 STABLE & CARRIAGE HOUSE ROOF FRAMING ON STABLEYARD PLAN

SCALE: 1/16" = 1'–0"

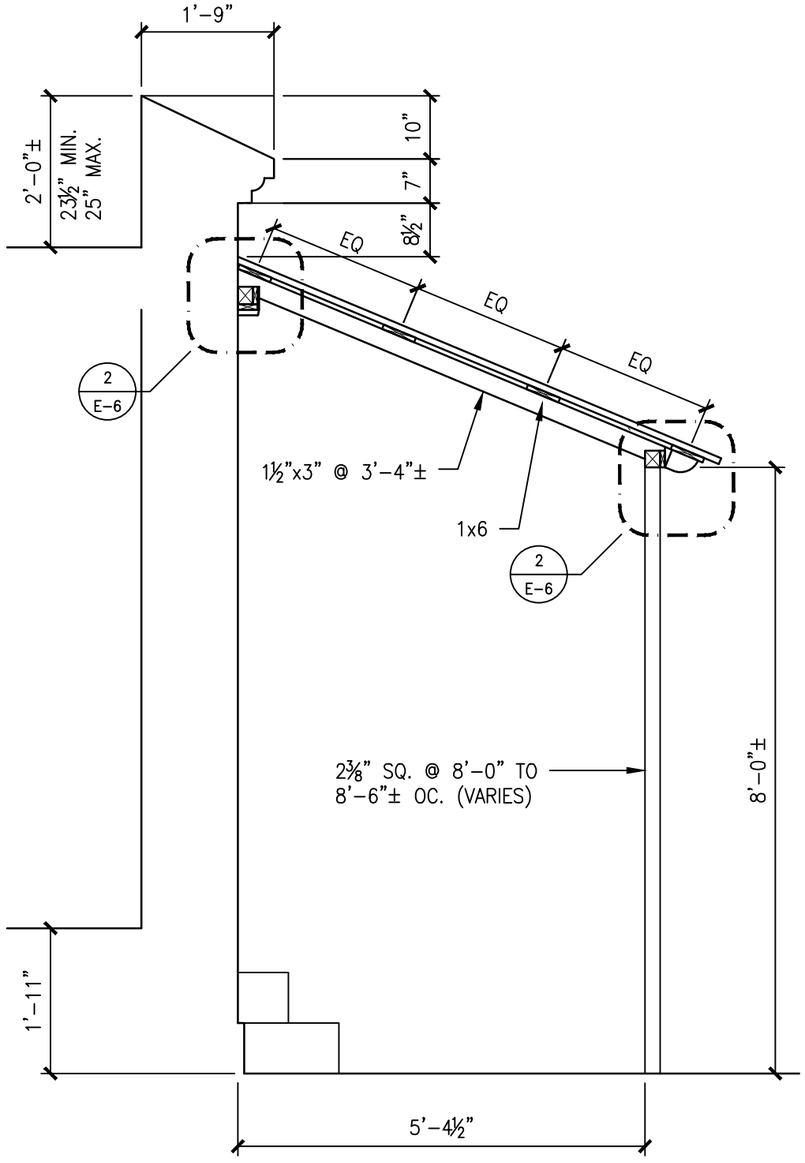
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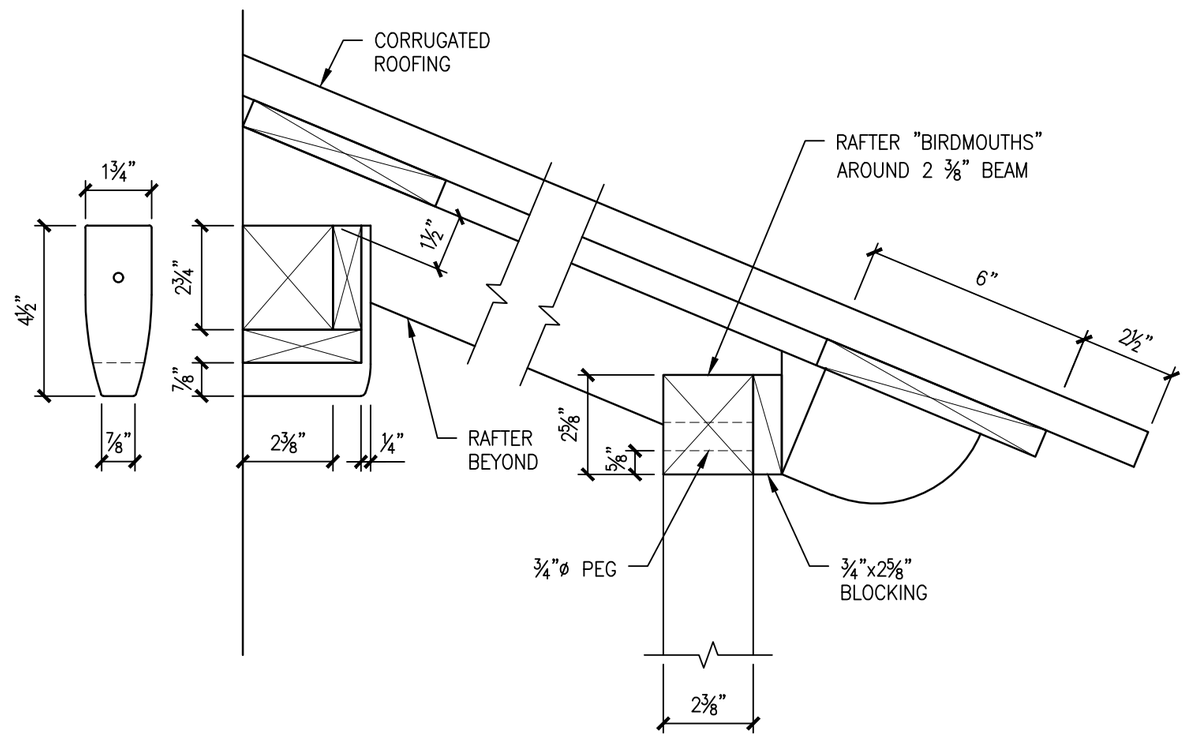
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1 / E–6 SECTION THROUGH EAST CURTAIN PORCH

SCALE: 1/2" = 1'–0"



2 / E–6 DETAIL AT RAFTER

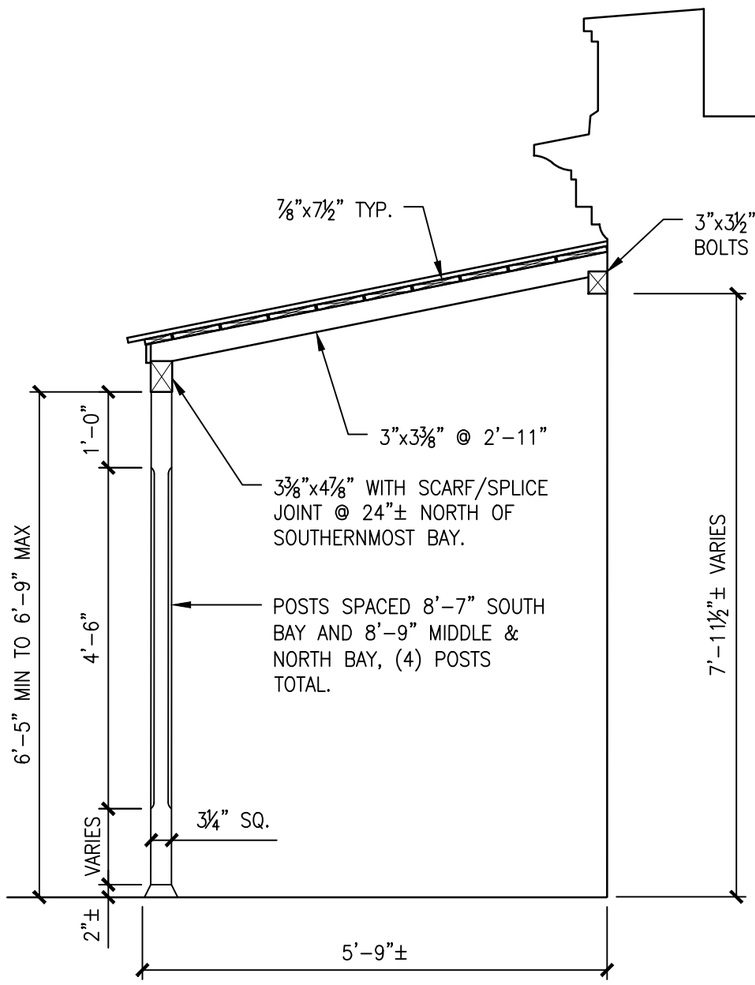
SCALE: 3" = 1'–0"

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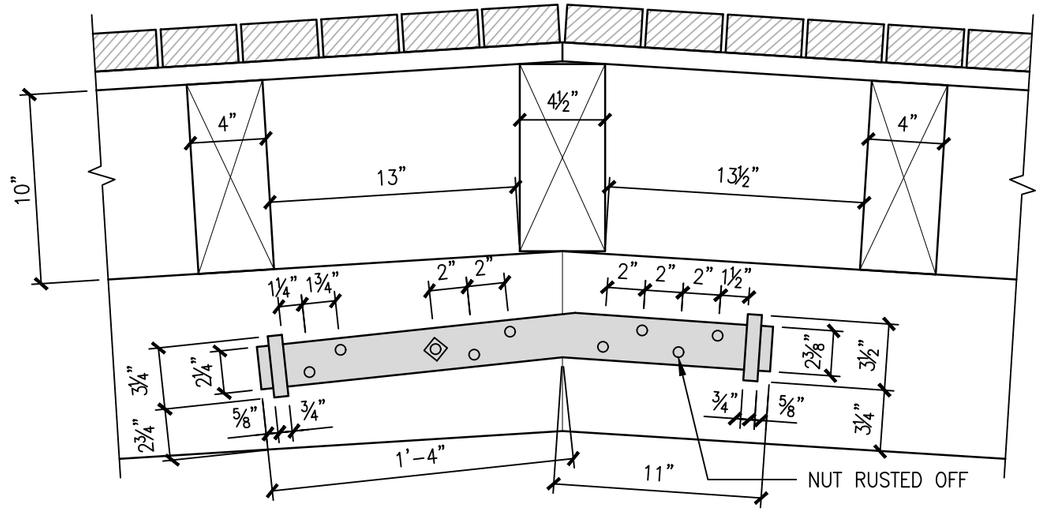
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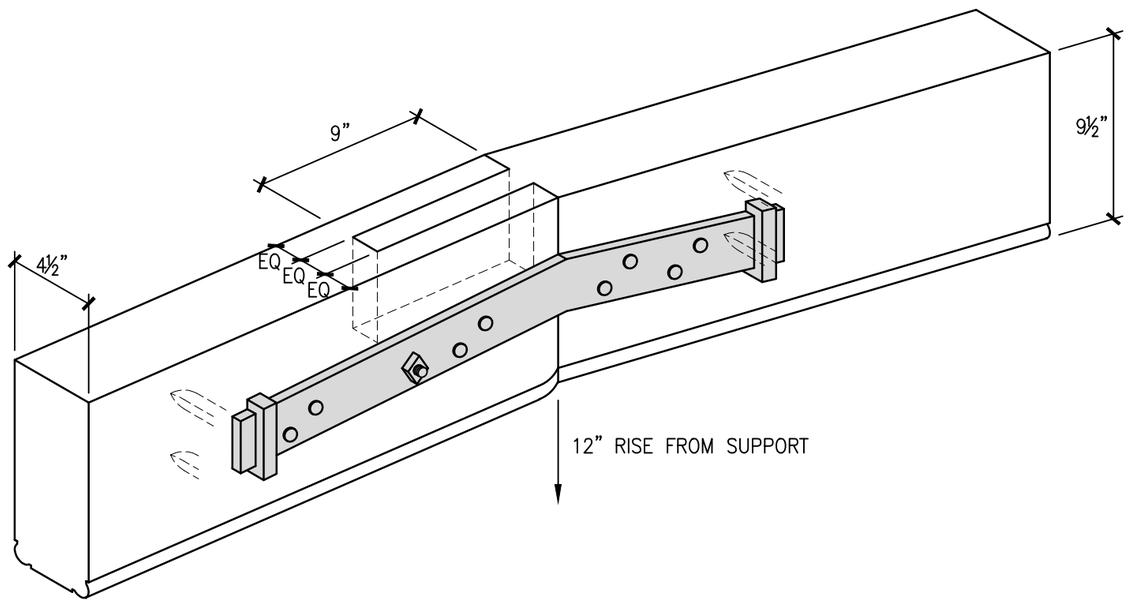
1 / E-7 SECTION THROUGH SOUTH CURTAIN PORCH

SCALE: 1/2" = 1'-0"



2 / E-7 KINKED BEAM DETAIL – EAST ELEVATION (NE BASTION)

SCALE: 1 1/2" = 1'-0"



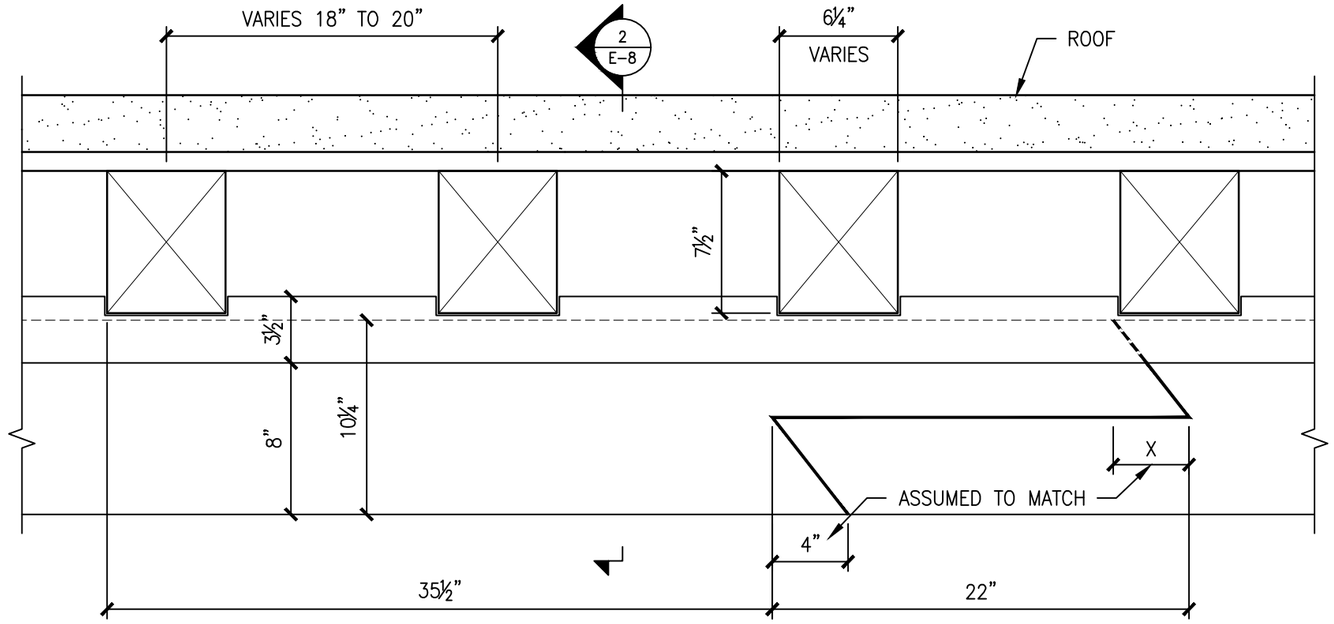
3 / E-7 KINKED BEAM DETAIL (NE BASTION)

SCALE: N.T.S.

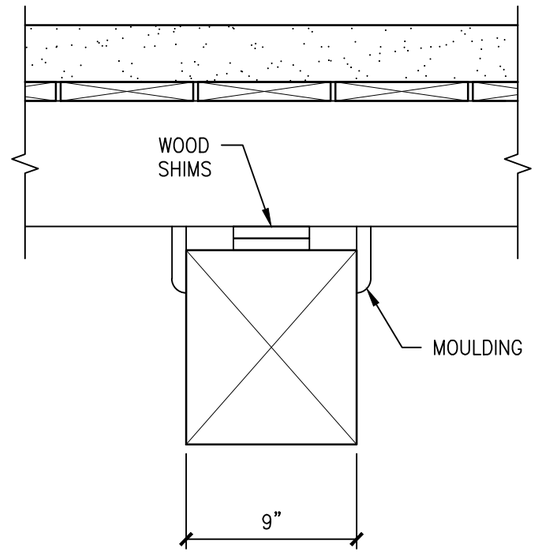
Submission: HISTORIC STRUCTURE REPORT
Project Number: 20-131
Date: 07-19-2023
Project Title: FORT CHRISTIANSVAERN AND STABLE BUILDING
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CHRISTIANSTED, ST. CROIX 00820
U.S. VIRGIN ISLANDS

E-7

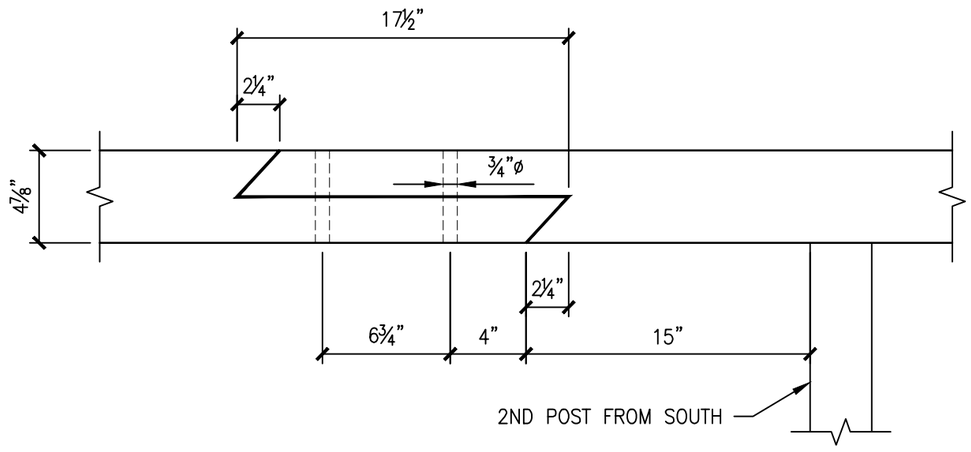
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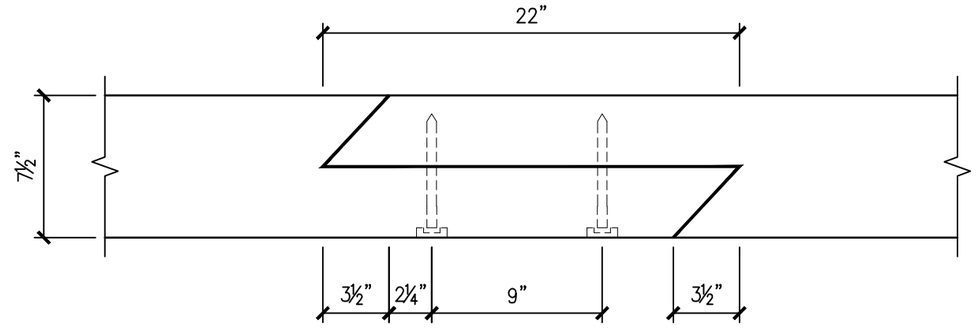
1 / E-8 **DETAIL KITCHEN/CISTERN ROOM BEAM SCARF JOINT**
SCALE: 1 1/2" = 1'-0"



2 / E-8 **DETAIL**
SCALE: 1 1/2" = 1'-0"



3 / E-8 **DETAIL SOUTH CURTAIN SHED ROOF SCARF JOINT LOOKING EAST**
SCALE: 1 1/2" = 1'-0"



(SIMILAR AT CISTERN / KITCHEN JOISTS)

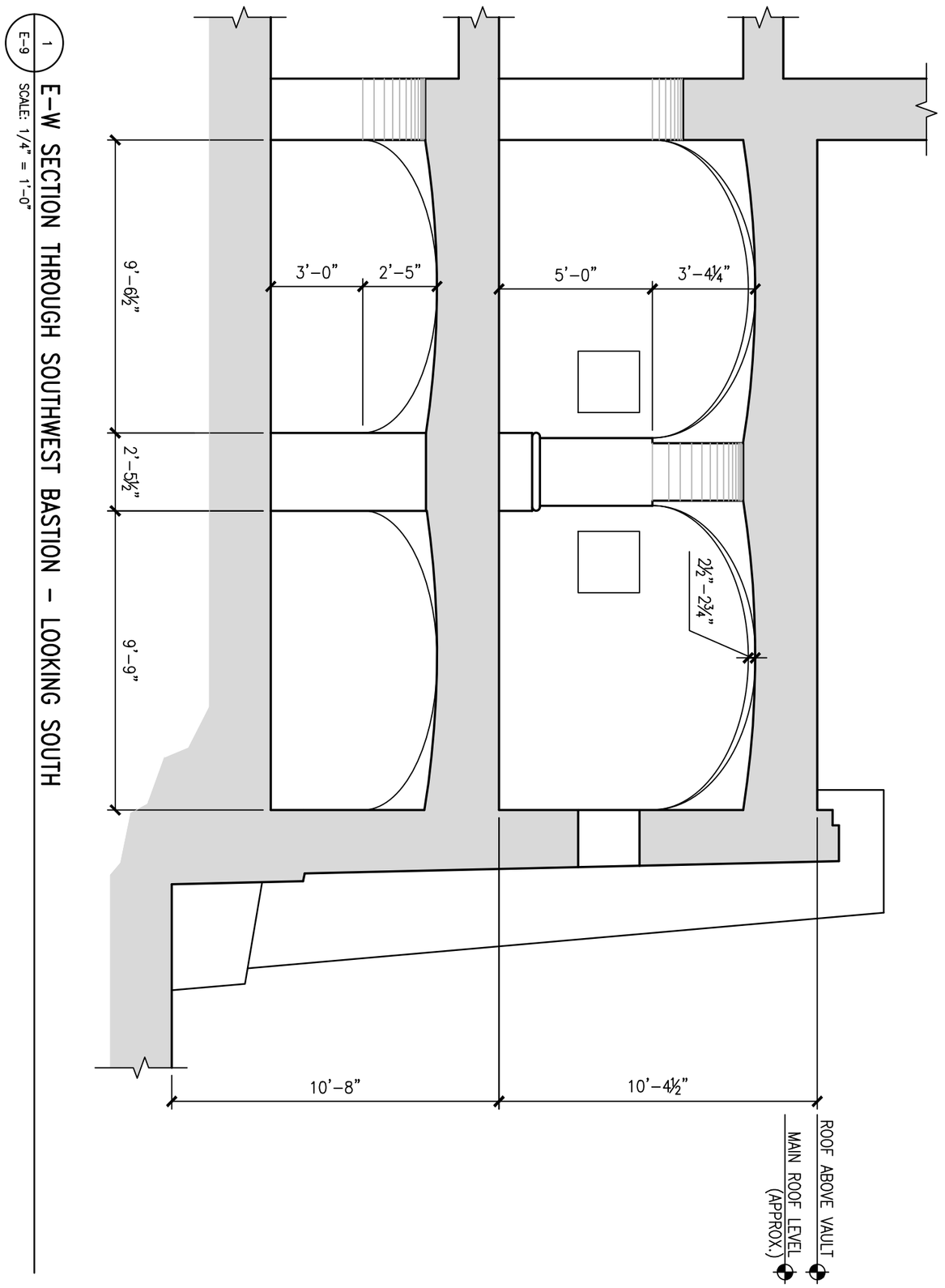
4 / E-8 **DETAIL ALEXANDER HAMILTON ROOM SCARF JOINT**
SCALE: 1 1/2" = 1'-0"

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E-8

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1 / E-9

SCALE: 1/4" = 1'-0"

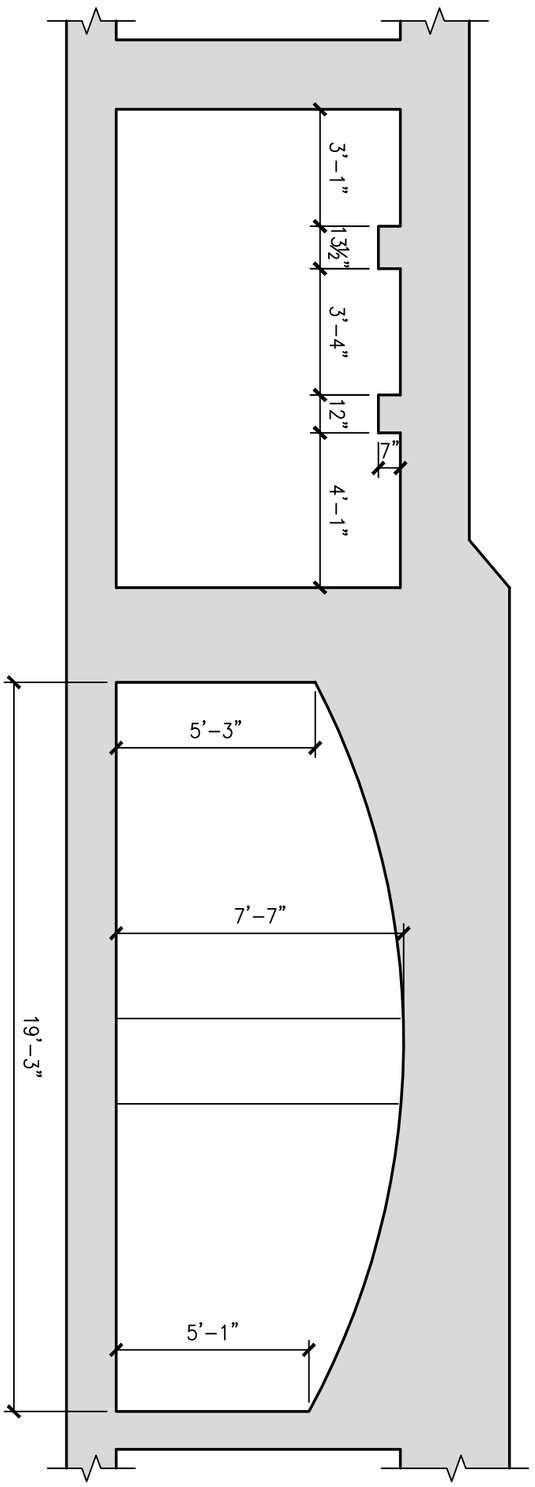
E-W SECTION THROUGH SOUTHWEST BASTION – LOOKING SOUTH

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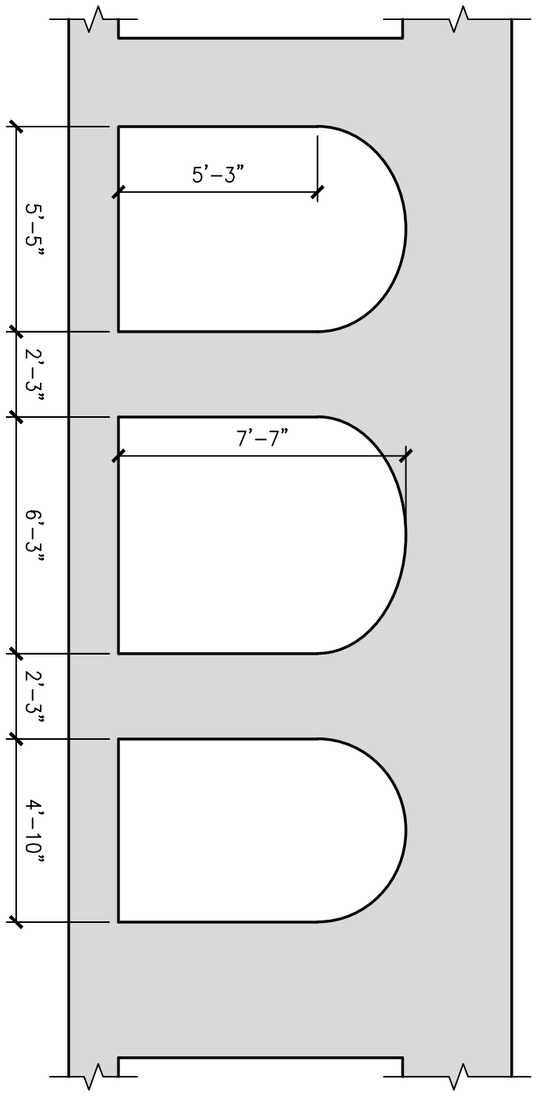
E-9



1 E–10

PARTIAL BUILDING SECTION THROUGH WEST CURTAIN – LOOKING WEST

SCALE: 1/4” = 1’–0”



2 E–10

PARTIAL BUILDING SECTION THROUGH WEST CURTAIN – LOOKING SOUTH

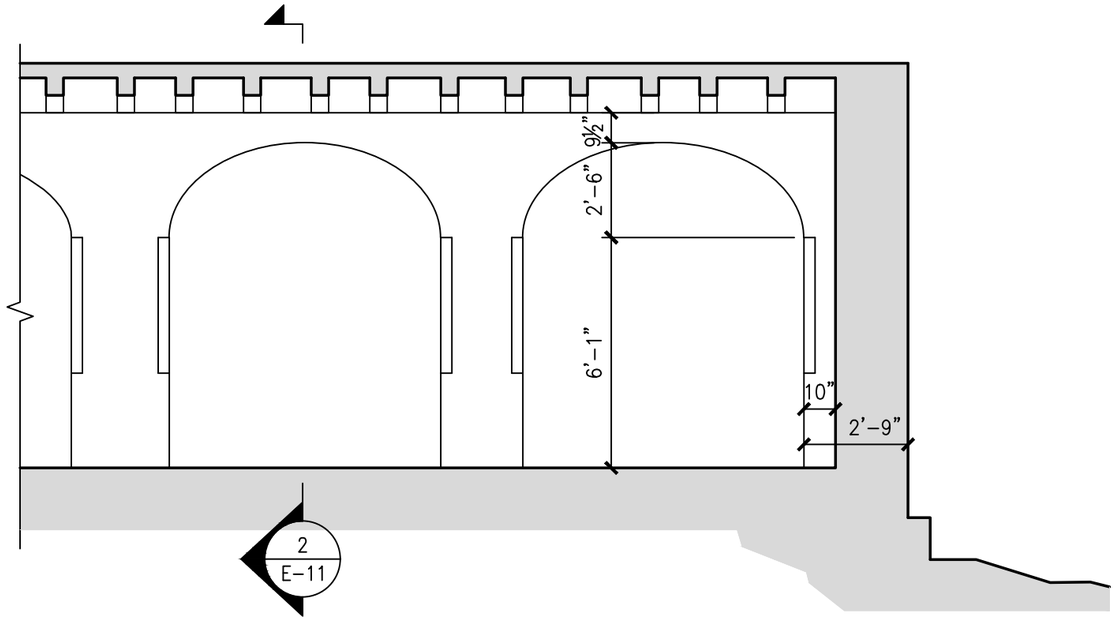
SCALE: 1/4” = 1’–0”

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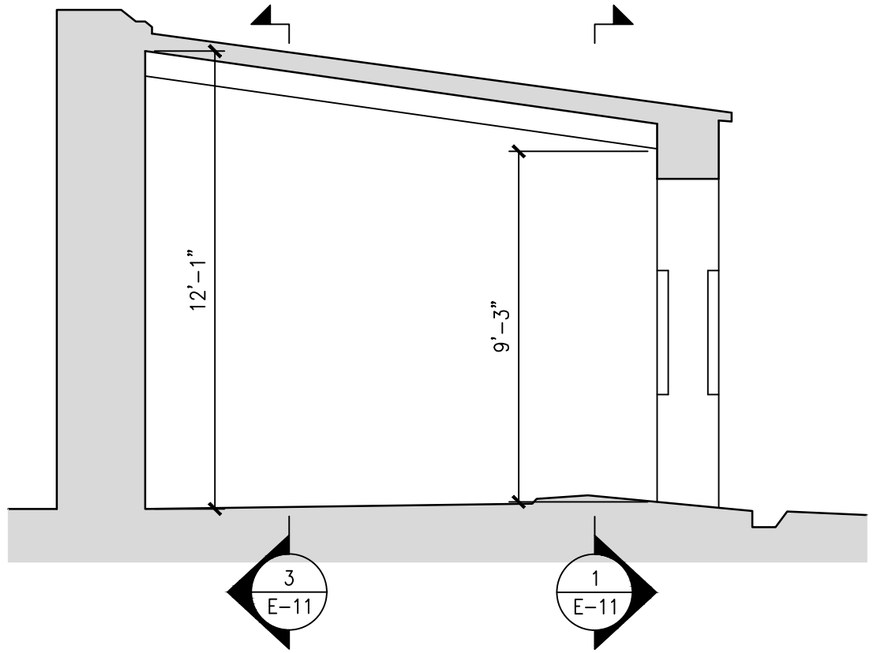
Project Title: FORT CHRISTIANSVAERN AND STABLE BUILDING
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E-10



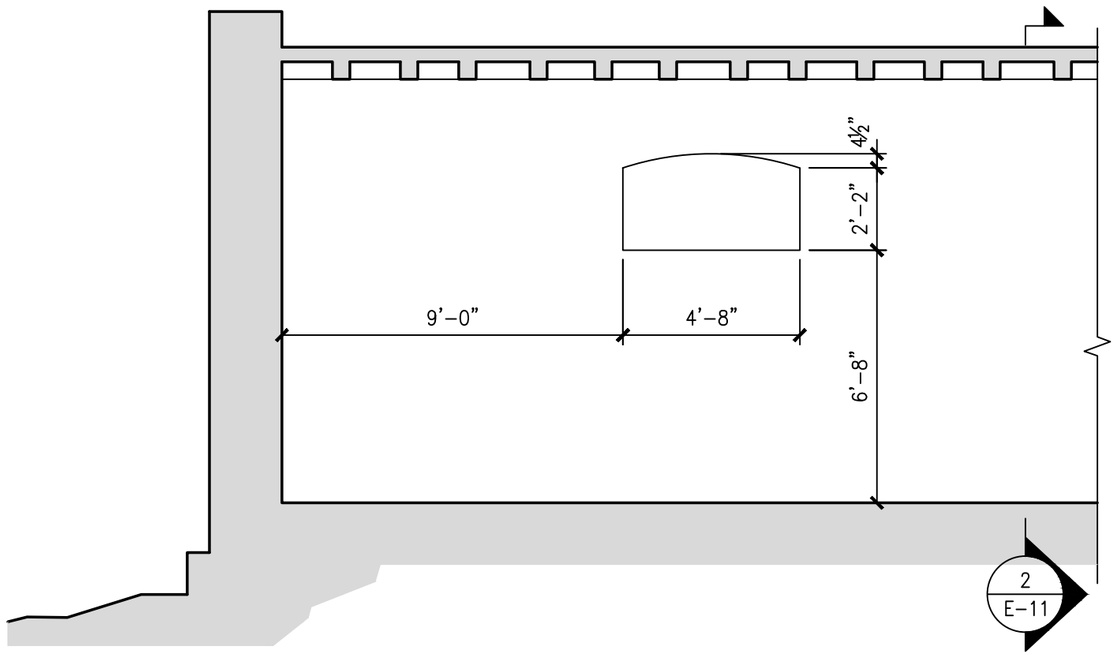
1 E-11 PARTIAL LONGITUDINAL SECTION THROUGH STABLE – LOOKING WEST

SCALE: 1/4" = 1'-0"



2 E-11 TRANSVERSE SECTION THROUGH STABLE

SCALE: 1/4" = 1'-0"



3 E-11 PARTIAL LONGITUDINAL SECTION THROUGH STABLE – LOOKING EAST

SCALE: 1/4" = 1'-0"

Date: 07-19-2023 | Submission: HISTORIC STRUCTURE REPORT | Project Number: 20-131

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E-11

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Appendix E.2: Detailed Assessment of Timber Girder at Commandant's Gallery

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DETAILED ASSESSMENT OF TIMBER GIRDER AT COMMANDANT'S GALLERY 100% REPORT

Date:	May 2, 2022	**Date(s) on site:**	February 14, 2022
Attention:	Christopher Woollard, Assoc. AIA	**Project name:**	Fort Christiansvaern – Girder Assessment
Company:	Joseph K. Oppermann – Architect, P.A. (JKOA)	**1200AE Proj. #:**	20-131.2
Weather:	Sunny, 75°F	**Location:**	St. Croix, USVI
Submitted by:	Nicole Ferran, PE John Matteo, PE	**Present on site:**	N. Ferran & J. Matteo (1200AE); Evan Gwilliam (NPS)
Cc:	Robert Hotes, Joseph Oppermann, File		

BACKGROUND

Fort Christiansvaern is a brick, rubble masonry and half-timber structure located on the shoreline of Christiansted Harbor, St. Croix, U.S. Virgin Islands and is part of the Christiansted National Historic Site. The construction was begun in 1738 and largely completed by 1749.

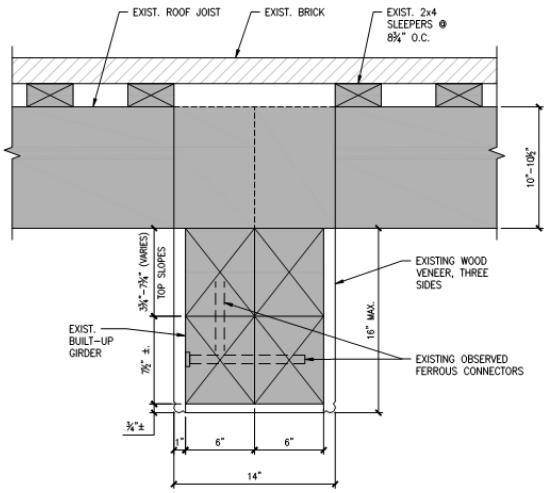
During the structural survey from 6/28/21 to 6/30/21, performed as part of the development of a Historic Structures Report, a primary timber girder at the Commandant's Gallery was found to be severely deteriorated. 1200AE issued a memo dated 7/16/21 recommending that temporary shoring be designed and installed, with public access to the area being restricted until the work is completed. Drawings for the temporary shoring were issued by 1200AE on 3/23/2022.

At the request of the National Park Service, 1200AE personnel performed a site visit on February 14, 2022 to conduct a detailed assessment of the timber girder, including hands-on documentation and probing of surface conditions, localized drilling with a small diameter bit to assess the integrity of interior wood material, and extraction of a wood sample for species identification. The intent of this review was to evaluate the extent of deterioration of the existing girder and make recommendations regarding its repair or replacement.



Figure 1: Exterior view of the Commandant's Gallery, looking South, with the area of study circled in red.

Detailed findings with accompanying photographs and sketches as well as repair and / or replacement recommendations are provided below.

FINDINGS	FIGURES
Geometry and Configuration The existing timber girder spans approximately 16.5 feet between masonry walls and supports a series of wood roof joists (Figure 2), which in turn support wood sleepers and a brick roof. The roof joists bear on the top surface of the girder, which slopes along its length to create the roof slope. A partial roof framing plan is provided on SSK-1, attached. The south face of the existing timber girder is exhibiting severe signs of deterioration, in particular at its east end (Figure 2). This deteriorated area facilitated observation of the girder by1200AE personnel, who accessed the girder by means of a tall ladder and discovered that the girder was, in fact, a built-up member comprised of four structural components and wood veneer on the three exposed sides. The two lower portions of the girder are approximately 6 inches wide by 7-1/2 inches tall. The two upper portions of the beam are the same width; however, the height varies along the span to create the roof slope. At the ends, the low points, the upper members are 3-3/4 inches tall and at the peak they are 7-3/4 inches tall. The veneer was approximately 1 inch thick on the sides and 3/4 inches thick at the bottom. A cross section is provided in Figure 3 and at a larger scale on SSK-2, attached. The plies are connected to each other by means of ferrous connectors. At the heavily deteriorated area, these could be observed approximately 2-1/2 feet from the east end of the girder (Figure 4). One vertical connector (red arrow) approximately 3/4 inches in diameter and one horizontal connector with a 1-1/4 inch square head (green arrow) were observed. Both were heavily corroded.	 **Figure 1:** Looking north at deteriorated timber girder  **Figure 3**: Existing section through girder  **Figure 4:** Existing connectors in deteriorated girder

At the bearing ends, the girder pockets into the masonry walls. At the east bearing end, a crack was observed emanating from the corner of the roof joist above. 1200AE personnel drilled a hole into the stucco wall finish to confirm that this crack coincided with the end of the girder within the wall (Figure 5). Given the level of deterioration of the girder at this end, it appeared plausible that the embedded girder end would crush with the load of the roof joist above and cause cracking in the stucco finish. It was confirmed that this crack, located 16 inches from the end of the wall, coincided with the girder end.

On the north face of the girder, remnants of a flagpole support can be seen at mid-span of the girder (Figures 6 and 7). A 5"x5" post is connected to the girder with a 3/4" diameter thru-bolt and four additional screws through a 1/2"x2" bent plate. Where the wood post extends through the roof the typical wood sleepers and brick roof were replaced with a solid concrete section. The flagpole is no longer visible above the roof (Figure 1); however, a historic photograph thought to have been taken in 1953 still shows the flagpole present (Figure 8). The wood and metal fasteners appear to be in good condition at this location.



Figure 7: Close-up view of the flagpole connection



Figure 5: East girder bearing condition. Note drill hole and crack in plaster finish coinciding with end of girder.



Figure 6: Looking south at north face of the girder and the flagpole connection



Figure 8: Exterior view of the Commandant's Gallery, looking South, thought to have been taken ca. 1953 by Frederik Gjessing. Note presence of flagpole.

Existing Conditions

As noted above and as can be seen in the photograph in Figure 2, severe deterioration of the existing girder was evident at the south face, east end of the girder. It is assumed that this deterioration is due to continued exposure to moisture, possibly from a previous leak at the roof penetration for the flagpole. The portion of the flagpole above the roof level has been removed and roof repairs have been performed, and it appears that there are no remaining roof leaks at this location (Figure 9).

To evaluate the extent of deterioration or decay in the existing girder, 1200AE personnel used a drill with a small diameter drill bit to drill into the sides and underside of the girder at regular intervals (Figure 10). Where the drill entered the wood easily, the wood was deemed to be deteriorated. Where substantial effort was required to penetrate the wood with the drill, the wood was considered sound. While just a qualitative method, this manner of drilling facilitated mapping of deteriorated areas in the girder.

The lower member of the southern ply was found to be the most severely deteriorated portion of the girder. Along the full length of the member, the lower south ply was found to have deterioration within up to 3-1/2 inches of the width, including the veneer (Figure 11) as well as at the east bearing, as noted above.

At the upper member of the southern ply, the bottom inch of the eastern third was deteriorated, as was a small portion near the west end. In addition, a shear crack was visible near the east bearing end (Figure 12). This shear crack is likely due to the severe deterioration and crushing of the lower member, which has caused the bearing end of the upper member to be overstressed.



Figure 9: Looking east at roof above girder.



Figure 10: Drilling at east bearing end to evaluate soundness of wood.



Figure 11: Resistance drilling at south face of girder. Screwdriver in drill hole indicates depth of deterioration.

The northern ply was typically found to be in much better condition than the southern ply of the girder. The regular drilling pattern showed both the upper and lower members to be sound with the exception of the west bearing, where a small portion of the lower member exhibited deterioration near the center of the beam (Figures 13 and 14). The extent of the deterioration was limited to an area approximately 3 inches wide by 1-1/2 inches tall by 10 inches long.

These conditions are documented in SSK-4 and SSK-5, attached.

Wood Species Identification

A small sample of wood from the southern plies was removed while on site and sent to a wood testing laboratory for species identification.

Testing by the Forest Service of the U.S. Department of Agriculture found that the wood is a species of Southern Yellow Pine, Pinus sp. As pine is not native to the Virgin Islands, it appears that this wood was imported. As no dendrochronology was performed at this time, we are not able to confirm whether this member was part of the original construction or was a later addition. The detailing is historic in nature and appears consistent with other components of the framing.

The results of the laboratory testing are provided in Appendix B.

Preliminary Analysis

A preliminary structural analysis of the wood girder was performed to evaluate the adequacy of its as-built geometry under current code-mandated loading. The girder was analyzed both as four individual members, neglecting their connections to each other, and as one composite member, assuming full connectivity between the four components.



Figure 12: Shear crack at east end, upper girder member



Figure 13: Looking south at north face of girder, west bearing. Red arrows indicate drilling locations.



Figure 14: Underside of west bearing end of girder with drilled holes

The analysis showed that the first approach, that of considering only an additive approach for four individual members, was not sufficient regardless of the existing or proposed wood species and grade. The required properties both for bending moment and for deflections exceeded typical values for timber. However, once the connectors were taken into account and the member was analyzed as a composite section, it was found that a range of wood types and grades would be sufficient to resist the current loading scenarios.

Recommendations

The deteriorated girder should be shored to allow safe visitor access to the areas surrounding the Commandant's Gallery. Shoring should remain in place during the girder replacement / repairs (see below). Temporary shoring drawings were issued by 1200AE on 3/22/2022 and are provided in Appendix C for reference.

Given the poor condition of the southern ply of the girder, we recommend that the entire southern ply be replaced to match the existing in geometry. Based on the findings of the preliminary analysis, rot-resistant wood with the following minimum properties should be used. Note that this assumes composite action between the girder components and a maximum deflection of 1/360 of the girder span.

E_{min} = 900,000 psi
fb = 900 psi
fc (perp.) = 100 psi
fv = 100 psi

White Oak No. 1 or pressure treated Southern Pine No. 1 both meet these requirements, among others. The final selection of replacement wood and the final design should include an evaluation of relative stiffness between new and old to assure compatible structural interaction.

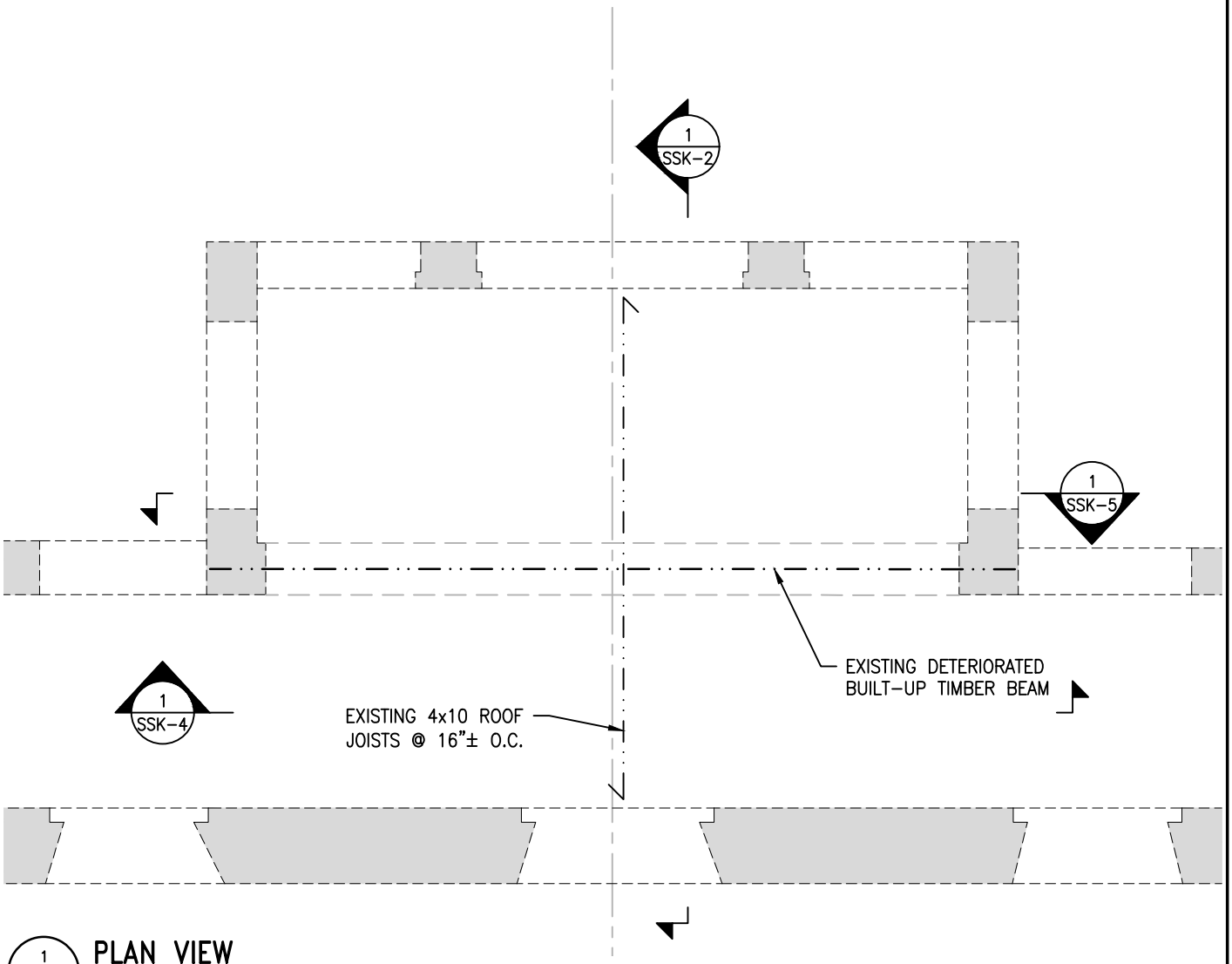
In order to remove the deteriorated ply, existing screws / connectors between the northern and southern plies will need to be removed or cut. New connections will be required after replacement of the deteriorated ply. Type and frequency of connectors will be determined as part of the final repair design.

For the northern ply, only a small area at the west bearing was found to be deteriorated. For this area, localized epoxy repairs would be an appropriate repair. It may be prudent to provide additional connectors between the upper and lower northern plies to ensure full composite behavior. We recommend repairing this side of the girder, as opposed to replacing it in full, because it is in-keeping with an approach to maximize the retention of historic structural fabric, including the detailing of the flagpole connection which serves as an interpretable artifact of this former feature. There is also a likely cost savings with this approach.

The existing wood veneer was found to be deteriorated at the south face and underside of the beam. We recommend replacement in kind once the structural repairs are complete, matching the existing thicknesses and profiles.

If you should have any questions or concerns related to the content of this report, please feel free to contact us at (703) 350-4151.

APPENDIX A: STRUCTURAL SKETCHES

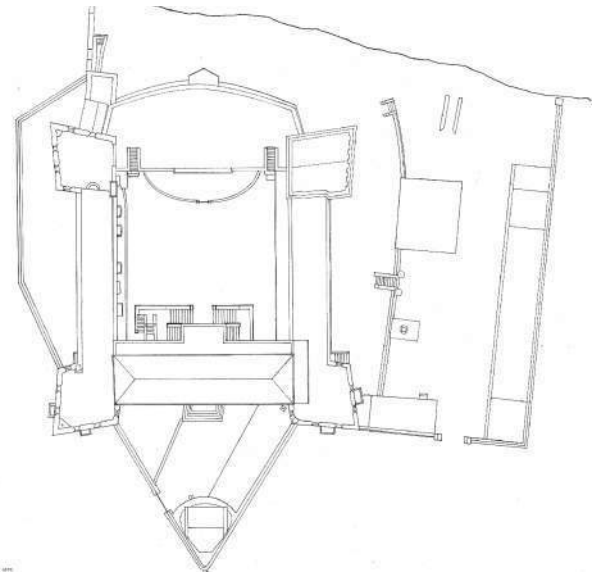


1 SSK-1 **PLAN VIEW**

SCALE: 1/4" = 1'-0"

MASONRY ABOVE

MASONRY BELOW



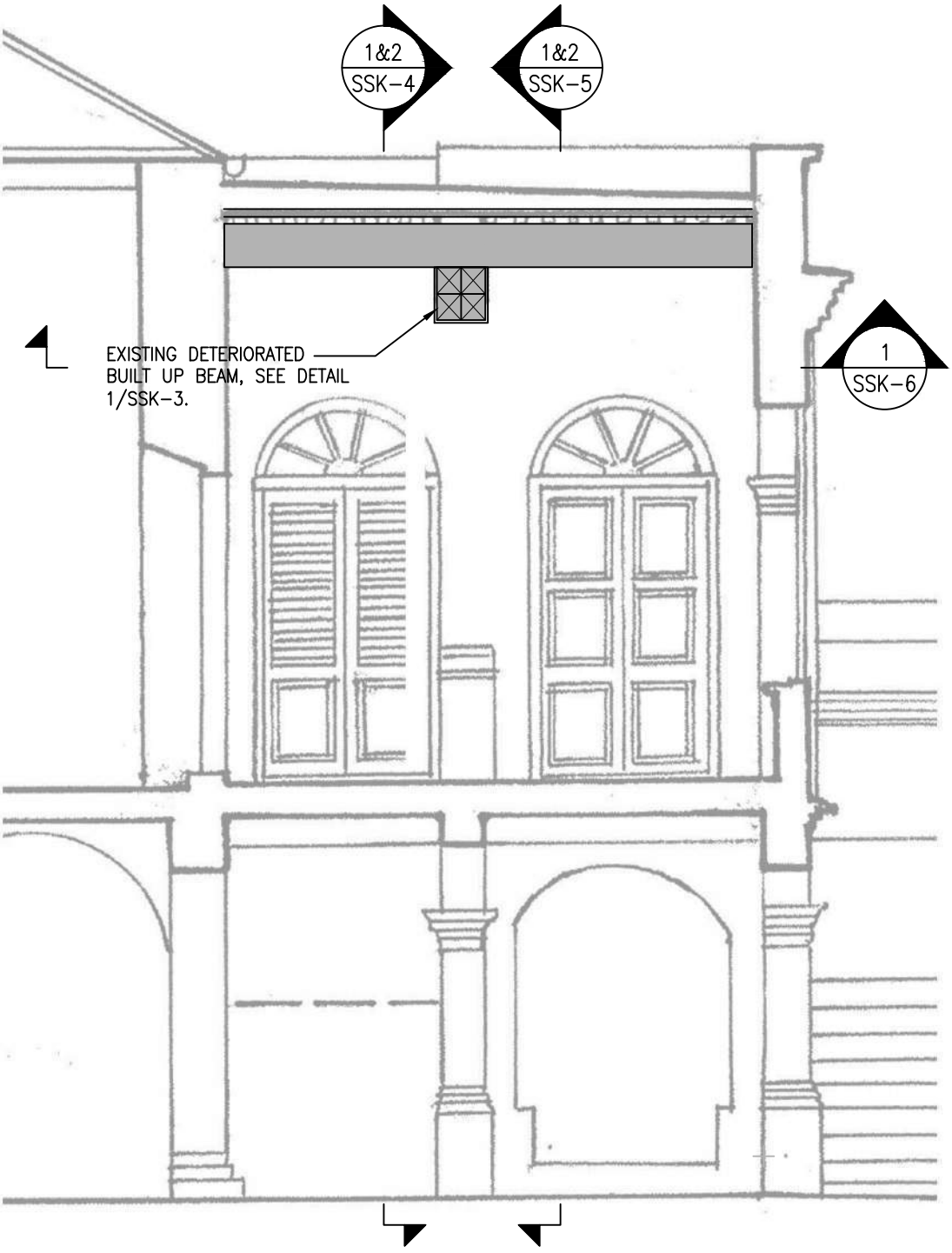
NORTH

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SSK-1



1 / SSK-2 SECTION THROUGH COMMANDANT'S GALLERY (LOOKING WEST)

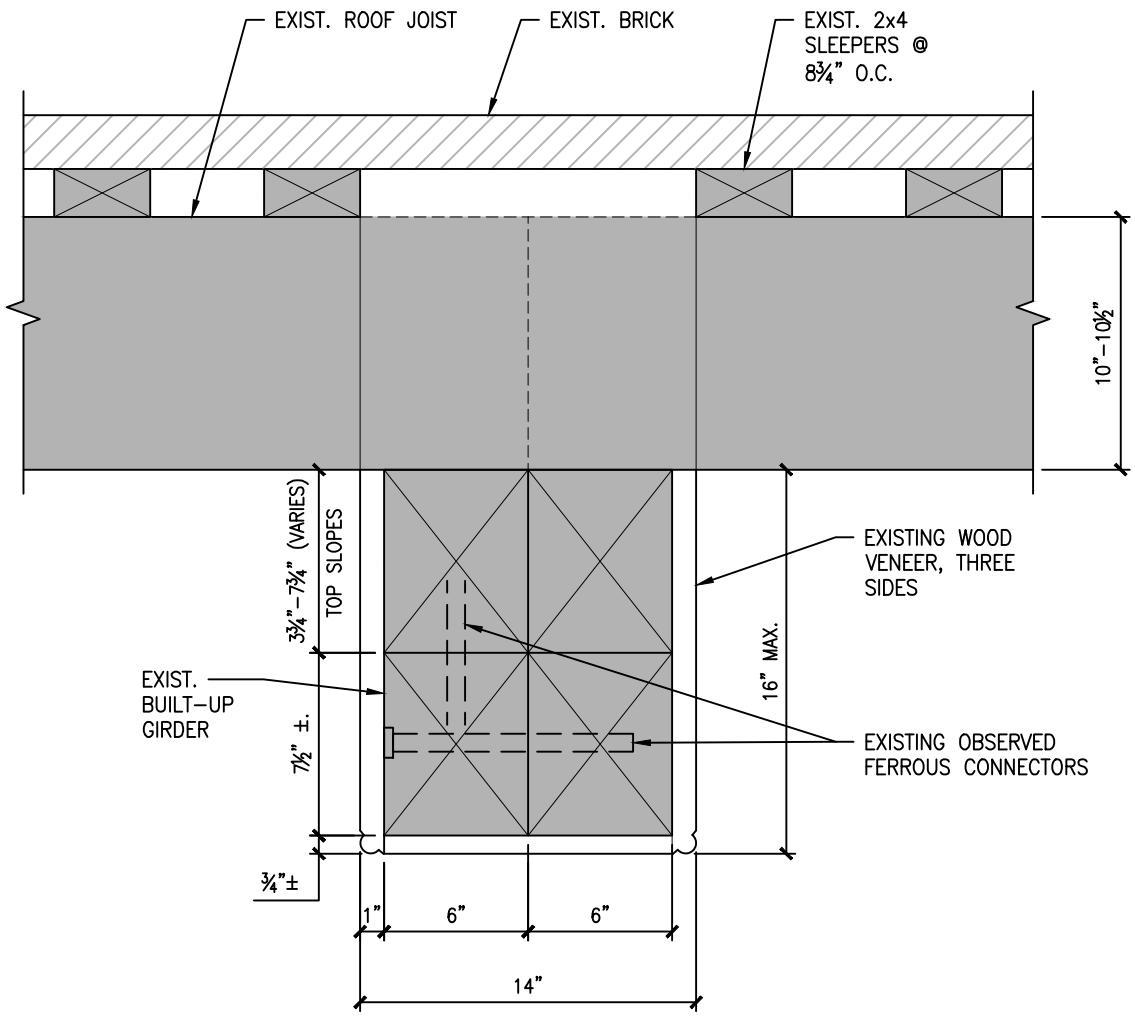
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Project Title: FORT CHRISTIANSVAERN
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SSK-2



1 / SSK–3 SECTION THROUGH GIRDER

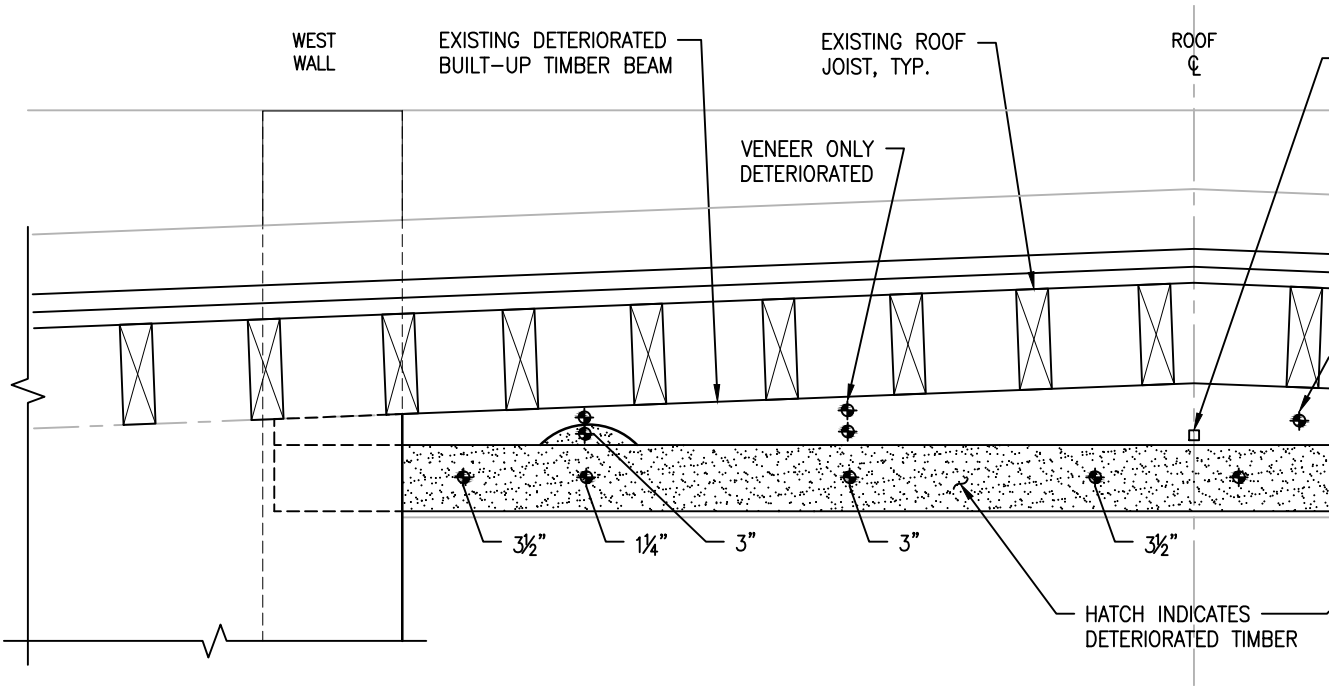
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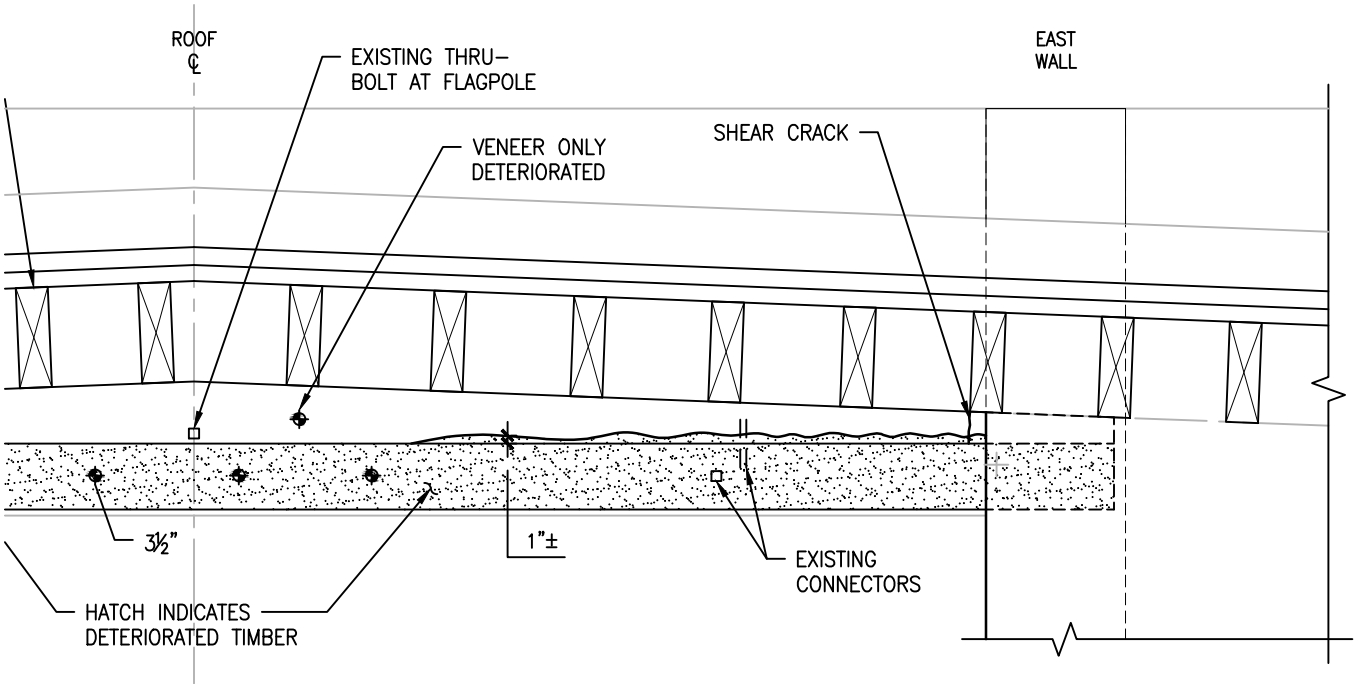
SSK-3



1 / SSK-4 **SOUTH GIRDER PLY ELEVATION, WEST END (LOOKING NORTH)**

SCALE: 1/2" = 1'-0"

DENOTES LOCATION OF DRILL HOLE. NUMBER INDICATES DEPTH OF PENETRATION (INCLUDING VENEER THICKNESS).



2 / SSK-4 **SOUTH GIRDER PLY ELEVATION, EAST END (LOOKING NORTH)**

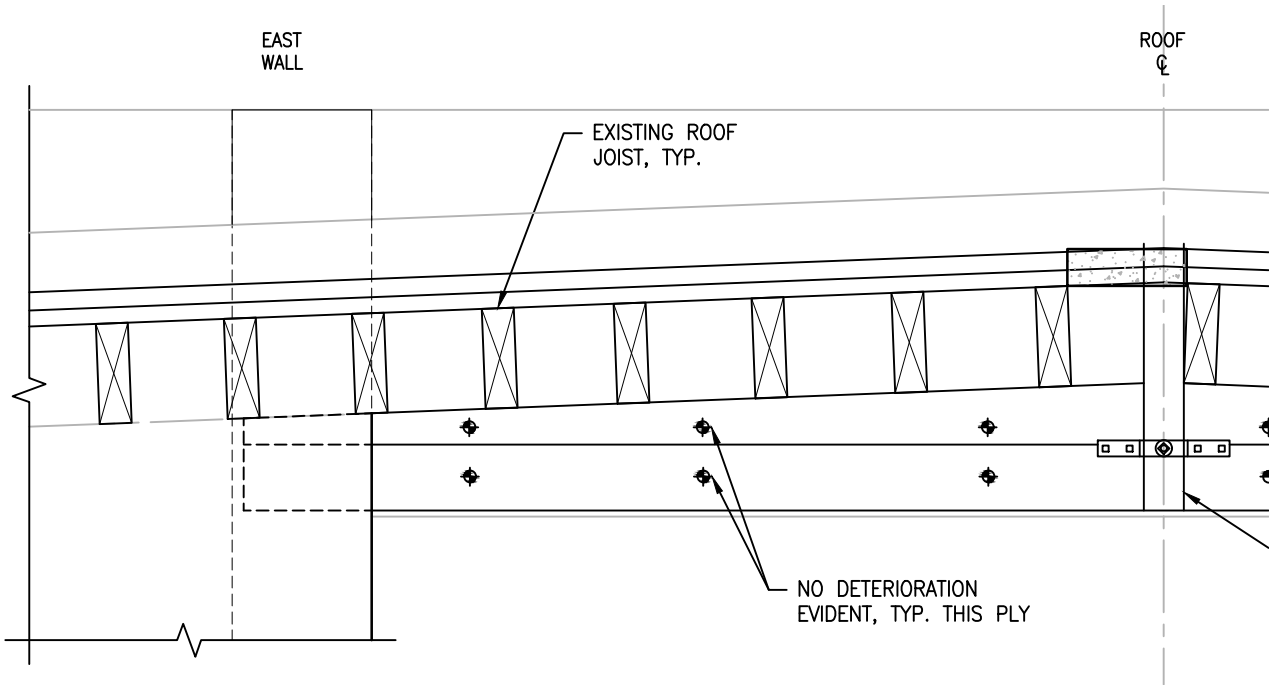
SCALE: 1/2" = 1'-0"

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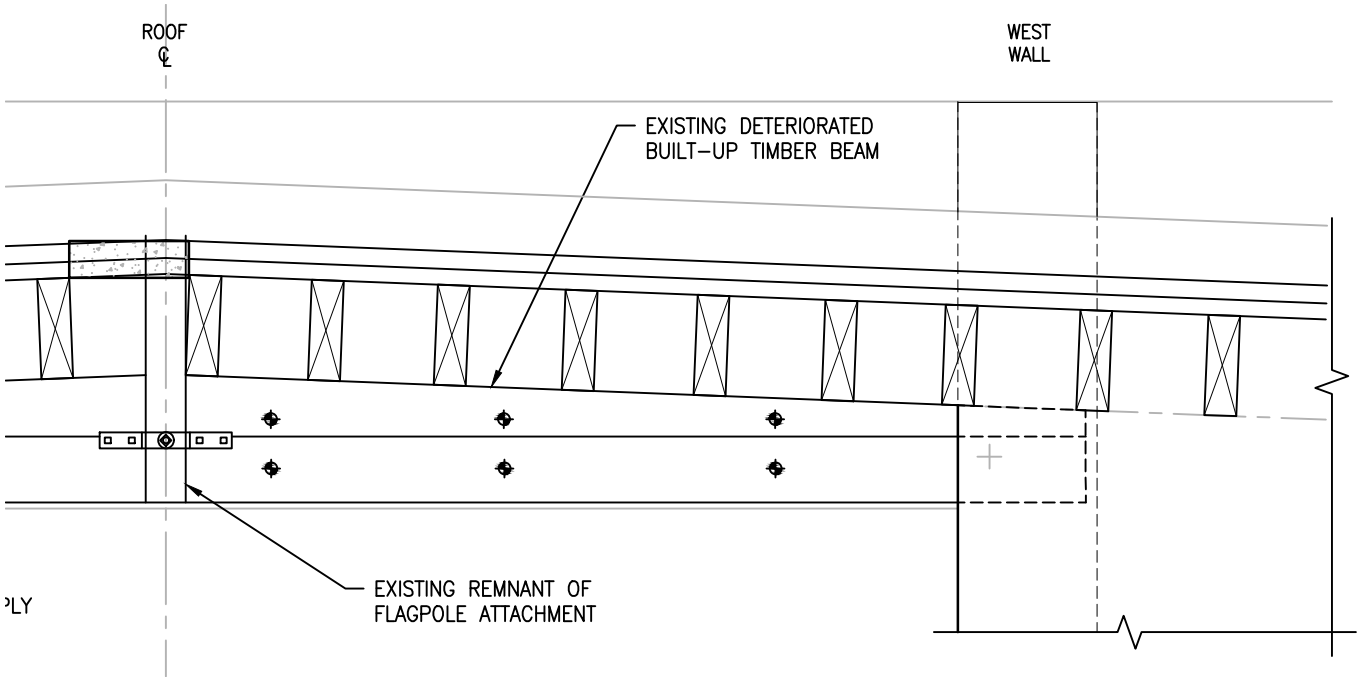
SSK-4



1 / SSK-5 NORTH GIRDER PLY ELEVATION, EAST END (LOOKING SOUTH)

SCALE: 1/2" = 1'-0"

DENOTES LOCATION OF DRILL HOLE. NUMBER INDICATES DEPTH OF PENETRATION (INCLUDING VENEER THICKNESS).



2 / SSK-5 NORTH GIRDER PLY ELEVATION, WEST END (LOOKING SOUTH)

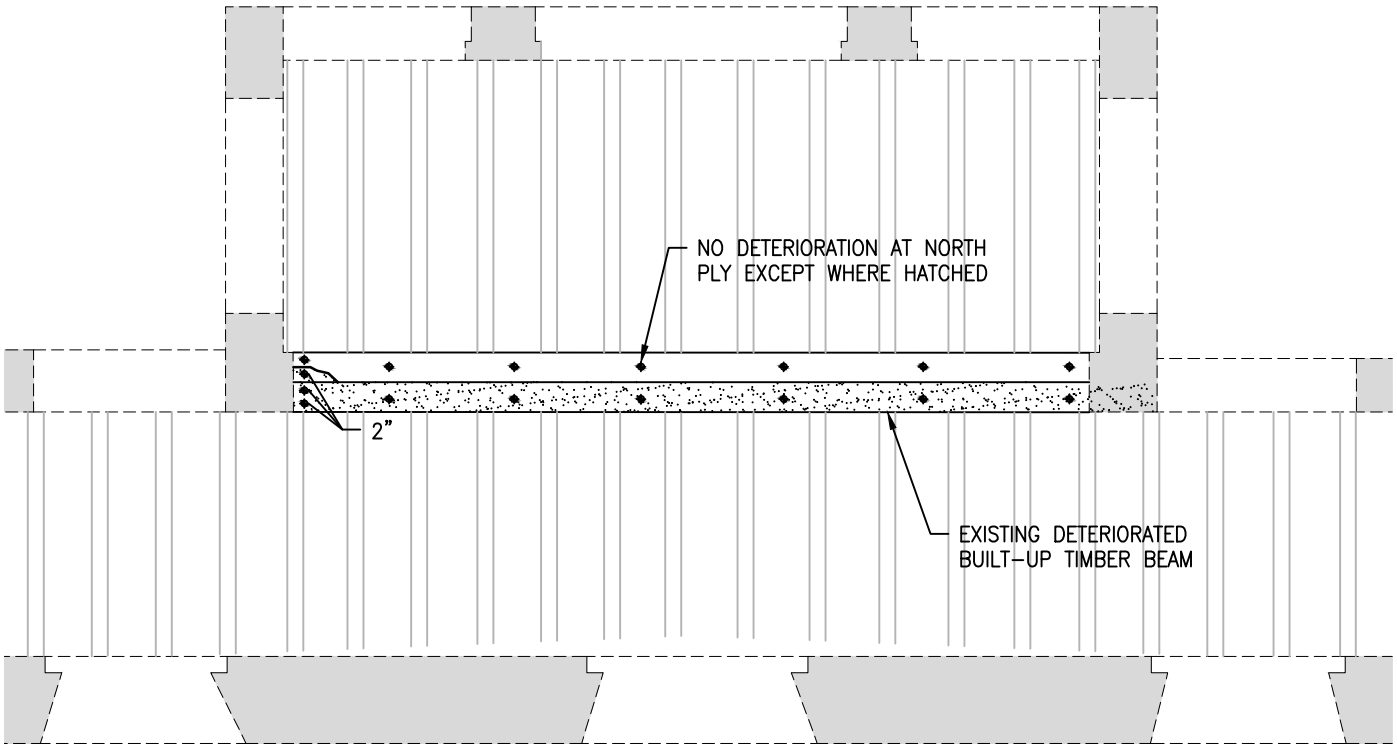
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SSK-5



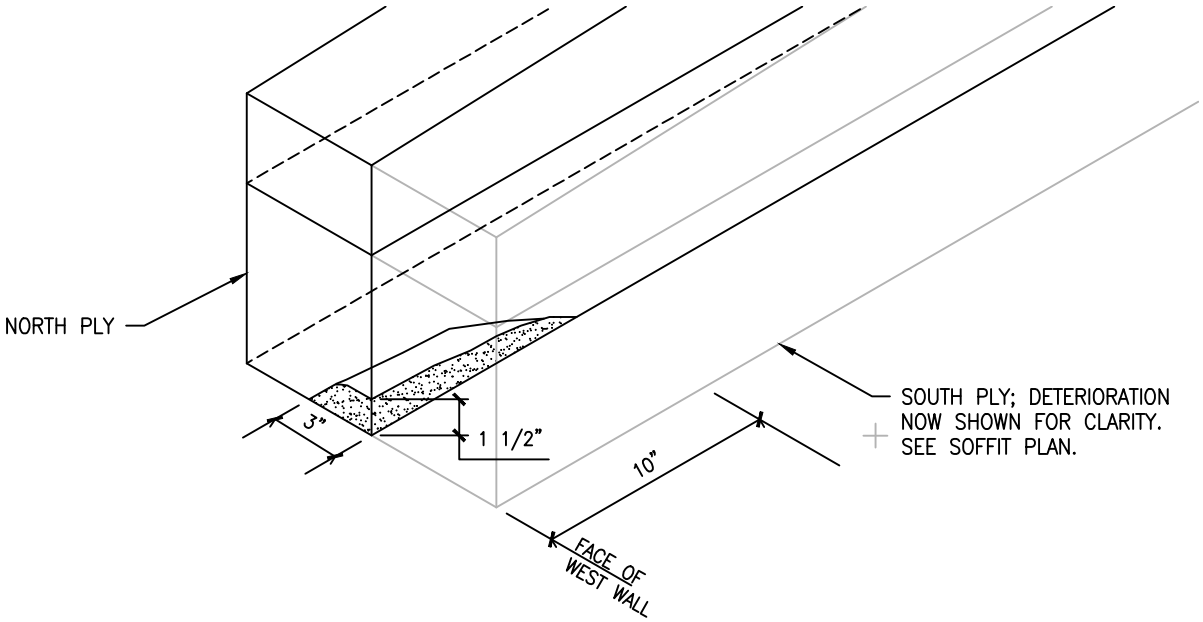
1 / SSK-6

GIRDER SOFFIT PLAN

SCALE: 1/4" = 1'-0"

NORTH

DENOTES LOCATION OF DRILL HOLE. NUMBER INDICATES DEPTH OF PENETRATION (INCLUDING VENEER THICKNESS).



2 / SSK-6

AXONOMETRIC VIEW OF DETERIORATION AT WEST BEARING END OF NORTH PLY

SCALE: N.T.S.

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Date: 04/15/22 | Submission: REPORT | Project Number: 20-131.2

Project Title: FORT CHRISTIANSVAERN GIRDER ASSESSMENT ST. CROIX, VI

SSK-4

APPENDIX B: WOOD TESTING REPORT

ATTN: MICHAEL WIEMANN

recd April 25

Center for Wood Anatomy Research Wood Identification Service Submission Form

Name NICOLE FERRAN

Address 210 N. LEE ST. SUITE 210, ALEXANDRIA, VA 22314

City, State Zip _____

Email address nferran@1200ae.com

Phone Number 240-731-0204

Date Submitted 4/22/2022

Specimen #1: FORT CHRISTIANSVAERN, COMMANDANT'S GALLERY ROOF GIRDER

Does it have prior identification: No X Yes_____

Origin known with certainty: Yes X **Claim:** ST. CROIX, VI

Origin uncertain: Yes_____ **Claim:** _____

Origin unknown: _____

Specimen #2: _____

Does it have prior identification: No_____ Yes_____

Origin known with certainty: Yes_____ **Claim:** _____

Origin uncertain: Yes_____ **Claim:** _____

Origin unknown: _____

Specimen #3: _____

Does it have prior identification: No_____ Yes_____

Origin known with certainty: Yes_____ **Claim:** _____

Origin uncertain: Yes_____ **Claim:** _____

Origin unknown: _____

By submitting this request, I accept the terms of the wood identification public service as described at:

https://www.fpl.fs.fed.us/research/centers/woodanatomy/wood_idfactsheet.php

PLEASE SEND REPORT TO:

megan_jenkins@nps.gov

evan_gwilliam@nps.gov

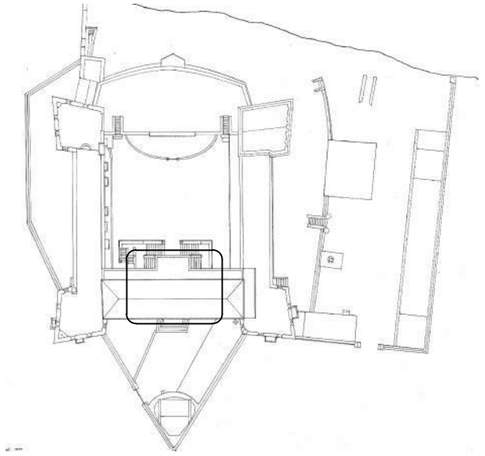
THANK YOU!

strong odor of pitch
abrupt transition
pinoid pits
dentate r. f.
fusiform

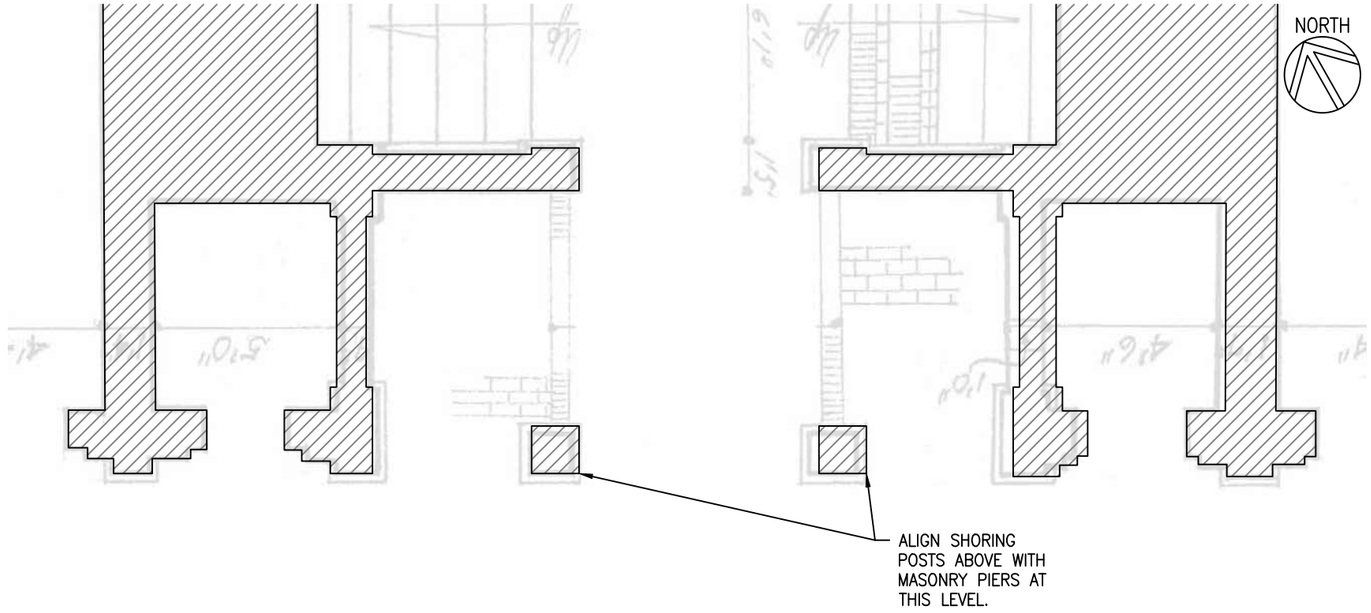
Pinus sp 25 April 2022

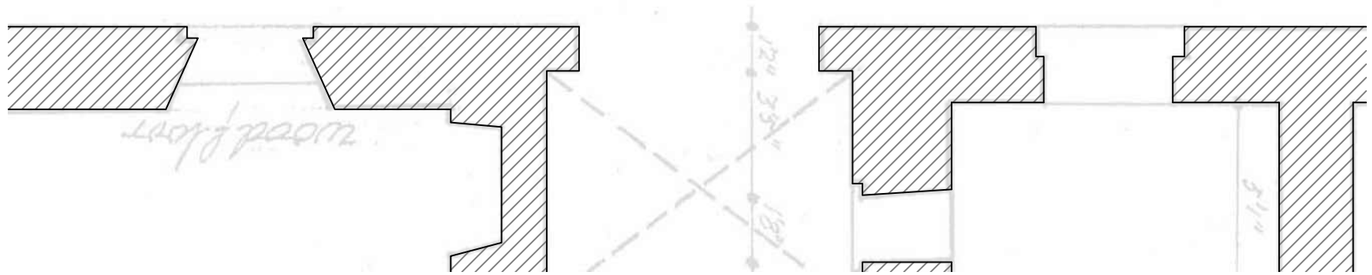
Southern yellow pine

APPENDIX C: TEMPORARY SHORING DRAWINGS



KEY PLAN





1 / SSK-1 PARTIAL FIRST FLOOR PLAN
SCALE: 1/4" = 1'-0"

FRAMING LUMBER

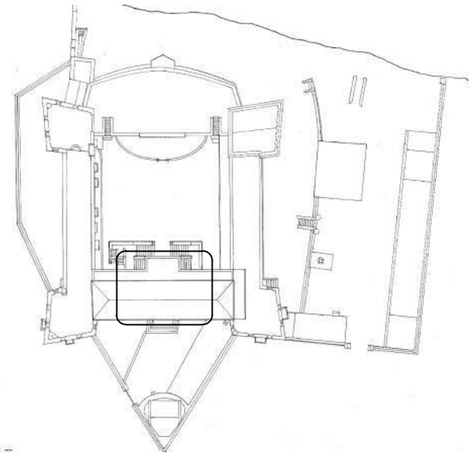
1. PRESERVATIVE-TREATED WOOD: PROVIDE TREATED SOUTHERN PINE #2 LUMBER COMPLYING WITH ACQ-D (CARBONATE), COPPER AZOLE (CA-B), OR SODIUM BORATE (SBX (DOT) WITH $NaSIO_2$) AT ALL LUMBER IN CONTACT WITH CONCRETE OR MASONRY, OR AS OTHERWISE INDICATED ON ARCHITECTURAL OR STRUCTURAL DRAWINGS. ACZA TREATMENT IS NOT PERMITTED. TREATED LUMBER AND/OR PLYWOOD SHALL BEAR THE LABEL OF AN ACCREDITED AGENCY SHOWING 0.40 PCF RETENTION. WHERE LUMBER AND/OR PLYWOOD IS CUT OR DRILLED AFTER TREATMENT, THE TREATED SURFACE SHALL BE FIELD-TREATED WITH COPPER NAPTHENATE (THE CONCENTRATION OF WHICH SHALL CONTAIN A MINIMUM OF 2% COPPER METAL) BY REPEATED BRUSHING, DIPPING, OR SOAKING UNTIL THE WOOD ABSORBS NO MORE PRESERVATIVE.
2. ALL WOOD FRAMING INCLUDING DETAILS FOR BRIDGING, BLOCKING, FIRE STOPPING, ETC., SHALL CONFORM TO THE LOCALLY APPROVED EDITION OF THE "NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION" AND ITS SUPPLEMENTS AND SHALL BE INSTALLED IN ACCORDANCE WITH THE INTERNATIONAL BUILDING CODE.
3. FASTENING SHALL BE IN ACCORDANCE WITH THE MOST RESTRICTIVE OF: THE INTERNATIONAL BUILDING CODE, OR THE MANUFACTURER'S RECOMMENDED FASTENING SCHEDULES.
4. BUILT-UP POSTS SHALL BE SPIKED TOGETHER WITH (2) 16D NAILS @ 16" O.C.
5. NO NEW OR EXISTING JOISTS SHALL BE CUT OR NOTCHED WITHOUT APPROVAL.
6. ALL LIGHT-GAGE HANGERS SUPPORTING PRESERVATIVE TREATED WOOD SHALL MEET OR EXCEED G185 (1.85 oz OF ZINC PER SQUARE FOOT). ALTERNATIVELY, STAINLESS STEEL CONNECTORS MAY BE USED. FASTENERS SHALL MATCH THE SELECTED HANGER FINISH AND MATERIAL.
7. ALL SILL PLATES / CRIBBING SHALL BE PRESSURE TREATED, SEE NOTE #1 FOR REQUIREMENTS.

MCC 1200
ARCHITECTURAL ENGINEERS PLLC
210 N. Lee St., Suite 210
Alexandria, VA 22314
T: 703.350.4151
1200ae.com

Date: 5-3-2022 | Submission: TEMPORARY SHORING | Project Number: 20-131.1

Project Title: FORT CHRISTIANSVAERN
HOSPITAL STREET
CHRISTIANSTED, ST. CROIX 00820
U.S. VIRGIN ISLANDS

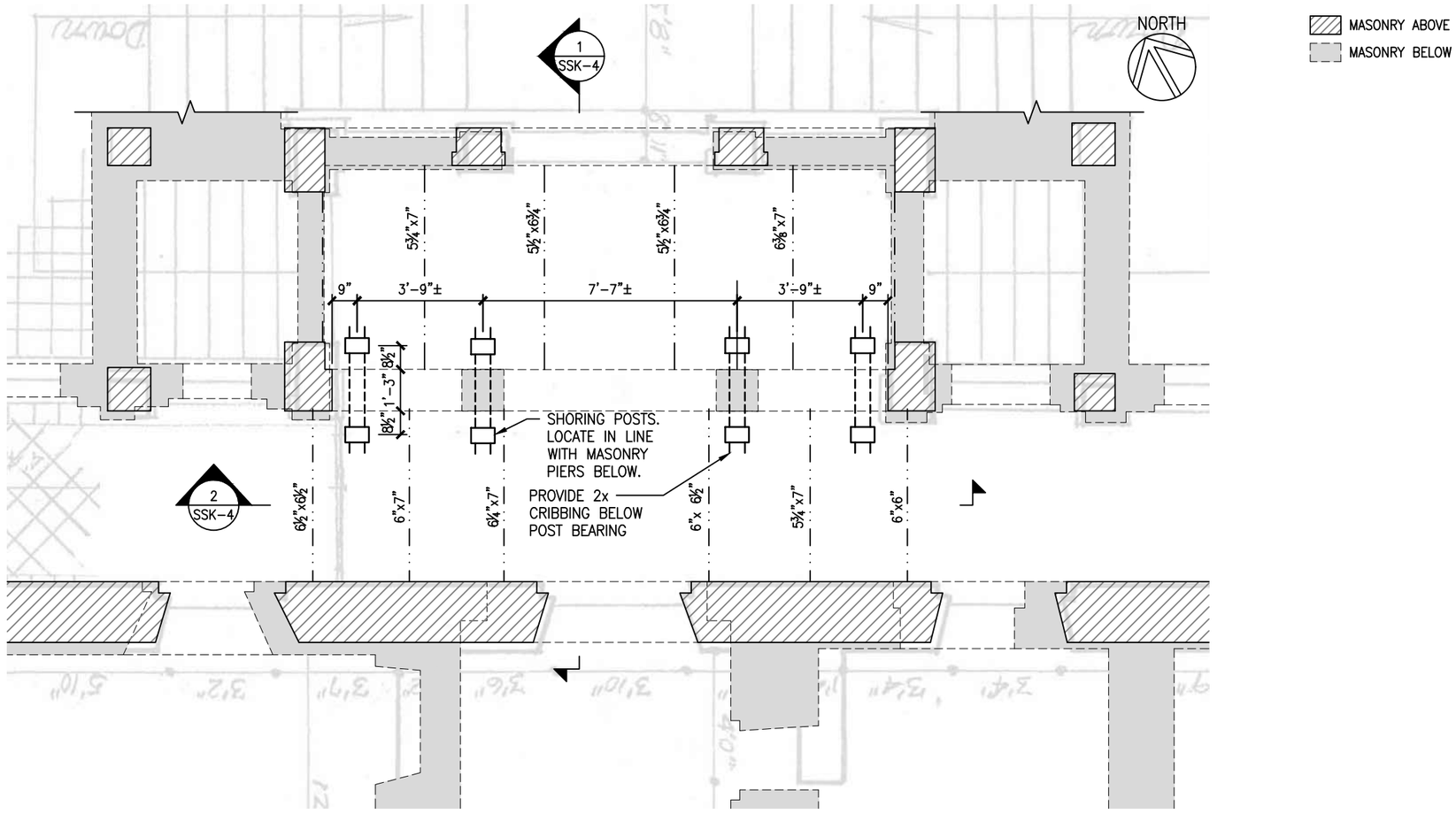
SSK-1



KEY PLAN

NOTE:

DIMENSIONS ARE BASED ON LIMITED FIELD MEASUREMENT AND EXISTING DRAWINGS MADE AVAILABLE BY THE NATIONAL PARK SERVICE. CONTRACTOR TO VERIFY ALL DIMENSIONS IN THE FIELD PRIOR TO PURCHASING MATERIALS AND CONSTRUCTION OF TEMPORARY SHORING.



1 SSK-2 PARTIAL SECOND FLOOR FRAMING PLAN

SCALE: 1/4" = 1'-0"

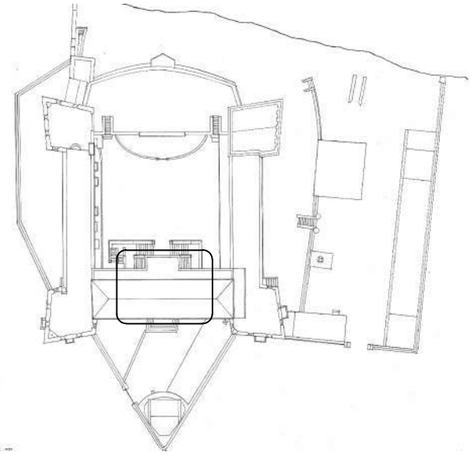
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Project Title: FORT CHRISTIANSVAERN
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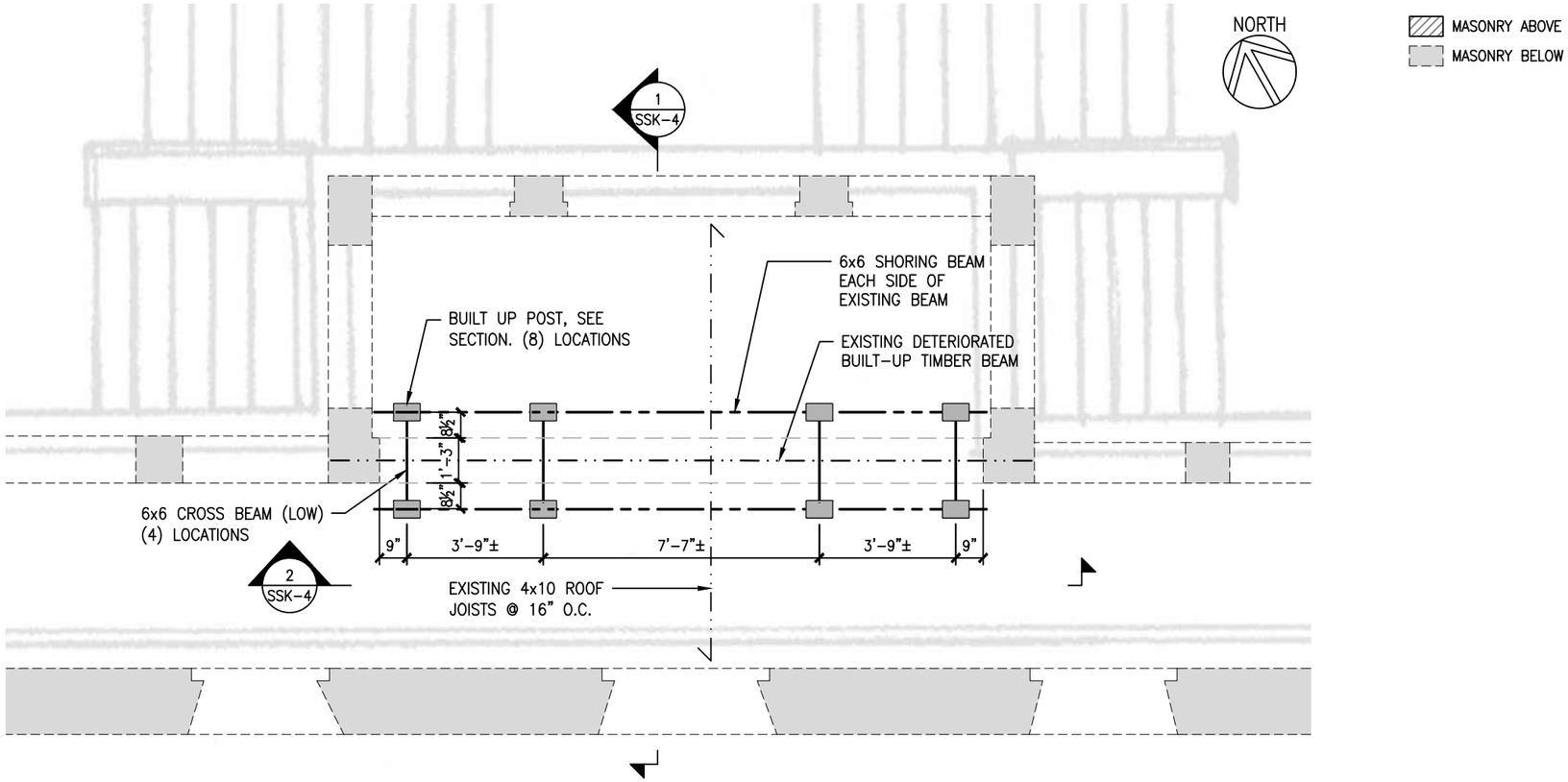
SSK-2



KEY PLAN

NOTE:

DIMENSIONS ARE BASED ON LIMITED FIELD MEASUREMENT AND EXISTING DRAWINGS MADE AVAILABLE BY THE NATIONAL PARK SERVICE. CONTRACTOR TO VERIFY ALL DIMENSIONS IN THE FIELD PRIOR TO PURCHASING MATERIALS AND CONSTRUCTION OF TEMPORARY SHORING.



1 SSK-3 PARTIAL ROOF FRAMING PLAN

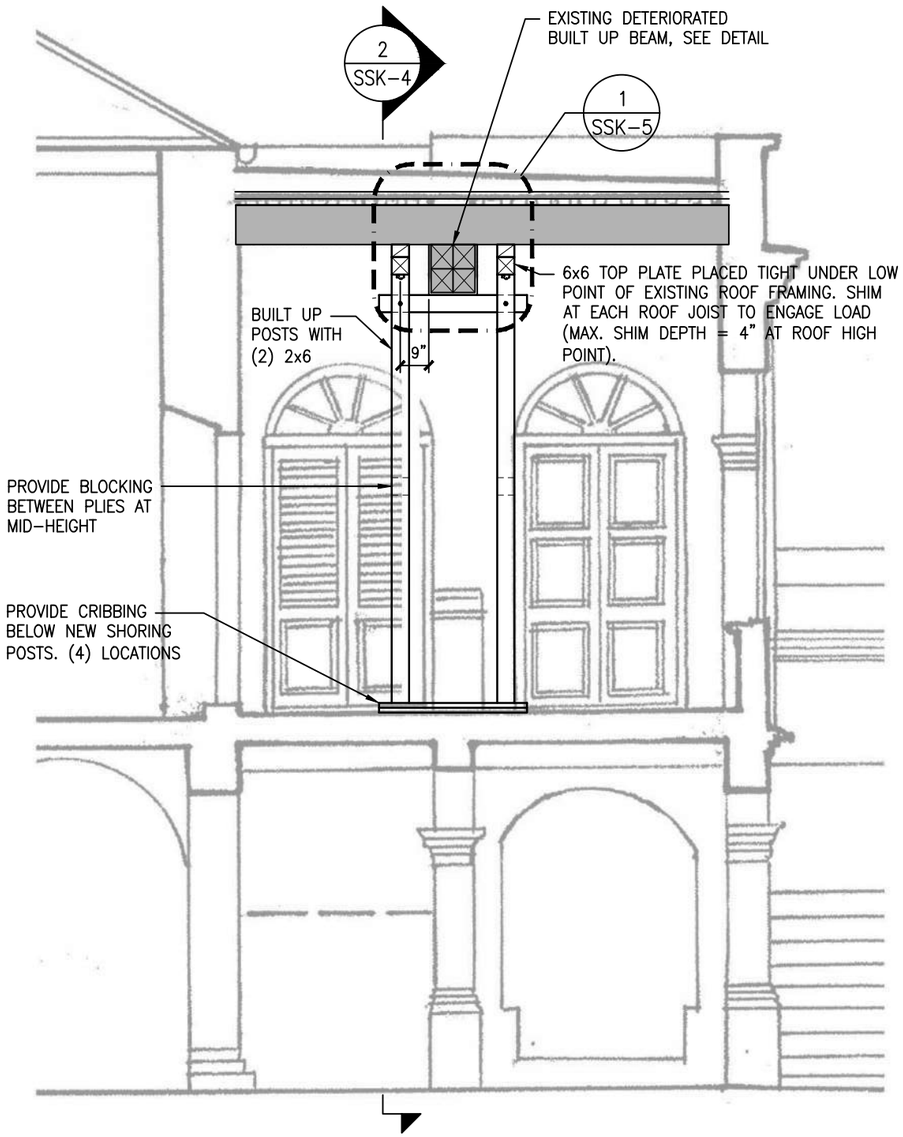
SCALE: 1/4" = 1'-0"

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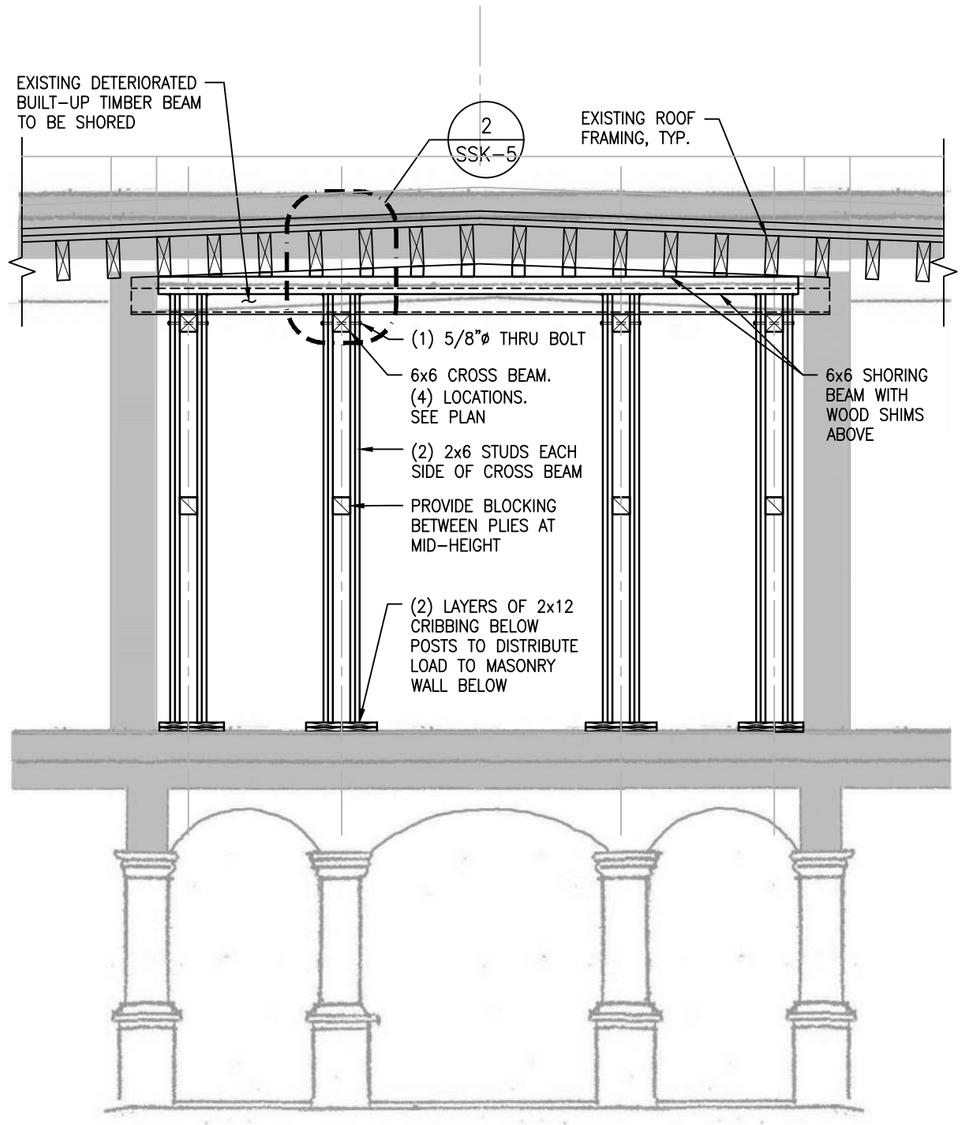
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SSK-3



1 SSK-4 SHORING SECTION (LOOKING WEST)
SCALE: 1/4" = 1'-0"



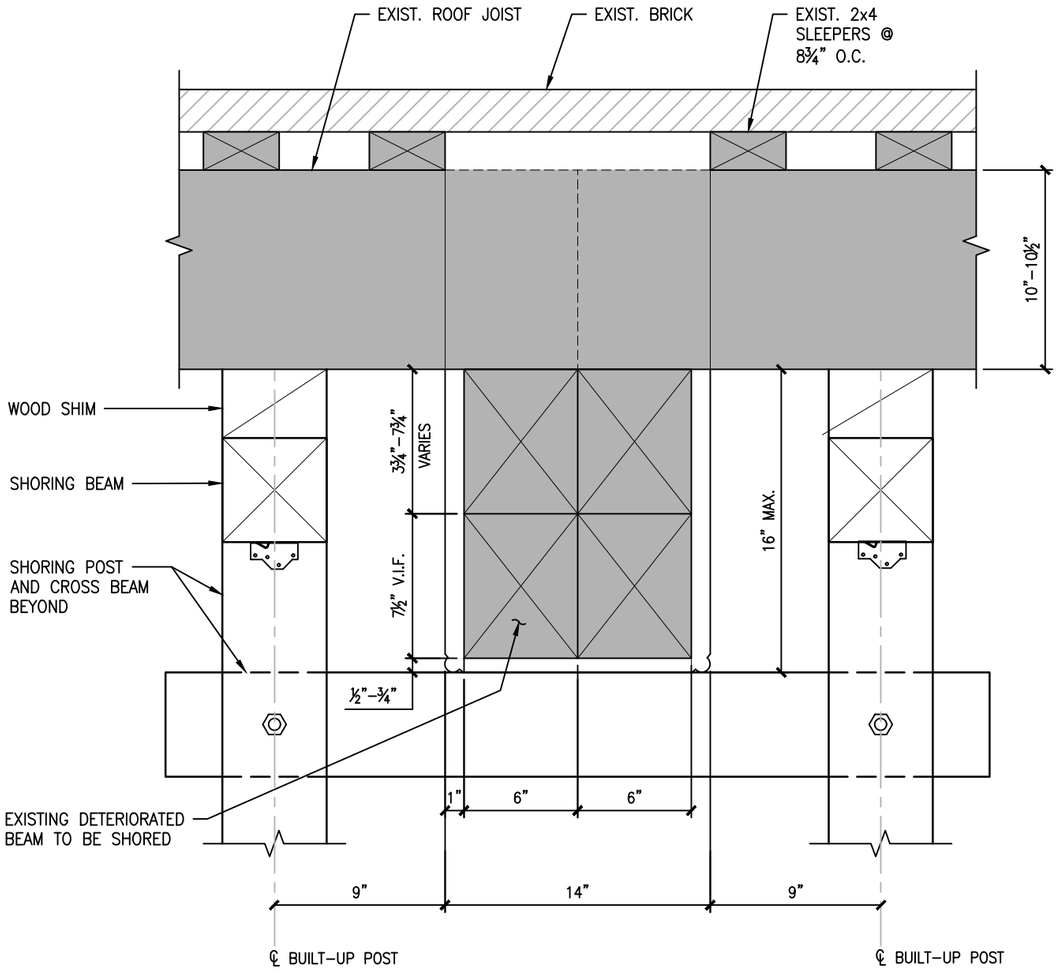
2 SSK-4 SHORING SECTION (LOOKING NORTH)
SCALE: 1/4" = 1'-0"

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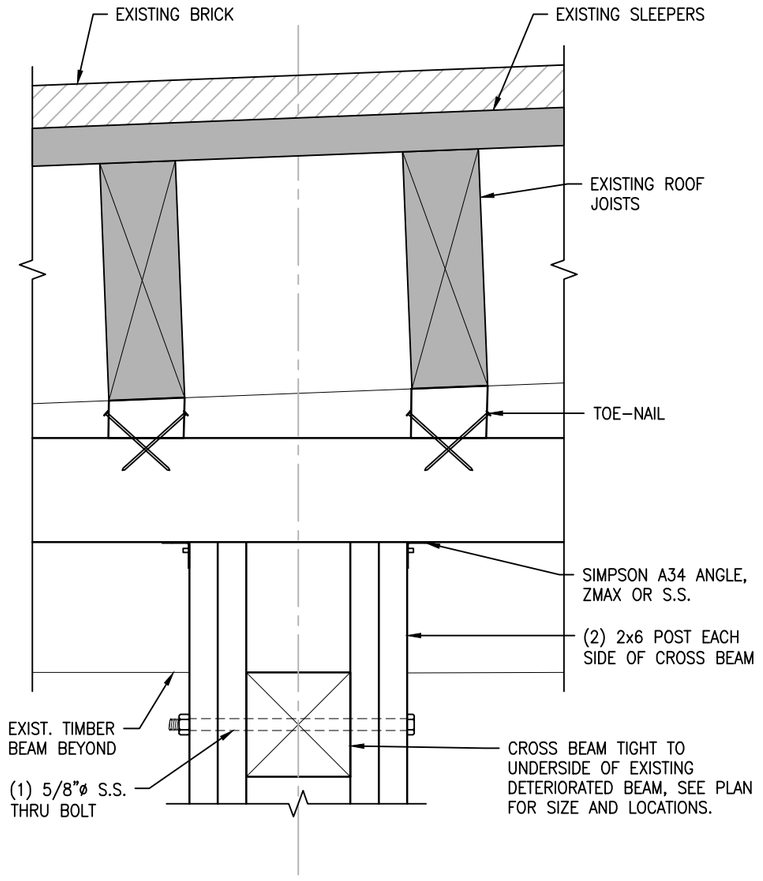
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SSK-4



1 SSK–5 **SECTION THRU GIRDER AT MID–SPAN**

SCALE: 1 1/2" = 1'–0"



2 SSK–5 **SHORING DETAIL**

SCALE: 1 1/2" = 1'–0"

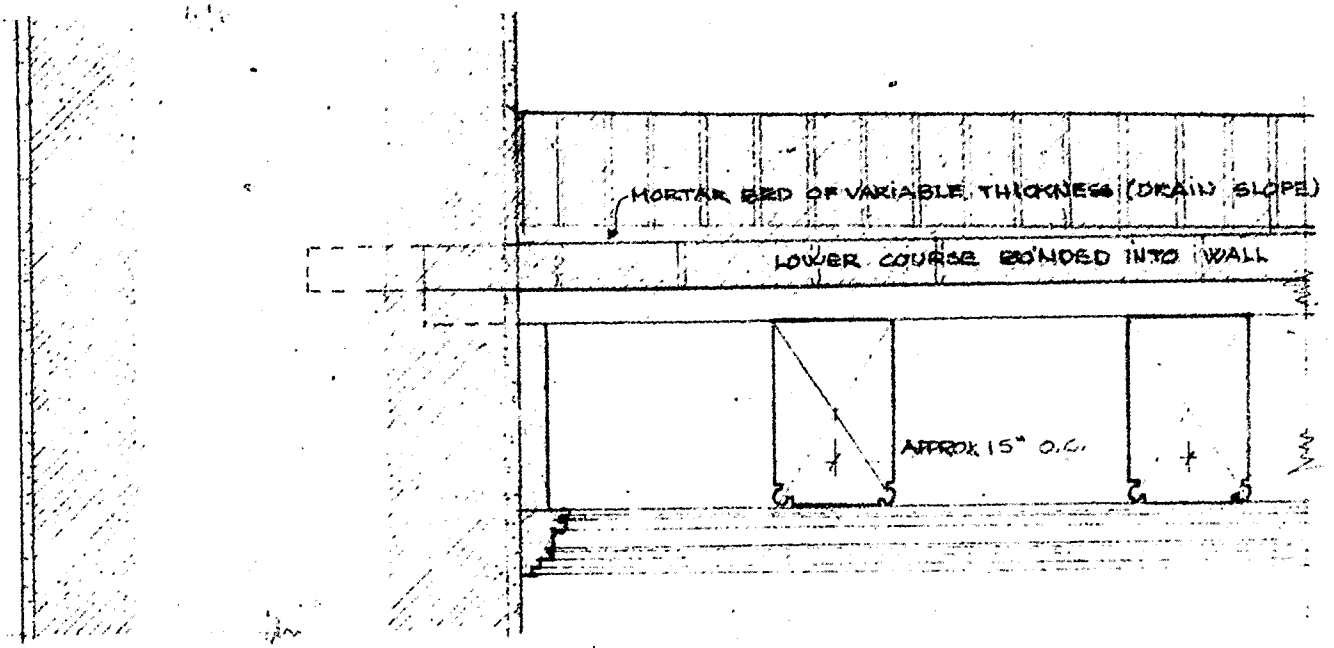
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SSK-5

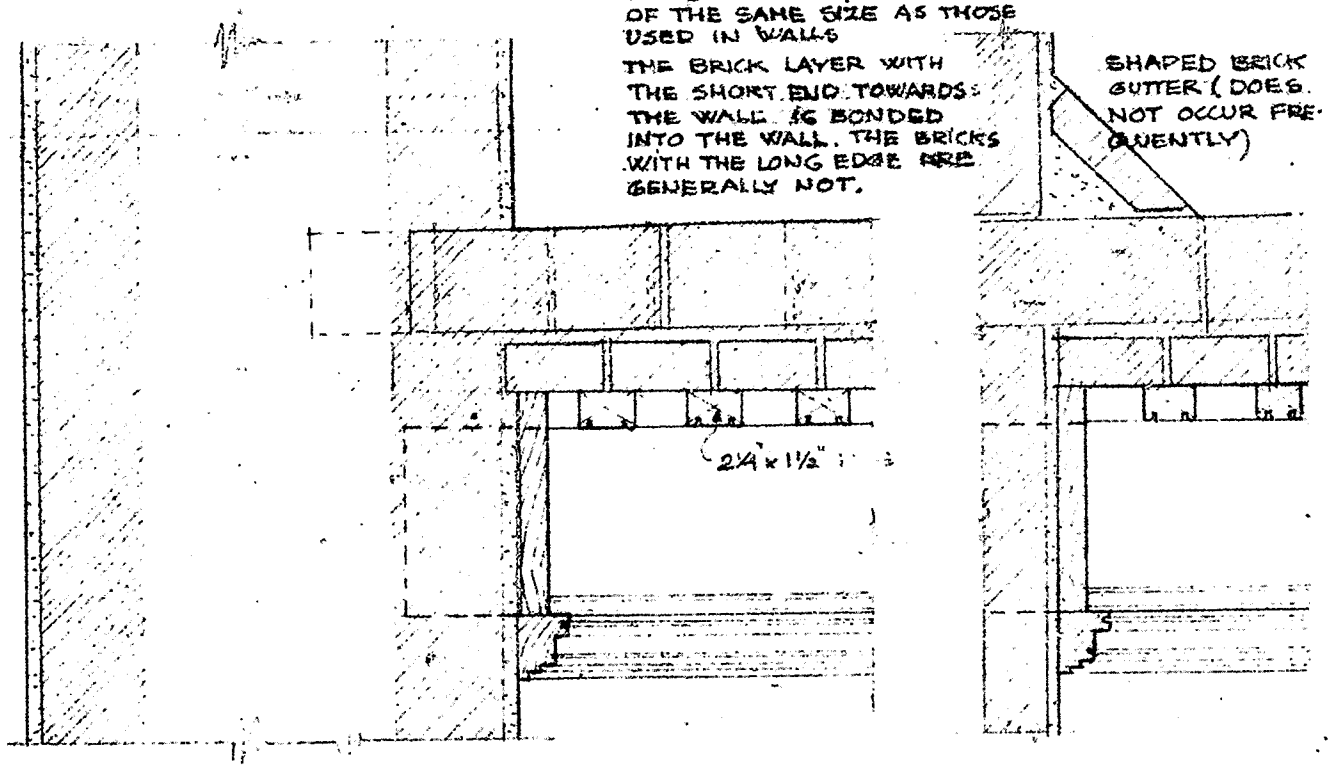
Appendix E.3: Existing Drawings



NOTE:

THE BRICKS USED IN ROOF OF THE SAME SIZE AS THOSE USED IN WALLS

THE BRICK LAYER WITH THE SHORT END TOWARDS THE WALL IS BONDED INTO THE WALL. THE BRICKS WITH THE LONG EDGE ARE GENERALLY NOT.



Typical Sections Barn Flat brick roofs.

Christiansvaern, Christiansted, St. Croix - Virgin Islands National Historic Site.
Scale 1½" = 1'-0"
April 1953

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE.

NHS-VI-2052

Appendix F:
Materials Analyses Report by BCA

Fort Christiansvaern

Materials Analyses

Christiansted, U.S. Virgin Islands



FINAL (Revised July 20, 2023)

BUILDING CONSERVATION ASSOCIATES INC

Fort Christiansvaern

Materials Analyses

Christiansted, U.S. Virgin Islands

FINAL (Revised July 20, 2023)

Prepared For

Joseph K. Oppermann Architects
Winston-Salem, North Carolina

Prepared By

Building Conservation Associates, Inc.
242 Cherry Street
Philadelphia, Pennsylvania 19106

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2.0 BACKGROUND INFORMATION 4
3.0 METHODOLOGY 7
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    5.1 Masonry (Mortar, Plaster, Stucco) 16
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APPENDICES

Appendix A: Previous Materials Analyses Reports

Appendix B: Existing Floor Plans with Room Names/Numbers Used by BCA

Appendix C: List of Sample Locations

Appendix D: Photomicrographs and Stratigraphy Charts of Finish Samples

Appendix E: Mortar Analysis Report (Highbridge Materials Consulting)

1.0 INTRODUCTION

At the request of Joseph K. Opperman Architects (JKOA), Building Conservation Associates, Inc. (BCA) has prepared an analysis of historic building materials of Fort Christiansvaern, located at the Christiansted National Historic Site in Christiansted, St. Croix in the U.S. Virgin Islands. (*Figures 1-3*) This study provides information about the fort's historic mortar, plaster, and stucco, as well as paint finishes of select architectural elements. It will revisit the findings of prior materials analyses and make recommendations for repair mixes for the materials examined based on the results of the laboratory analysis. The goal of the materials analyses is two-fold: one, to ensure that physically and visually compatible repair mixes are being used for contemporary repair campaigns; and two, to confirm the accuracy of prior materials analyses studies, especially in relation to the fort's appearance over time.

Following introductory information and a discussion of the materials analysis methodology, the report is organized into two primary sections. *Section 4.0* summarizes the in-situ observations of both masonry and paint materials and *Section 5.0* summarizes the results of the laboratory analysis. All photographs included in the report were taken by BCA unless otherwise noted.

All mounted paint cross-sections will be permanently housed at BCA's Philadelphia office. All work required for this study was performed by Dorothy Krotzer, Director. BCA performed a site visit and removed paint and masonry material samples in June 2021 and analyzed the samples from August 2021 through October 2022. For the execution of this study, BCA collaborated with Highbridge Materials Consulting for the laboratory analysis of the historic mortar, stucco, and plaster.

It should be noted that the current materials analysis is fairly limited in terms of scope due to budgetary constraints. While it documents in great detail certain mortar, plaster, and stucco materials and contributes to a better general understanding of the fort's physical evolution over time, it is by no means meant to be an exhaustive study of the fort's masonry materials and paint finishes. This fort contains numerous unique mortar materials, and this study was only able to analyze a few that are believed to be representative of the most common mortars observed at the fort. Additional study and testing will be required to more fully understand and document the fort's construction materials. This report, in combination with earlier materials analyses studies, represents a foundation on which this subsequent analysis can build. To guide future studies, this report will make recommendations for additional materials testing and analyses.



Figure 1. Fort Christiansvaern, exterior, south (entrance) elevation.



Figure 2. Fort Christiansvaern, interior courtyard, view of the north elevation of the south curtain.



Figure 3. Fort Christiansvaern, exterior, north elevation, view from the bay.

2.0 BACKGROUND INFORMATION[1]

Fort Christiansvaern was built for the Danish West India and Guinea Company from 1739-1750. It is a brick and rubble masonry structure currently covered with stucco, located on the shoreline of Christiansted harbor, St. Croix, U. S. Virgin Islands. The fort remains largely an 18th century structure with significant alterations and additions occurring in the 19th century and numerous repair campaigns throughout its history.

The following is a brief list of the more significant changes to the fort which are relevant to the materials examined in this study:

- 1739-1750 (original period of construction)
- 1774-78 (partial reconstruction after a hurricane)
- 1817-18 (major rehabilitation including repointing and stucco work)
- 1834-35 (major additions/alterations including repointing and stucco work)
- 1849-77 (very little work done, time of austerity/declining economy)
- 1878 (converted from a fort to use as a police station/courthouse)
- 1909-16 (general building rehabilitation)
- 1955 (NPS takes over ownership/site management)
- 1999 (masonry repairs and limewashing)
- 2010 (significant post-hurricane stucco repairs, approximately 35% of fort re-stuccoed)
- 2021 (minor stucco repairs, all stucco completely repainted with a silicate paint)

BCA reviewed materials and reports as part of this study, primarily the *Historic Structures Report, Part 1: Fort Christiansvaern, Christiansted, St. Croix, U.S. Virgin Islands* from 1960 and two materials analysis reports from 1983, "Narrative Report on the Findings of Historic Structure Inspection: Conclusions and Recommendations" and "Report on Architectural Finishes at Fort Christiansvaern: The Von Scholten Period: 1827-1848." The latter two documents have been included with this report, for reference, as *Appendix A.*

[1] The content of this section was derived from *Historic Structures Report, Part 1: Fort Christiansvaern, Christiansted, St. Croix, U.S. Virgin Islands.* National Park Service, 1960.

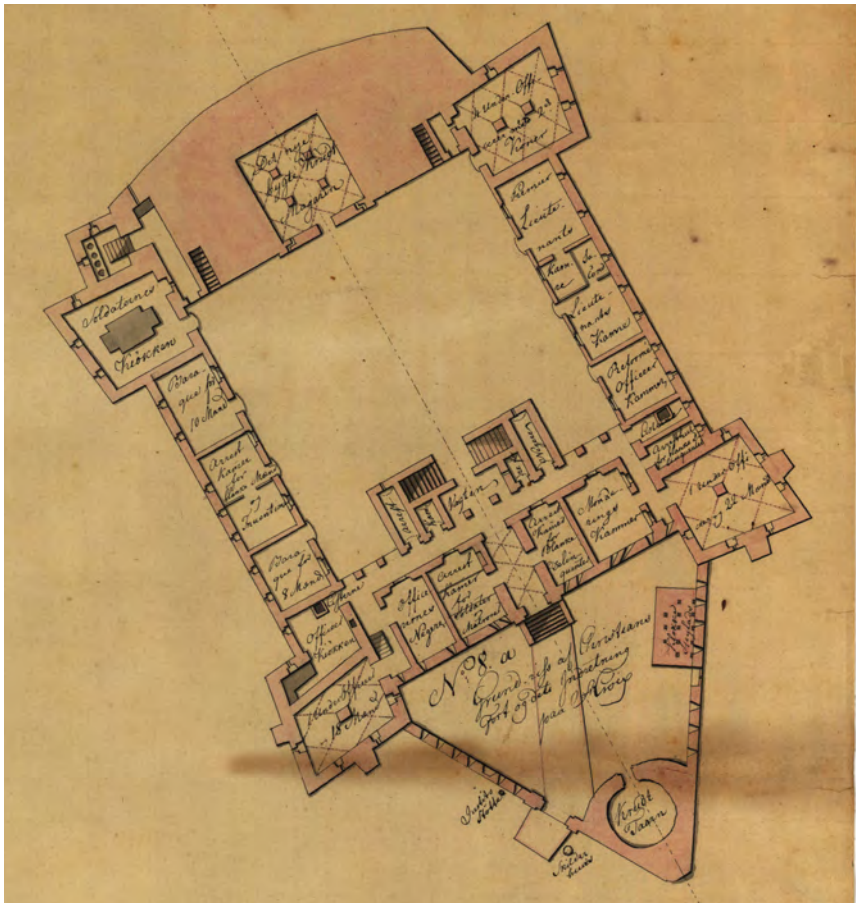


Figure 4. Fort Christiansvaern, first floor plan, ca. 1778-1780, by Peter Lotharius Oxholm. (Danish National Archives, Chamber of Revenue, Maps and Drawings Collection, card no. 337.304, cs.sa.dk/picture/view-values/676872?selectedTab=116 &locale=en).

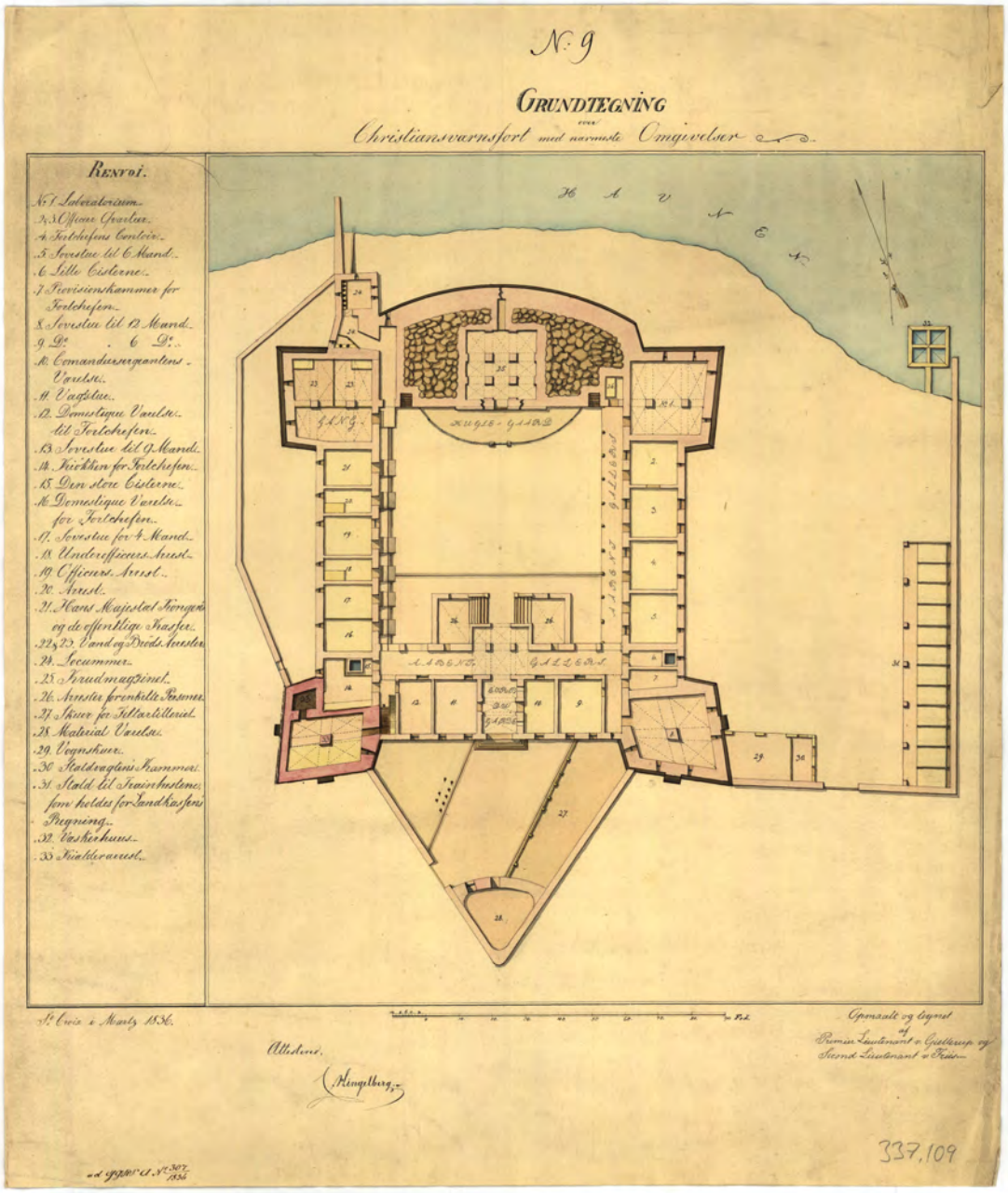


Figure 5. Fort Christiansvaern, first floor plan, 1836, by First Lieutenant Gjellerup and Second Lieutenant Friis. (Danish National Archives, Chamber of Revenue, Maps and Drawings Collection, card no. 337.109, cs.sa.dk/picture/view-values/676797?selected Tab=116&locale=en)

3.0 METHODOLOGY

BCA performed a site visit in June 2021 to investigate the fort's masonry materials (mortars, stuccos, plaster) in situ and remove representative samples. Paint finishes on wood and masonry were also investigated in situ and sampled. BCA removed 15 samples of finishes and 23 samples of mortar, plaster and stucco. Each sample was bagged, labeled with its location, and returned to BCA's Philadelphia conservation laboratory. All 15 finish samples were analyzed as part of this study, however, only three of the 23 masonry material samples were analyzed due to budget constraints. It should also be noted that BCA's site investigation and sampling focused on the interior elevations of the fort and not the exterior, as the exterior walls had been recently re-stuccoed and painted. See *Appendices B and C* for a list of the locations from which all samples were removed, as well as a key to the room names and numbers used by BCA for this study.

Each finish sample was embedded in Extec® polyester resin[2] 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.[3] Photomicrographs of representative samples were taken using a 5.9-megapixel DS-Fi3® color digital camera system and are included in this report to illustrate specific observations. Photomicrographs and stratigraphy charts for all finish samples are included in *Appendix D*.

Highbridge Materials Consulting, Inc. performed petrographic, chemical, and gravimetric analysis of the masonry material samples using the procedures specified in *ASTM C1324 – Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*. The results of the analysis are summarized in Section 5.1 and Highbridge's full report is included in *Appendix E*.

[2] Extec® polyester resin is a commercial polyester/methacrylate resin polymerized with a methyl-ethyl-ketone peroxide catalyst.
[3] The ultraviolet light was generated by a mercury illumination system passed through a violet filter cube (EF4 V-2A Ex400/40 Dm 430 Bar 450).

4.0 In Situ Observations

4.1 In Situ Observations: Masonry Materials (Mortar, Plaster, Stucco)

The masonry materials (mortars, plasters, and stuccos) of the fort were visually examined over the course of a three-day site visit. The focus was on the interior elevations of the fort since the exterior was recently re-stuccoed and painted. The visual investigation allowed for a general understanding of the physical evolution of the various materials simply by looking at their placement (by looking at which material was placed over another, relative dates of installation can be determined), in tandem with archival information such as historic plans of the fort. Because of the large quantity of masonry materials present at the fort, an emphasis was placed on identification and discussion of the earliest existing masonry materials. These early materials were also the subject of the laboratory analysis. Therefore, significantly more information is provided on these materials in this report.

Based on this site examination, the masonry materials could be classified into four primary groupings, as discussed below and as depicted in the following photographs.

Mortar Type A. Earliest Existing Mortar (possibly ca. 1739-50)
(Samples Mortar.4, Mortar.19, Mortar.20, Mortar.21B)

This mortar appears to be the earliest mortar at the fort and most likely dates to the original period of construction, 1739-50. It is bright white in color with a slight pinkish hue and appears to have relatively fine aggregate, none of which is particularly visible in hand samples. As discussed in Section 5.2, the mortar is a high calcium lime-based mortar made with natural corraline sand.

This mortar was found in brick masonry in multiple locations (inside the slave cells of the south curtain, on the east exterior wall of the south curtain at the second-floor level and in a window opening of the second-floor level of the south curtain). In two of these locations (the slave cell interior and the south curtain window opening), where the brick surface had not been stuccoed over, the mortar joint was tooled to create a convex, rounded bead. It also had evidence of washes applied over top (see discussion of finishes in *Section 5.2* below). In addition, the mortar is installed to compensate for irregular brick arrises, with the tooling creating a uniform horizontal line. This decorative treatment was seen on the columns as well as the underside of the arched opening in the slave cells (now enclosed) and the arched window openings of the second-floor gallery of the south curtain. (*Figures 6-9)*

The decorative nature of the joint treatment, as well as the presence of washes over top of the brick masonry, indicate that the brick masonry was originally exposed and intended to be seen. It was not stuccoed originally. How extensive this treatment was on the fort is not clear. The physical evidence observed in this study is unfortunately not sufficient to definitively identify which portions of the fort's masonry were stuccoed vs. exposed brick masonry. It is possible that the interior-facing walls of the fort were exposed brick while the exterior-facing walls were stuccoed. However, this could not be determined as part of the current study.

The 1983 "Narrative Report on the Findings of Historic Structure Inspection: Conclusions and Recommendations" mentions washed brick masonry existing under later applied plasters and stuccos, but it does not discuss the earliest existing mortar identified in this study. Nor does it

discuss the original tooling and mortar installation documented in this study, which most likely represent the original masonry appearance (at least on the interior elevations of the fort).

Mortar Type B. Second Oldest Mortar/Plaster (possibly ca. 1779)
(Samples Mortar.1, Mortar.3, Mortar.14B)

This mortar is pale warm yellow with large visible aggregate particles that are typically brown and gray in color. It is also a high calcium lime-based mortar made with corraline sand. It was found as the earliest mortar in Room 12, suggesting this room may have been constructed or significantly altered after the original period of construction since the earliest mortar referenced above was not found in this room. In Room 12, it appears as a parging or possibly a concrete/rubble wall infill. As a mortar, it was also found in the brick walls that were added to the ground floor level of the south curtain, enclosing the once exposed brick columns, and creating the slave cells, as discussed above in the "Mortar Type A. Earliest Existing Mortar" section. These walls are shown on the 1779 floor plan of the fort, so they existed at that time but are not original since they were clearly added after the brick columns, which they enclose. (*Figure 4)* The mortar also appears to be present on the north wall of Room 24B, which is in the northwest bastion, but on a wall identified as a later added partition wall on the 1959 HABS drawing. (*Figures 10-13)*

This mortar may be the same material described as "light pink stucco" in the 1983 "Narrative Report on the Findings of Historic Structure Inspection: Conclusions and Recommendations". This stucco, which the author of that report considered historic, was found under a white cementitious plaster in the interior rooms of the fort.

Mortar Type C. Third Oldest Mortar/Plaster (possibly ca. 1817-18 or ca. 1834-37)
(Samples Mortar.2, Mortar.8, Mortar.9, Mortar.21C, Mortar.22, Mortar.23)

This material, which exists as both a mortar and a plaster, was found in multiple locations throughout the fort. It is white in color with distinct black aggregate, occasionally large. While similar in color to the earliest existing mortars, it appears to have more sand and a slight grayish hue. It is also typically quite thick. As discussed in Section 5.2, like the other two mortars, it is a high calcium lime mortar made with coralline sand. Although it is the third oldest mortar observed during BCA's site visit, it is still relatively early in terms of its placement in relation to other mortar materials. (*Figures 14-15)* Given its relatively early date of installation as well as its ubiquitousness, it is believed to date to either the 1817-18 or 1834-35 period of alteration to the fort. The former period (1817-18) was known to have included significant repointing and stucco work. However, it was not possible to definitively date this mortar based on the results of the laboratory analysis or field investigation.

This material was found as both a mortar and a plaster in Room 12. As a mortar, it was found in the entire east wall, in the infilled window opening at the south end of the west wall and in the existing window opening at the north end of the west wall. As a plaster, it is applied on all walls of Room 12. It extends past the current tongue-and-groove ceiling, indicating it pre-dates the installation of this wood board ceiling.

It was also found as a mortar and plaster on the underside of the west stair of the south curtain that leads to the second-floor level. This stair is believed to date to ca. 1834-35 based on the ca. 1836 plan of the fort. (*Figure 5*) Several finishes and subsequent plaster skim coats were applied over top of it.

It is also present as both a mortar and a plaster in Rooms 26E and 24A. In Room 24A, it is found in the embrasure opening on the north wall, where iron bars make it difficult to re-stucco, preserving this earlier evidence.

This material may be the same as the "soft white" plaster referenced in the 1983 "Narrative Report on the Findings of Historic Structure Inspection: Conclusions and Recommendations". That report states that the earliest existing stucco found on the exterior walls of the fort was a soft white plaster that existed under a hard white plaster as well as several hard grayish layers.

Mortar Type D. Later Mortars, Plaster and Stuccos
(Samples Mortar.5, Mortar.6, Mortar.7, Mortar.10, Mortar.11, Mortar.12, Mortar.13, Mortar.14, Mortar.15, Mortar.16, Mortar.17, Mortar.18)

The rest of the mortar, plaster and stucco samples are typically more modern or anomalous materials from a wide range of non-original repair campaigns. This study did not focus on the analysis or characterization of these later masonry materials.





Figures 6 and 7. Fort Christiansvaern, first floor level, Room 26C. This room contains the earliest existing mortar found at the fort (Type A). It is visible on these columns, which were enclosed by the adjacent masonry walls some time before 1779 according to an historic floor plan of the fort dated 1779. This mortar is likely the earliest mortar at the fort, dating to ca. 1738-39. Note the tooled mortar joints with the convex rounded profile that were obviously intended to be visible. The mortar is also used to fill irregularities in the brick arrises and, when struck, create the appearance of a straight, regular, thin joint. This is also the location of sample Mortar.4, which was subjected to laboratory analysis.



Figure 8. A location at the second-floor level where a tooled brick mortar treatment similar to that found in the location shown in Figures 6 and 7 was uncovered behind a removed window frame. Note the red-colored washes applied over the brick and mortar.



Figure 9. Samples Mortar.4 and Mortar.20, which both represent the earliest existing, white-colored mortar found at the fort. Sample Mortar.20 on the right contains evidence of the convex rounded tooling at the surface of the mortar joint (arrow) as well as applied red washes.



Figure 10. The warm yellow mortar associated with the second oldest mortar/plaster campaign (Type B). On the west wall of Room 12 shown above, it appears to be applied either as a parging or part of an early concrete/rubble wall infill. This is the location of sample Mortar.1.





Figures 11 and 12. The second oldest mortar was also observed on the walls that were added to the ground floor level of the south curtain enclosing the once exposed brick columns (visible in the left photo) and creating the slave cells. In the photograph on the right, sample Mortar.1 removed from Room 12 is shown for comparison. They appear to be the same material.



Figure 13. Samples Mortar.1 (left), Mortar.3 (middle) and Mortar.14B (right) represent the second oldest mortar found at the fort (Type B), which is warm yellow in color and contains larger, more visible aggregate than the oldest mortar (Type A).



Figure 14. The third oldest mortar (Type C), which is also often found as a plaster, can be seen in the right side of this photograph (arrow). It is whitish gray in color and has been used to fill in an older window or door opening on the west wall of Room 12. The mortar in the left side of the photograph is the second oldest mortar (Type B), which is warm yellow in color by contrast.

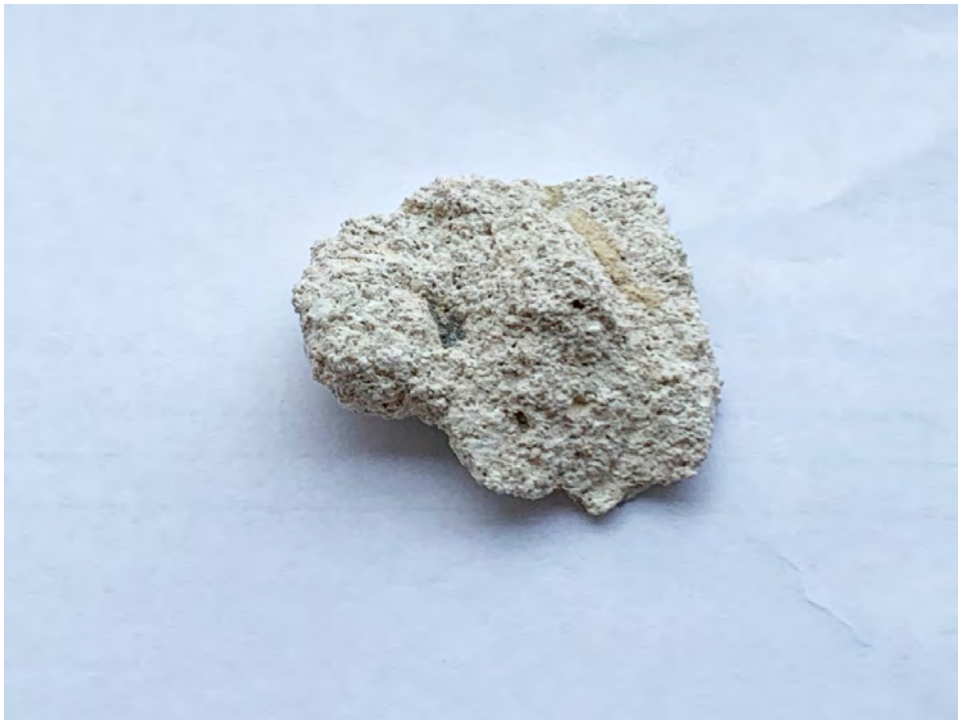


Figure 15. Sample Mortar.2 represents the third oldest mortar, which sometimes also occurs as a plaster.

4.2 In Situ Observations: Finishes

Because of the limited number of finish samples included in this study, it was decided to focus on two aspects of the fort's paint finishes: the masonry finishes and the paint finishes of Room 12. Understanding the finishes applied to the fort's masonry surfaces (brick, plaster, stucco) throughout its history is obviously a critical part of documenting the fort's overall appearance over time and it goes hand-in-hand with the current study of its masonry materials. As for the selection of Room 12 as a focus area, Room 12 is one of the few rooms at the fort that has not been significantly altered and still retains evidence of historic paint finishes, including decorative stenciling on the walls. Therefore, it was seen as a good potential location for historic paint evidence that might be representative of the interior rooms of the fort. Paint samples were removed from both plaster and wood elements of this room.

The results of the paint finishes investigation are summarized in *Section 5.2* because they are primarily derived from the laboratory analysis of the paint samples.

As mentioned before, the exterior walls of the fort were not investigated for historic paint evidence because they had been recently re-stuccoed and painted prior to BCA's site visit.

5.0 Laboratory Analysis

5.1 Laboratory Analysis: Masonry Materials (Mortar, Plaster, Stucco)

BCA removed 23 masonry material samples from the site for laboratory analysis. Three of the samples were identified as representative of the earliest existing masonry materials at the fort and were selected for laboratory analysis. They were examined petrographically and chemically by Highbridge to determine their composition and condition.

The analyzed samples include:

- CHRI.Mortar.2: First floor level, Room 12, interior, west wall, brick mortar/plaster. This sample represents the third oldest masonry mortar material observed (Type C), which is believed to date to either 1817-18 or 1834-37. (*Figures 16-17)*
- CHRI.Mortar.3: First floor level, Room 26C, interior, south wall, mortar. This sample represents the second oldest masonry mortar material observed (Type B), which is believed to date to 1779. (*Figure 18)*
- CHRI.Mortar.4: First floor level, Room 26C, interior, east wall, brick mortar. This sample represents the oldest existing masonry mortar material observed (Type A), which is believed to date to 1739-50. (*Figures 19-20)*

The results of the laboratory analysis indicate that all three mortars are generally similar in terms of composition with some variation in sand, most likely due to the fact that the mortars are believed to date to three different construction campaigns. All of the mortars are composed of high-calcium, non-hydraulic lime and well-graded, natural coralline sands. Volcanic grains and other siliceous materials were also noted as minor components of the sand. There is no evidence of any cements or other additives in any of the mortars.

Lime-based mortars are typical for the 18th and early 19th centuries, which is consistent with the date of the masonry from which the samples were removed. It is interesting to note that there is evidence in Sample Mortar.3 that the lime was manufactured from fossil coral.

Binder to sand ratios for the mortars analyzed were determined to be the following:

Mortar.2 (Type C mortar, third oldest mortar observed at fort): 1 part lime: 1.7 parts sand
Mortar.3 (Type B mortar, second oldest mortar observed at fort): 1 part lime: 0.9 parts sand
Mortar.4 (Type A mortar, oldest mortar observed at fort): 1 part lime: 0.5 parts sand

In terms of physical characteristics, Samples Mortar.2 and Mortar.4 are fairly cohesive and hardened, while Sample Mortar.3 is a bit softer and more friable. All three mortars are highly water permeable. Petrographic examination of the mortar samples indicates that they were mostly well-prepared, although Sample Morter.3 appears to have been prepared with more mix water than necessary to yield good workability. This fact is likely responsible for the weaker character of this particular sample.

See *Appendix E* for Highbridge's full mortar analysis report.



Figure 16. Fort Christiansvaern, first floor level, Room 12, west wall, location of sample CHRI.Mortar.2.



Figure 17. Location of CHRI.Mortar.2. This sample represents the third oldest masonry material at the fort, as observed during the current study's site visit.



Figure 18. Fort Christiansvaern, interior, Room 26C, location of Mortar.3, the second oldest mortar observed at the fort.

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Figures 19 and 20. Fort Christiansvaern, first floor level, Room 26C, northeast corner. Location of CHRI.Mortar.4, the oldest mortar observed at the fort.

5.2 Laboratory Analysis: Finishes

Masonry Finishes

The earliest masonry finishes observed by BCA were washes applied to the brick that was originally exposed on the interior elevations of the fort. The washes were found in two locations of the south curtain where the original brick masonry had not been stuccoed over (inside the slave cells on the ground floor and at the jambs of the window openings of the second-floor level gallery), as well as one location where the brick has been stuccoed over (the east elevation of the south curtain at the second-floor level). As discussed previously in the report, the original brickwork found inside the fort was meant to be exposed and not stuccoed over. It contained a tooled mortar joint that was obviously intended to be seen and not covered. In addition, it is likely that the brickwork was always intended to be painted. Not only do the original bricks appear to be two different colors—brown and yellow—but they also are irregularly shaped with undulating arrises that had to be filled with mortar and tooled to create the illusion of a straight, narrow joint.[4] Painting the different colored brick, as well as the decorative mortar treatment, would have provided the appearance of a uniformly colored and neatly installed masonry wall. (*Figures 21-26)*

The earliest finishes applied to the original brick masonry appear to be limewashes, based on their translucent appearance in cross-section. They are matte when viewed in bulk samples and in situ, which is also characteristic of limewashes. The color of the limewash varies by location. The limewash applied over the brick masonry of the slave cells (brick units and mortar alike) is brown in color, similar to the dark brown color of the brick itself. It is also fairly thick, more like a mortar parging or a sanded limewash. The color of the limewash applied over the brick masonry at the second-floor level is dark pink/dark red. It may actually be an even darker red than recorded, as the saturation of the color varies greatly and the removed samples that were used for color matching may not contain the darkest, most saturated version of the limewash color. The dark pink/red limewash was found in two locations on the second-floor level of the south curtain—the window openings of the gallery and the east elevation of the building, which is now stuccoed. The color of the early dark pink/red limewash is the same in both locations. In all three locations, there appears to be only one layer of limewash.

It is not clear why two different-colored washes would have been applied to brickwork that presumably dates to the same period. Perhaps it was an intentional differentiation between the masonry of different floor levels or of different uses. It is also possible that the finish evidence may not be complete in these locations and that the washes date to two different periods. It is also unclear when these washes were applied. The 1960 HSR states that the arched openings of the second-floor level of the south curtain were enclosed in 1839, meaning the dark pink/red wash found on the bricks pre-dates this time.[5]

The prior materials analysis reports and archival information provided to BCA were not particularly helpful in answering the question about when these washes might have been applied and how extensive their application was throughout the fort. The prior studies focus primarily on the color of the exterior masonry walls of the fort and the archival information provided in

[4] Although this study did not include an examination of the historic brick unit, it was observed during the course of examining the mortar materials, that the earliest brick appears to be two colors, brown and yellow. In some cases, individual bricks contain both colors, indicating two different colored clays may have been used to make the bricks or possibly the firing of the brick resulted in the bicoloration.
[5] HSR, 46.

these reports as well as the 1960 HSR is not always clear in terms of whether they are referring to interior or exterior wall surfaces. None of the previous reports discuss the limewashed brick that is believed to be an original feature of the fort.

It should be noted that there is archival evidence for the use of brown limewashes early in the fort's history. The 1960 HSR states: "The earliest… accounts indicate that the masonry walls of the fort were stuccoed with lime mortar and limewashed with a combination of yellow ocher and brown red until 1829."[6] It also says the walls were "limewashed with a yellow-brown stone color" in 1839. Whether these descriptions refer to the exterior or interior walls of the fort, or both, is unclear. Perhaps the exterior of the fort was limewashed yellow-ochre while the interior surfaces were limewashed brown-red. These archival references also state that the washes were applied over stucco, which would not have been the case originally for the interior brick masonry surfaces of the fort. The 1960 HSR also states that "the first entry in the accounts for the purchase of red ochre occurs in 1909."[7] However, it seems unlikely that the exposed brick surfaces on the interior of the fort would have been unpainted until 1909 and that the stucco over top of the brick dates to after this time. It is more likely that there is simply no record of an earlier purchase of the pigment used for these brown and dark pink/red washes, and that there were red washes on the interior walls of the fort earlier than previously thought. Clearly, more research is required on this topic, as it could have broader implications for the interpretation of the fort.

After these early limewashes, the exposed brick was stuccoed in the slave cells and at the east elevation of the south curtain. At the second-floor level location, the openings were enclosed with wood jalousies. In the slave cells, the plaster was limewashed white and then painted white with a more modern paint. At the east elevation of the south curtain, two layers of stucco have been applied over the brick, a white one and a gray one. The more recent paint finishes include white, dark red and yellow finishes.

Other locations of painted masonry were investigated and sampled by BCA. These additional areas include the stucco walls of two embrasures, one in Room 24A on the north wall of the fort and the other in Room 24B on the west wall of the fort. These locations were selected because they retain evidence of red-colored finishes that pre-dated the use of a yellow finish on the fort's exterior walls. Given the presence of iron bars, these openings are also not able to be accessed from the exterior during exterior repair and repainting projects. In these locations, the red finishes look different from that found on the exposed brick columns discussed above. The samples removed from the west embrasure (Samples F.9 and F.10) have only one layer of dark red finish that appears to be a sanded paint and not a limewash. The sample removed from the north embrasure (Sample F.8) has three different red finishes, each applied over a different stucco. The first and third layers look more like paint while the middle (second) layer looks more like a limewash. None resemble the red or brown washes documented on the brick. The previous materials analysis report from 1983, "Report on the Architectural Finishes at Fort Christiansvaern: The Von Scholten Period: 1827-1848", dates the red-colored finishes to the 20th century and states they are applied over top of earlier layers of white and yellow limewashes. This is consistent with the information contained in BCA's samples, although BCA's samples lacked the earlier white and yellow washes. (*Figures 27-28)*

[6] HSR, 47.
[7] HSR, 139 (footnote).

BCA also removed samples from the stucco on the interior of the fort in two other locations, the underside of the west stair of the south curtain and the south wall of the ground floor corridor of the south curtain (above the door to Room 12). The stucco under the stairs is constructed of yellow brick with a soft white stucco applied over top. As observed in situ, there are gray washes applied over the stucco followed by red-brown washes. Following this, an additional white-colored stucco (harder than the first) was applied and topped with yellow-brown washes, another then layer of stucco and the current yellow paint. Unfortunately, only the more recent finishes were captured in the cross-section sample (Sample F.14). The gray washes observed on the earliest layer of stucco may relate to the "blue-gray" finish applied to the walls in 1829, according to the 1960 HSR.[8] *(Figures 29-30)* The sample removed from the south wall of the corridor only contains more recent stucco and paint finishes (Sample F.15). (*Figure 31)*

[8] HSR, 47.



Figure 21. In one of the slave cells (Room 26C), the brown wash (red arrow) applied to the bricks is visible under the current white finishes. Note the bicoloration of the bricks, yellow and red brown (black arrows). The original tooled, white-colored mortar joint is also visible in this location.



Figure 22. In the window openings on the second-floor level of the south curtain, the dark pink/red wash applied to the original brickwork is clearly visible. It is a different color, redder, than the wash found on the bricks of the first-floor level (as seen in Figure 21).

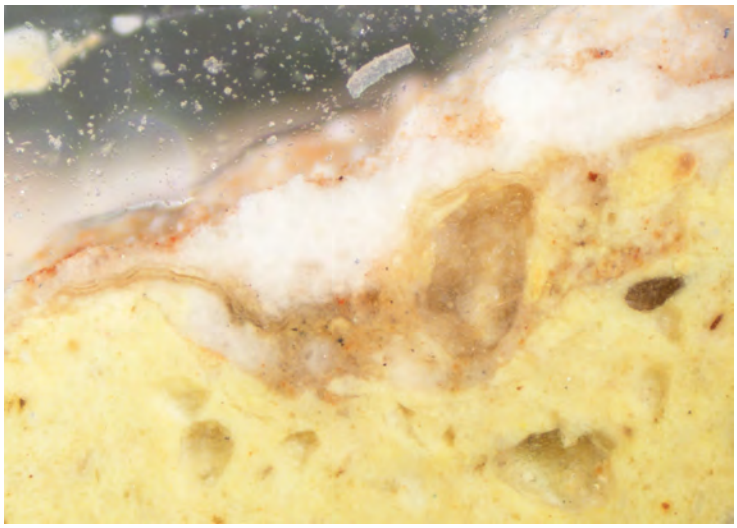


Figure 23. A photomicrograph of Sample F.11 removed from the painted brick above. It shows both the yellow brick and a small amount of white-colored mortar, as well as a single layer of red limewash (arrow). Visible light, 40x magnification.



Figure 24. A piece of mortar (sample Mortar.20) removed from the jamb of the window opening on the second-floor level of the south curtain (the location on Figure 22 above). Note the red limewashes applied over the mortar, as well as the profile of the mortar in the photograph on the right, showing the curved portion that was installed in the joint in section.



Figure 25. This piece of yellow brick (Sample F.13) was removed from the east exterior wall of the south curtain. It was taken from underneath layers of later stucco and paint finishes. It contains one to two layers of red/red brown washes, similar to that found on the window opening illustrated in Figure 22.

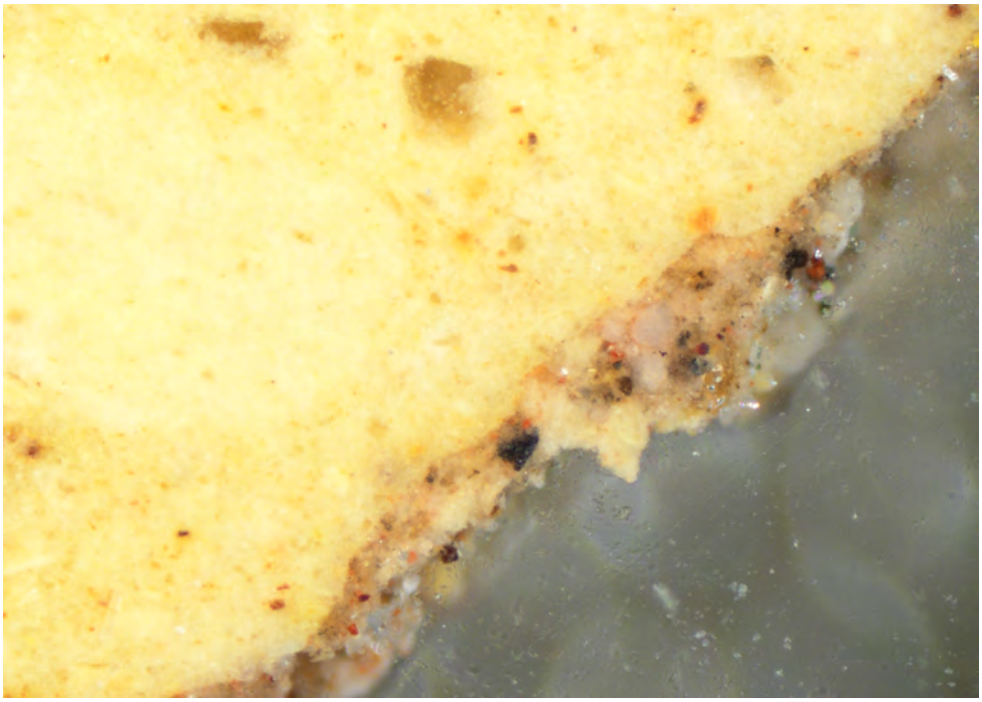


Figure 26. Photomicrograph of Sample F.13 showing the reddish-brown washed applied over the yellow brick. Visible light, 40x magnification.



Figure 27. Photomicrograph of Sample F.8. Visible light, 40x magnification.



Figure 28. Photomicrograph of Sample F.9. Visible light, 40x magnification.



Figure 29. The location under the west stair where Sample F.14 was removed from. Note the early gray finish that may date to ca. 1829 (arrow). The overall yellow color is due to the light in the space at the time the photograph was taken.

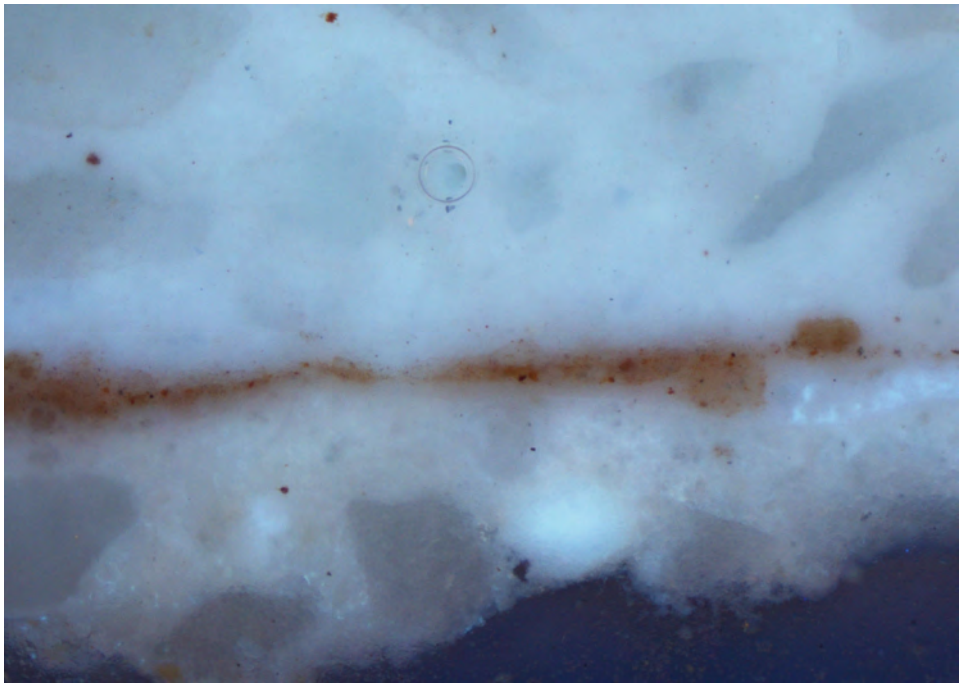


Figure 30. Photomicrograph of a portion of Sample F.14, showing an early layer of stucco plus a red-brown wash and then a later stucco. Visible light, 40x magnification.

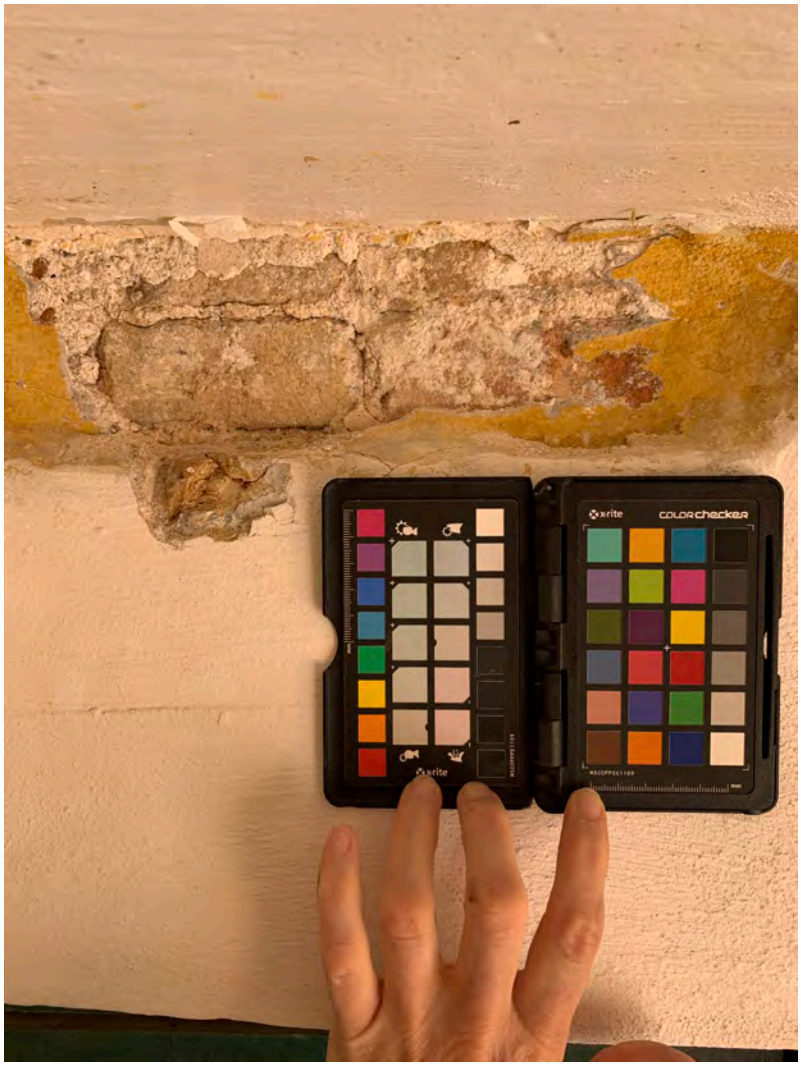


Figure 31. This is the location where Sample F.15 was removed from. It contains only more contemporary stuccos and paints.

Room 12 Finishes

Samples were removed from both plaster and wood elements of Room 12, including the door trim on the exterior (corridor) face of the door into the room. The samples removed from the woodwork outside of the door into Room 12 will be discussed first, since they relate to the preceding discussion of masonry finishes in this area. (*Figure 32)*

Woodwork

The exterior face of the wood frame of the door into Room 12 has a rich finish history (F.2). It has been painted approximately 25 times. The first layer, applied directly to the surface of the wood, is a dark gray. After this, it was painted dark green, cream, olive green, dark gray again, and then yellow-brown, olive green or tan approximately 14 times. All of these paint layers appear to be early paints given the coarseness of their pigment particles and overall heterogeneous appearance. After these early paint layers, the wood frame was painted pale gray, khaki, pale green, and dark green. The wood frame of the corridor opening (F.1) has a similar stratigraphy but lacks the earliest paint layers. Its first finish is the yellow brown found as the fourteenth paint layer in sample F.2. Sample F.1 also has evidence of a red material at the surface of the wood, most likely a pore filler used to prepare the wood for painting. It also has many more modern dark green paint layers than sample F.2 (nine versus one). (*Figures 33-34)*

The earliest dark gray finish found on the woodwork of the south curtain first floor passage is consistent with the historic paint evidence discussed in the 1960 HSR and the 1983 materials analysis report. Both documents state that the earliest finish on the fort's woodwork is dark gray.[9] The HSR then goes on to say that subsequent paint colors for the woodwork were light yellow (1829-36) and dark green (1836, 1839). The 1983 paint analysis also lists subsequent paint colors for the fort's exterior woodwork, many of which are comparable to the ones found in these two samples (e.g., tans and yellow browns). Since the first layer present on the wood frame of the passageway is an early but non-original yellow brown, it would be helpful to know what year this wood element was installed (since it would help to date this layer as well as all layers before it that are present in Sample F.2).

The paint history on the interior side of the door into Room 12 is very similar to that on the exterior side. Sample F.3, removed from the wood lintel on the interior (room) face of the door, has the same first two paint layers as found in Sample F.2: dark gray and dark green. After this, the two stratigraphies diverge. The interior woodwork was painted olive green, brown, pale gray, and then various shades of tan, gray and khaki. Its most recent layers are pale green and three layers of dark green. While many of these layers match those found on the exterior woodwork, the sequence is slightly different and there are a few colors present in Sample F.3 that are not in F.2.

A sample was also removed from the beaded joist of the second floor, visible behind the current tongue-and-groove ceiling (F.4). The earliest finish is a yellow brown followed by a pale gray. These might be the same as the fourth and fifth layers in Sample F.3. If the date that the current ceiling was established could be determined, it would help to date these finishes. (*Figure 35)*

[9] HSR, 47.

Plaster

Two samples were also removed from the plaster walls of Room 12, one from the stencil on the east wall (F.5) and one from the gray dado of the west wall (F.6). The sample removed from the dado, which is covered with a white plaster (the same as Mortar.2), contains only a single layer of dark gray paint. There may have been an earlier iteration of a gray dado, but lower on the wall: there appears to be a thinner band of a paler or more weathered gray lower down on the same wall underneath the current dark gray. (*Figure 38-39)*

The sample removed from the stencil area (F.5) contains a layer of yellow ochre followed by dark gray, which represents the stencil design. These finishes may be pigmented limewash, based on their appearance in cross-section. Although not visible in the cross-section, this portion of the wall also contains a pale pink over top of the stencil campaign. It appears matte in bulk and may be a pigmented limewash. After this, the walls appear to have been limewashed white several times. (*Figure 36-37)*

On site, a narrow band of pale gray (possibly the same as observed at the bottom of the east wall) is visible around the door to the corridor on the north wall. It is underneath the ochre/stencil and pale pink finish layers. (*Figure 40)*

The 1960 HSR does not discuss stenciling on the interior walls of the enclosed rooms of the fort. It states that the majority of the rooms were limewashed white originally, although some rooms were also wallpapered. It does mention that the rooms of the west curtain were limewashed yellow in the 1830s and 1840s.[10] Perhaps the ochre-colored limewash found in Room 12 dates to the same period.

[10] HSR, 73.



Figure 32. Samples F.1 and F.2 were removed from the wood elements in the passageway outside of the door to Room 12. F.1 from the wood frame on the left and F.2 from the door frame on the right.

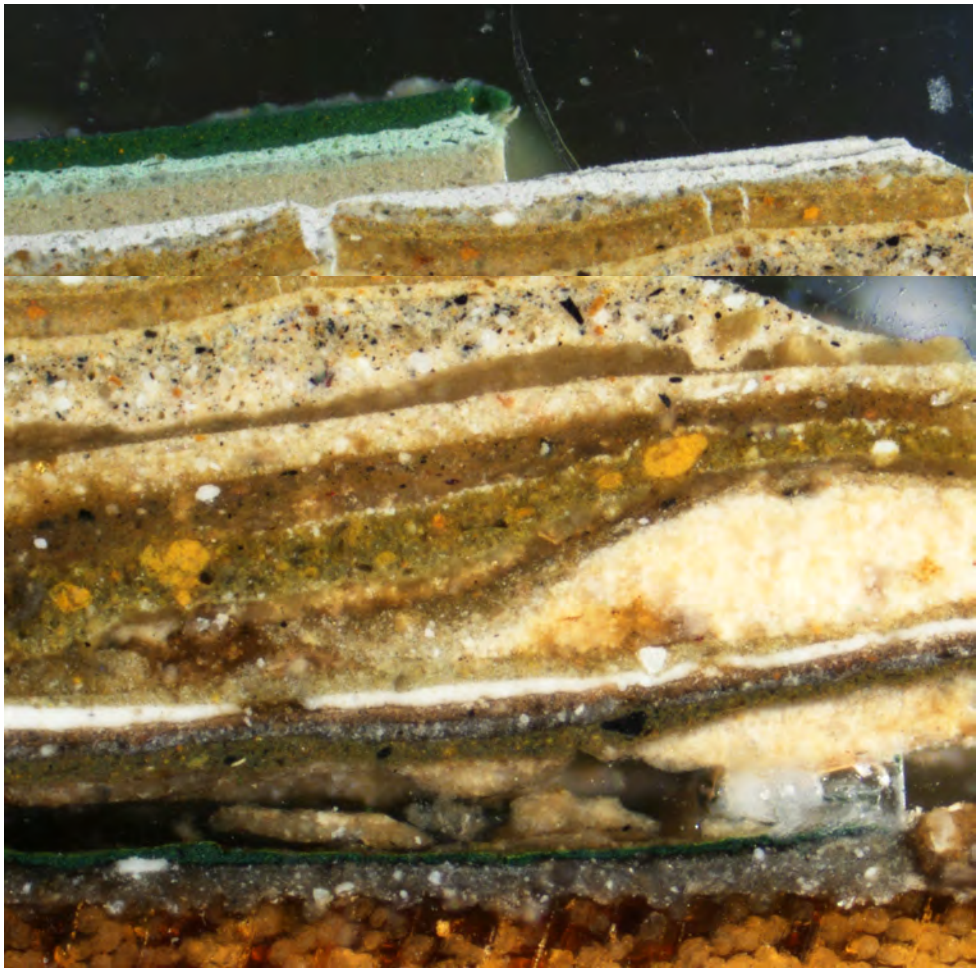


Figure 33. A montage of two photomicrographs of Sample F.2, removed from the exterior door frame into Room 12, shows the original dark gray layer on the wood (arrow), as well as numerous later layers that range in color from yellow brown to tan to green. Visible light, 40x magnification.

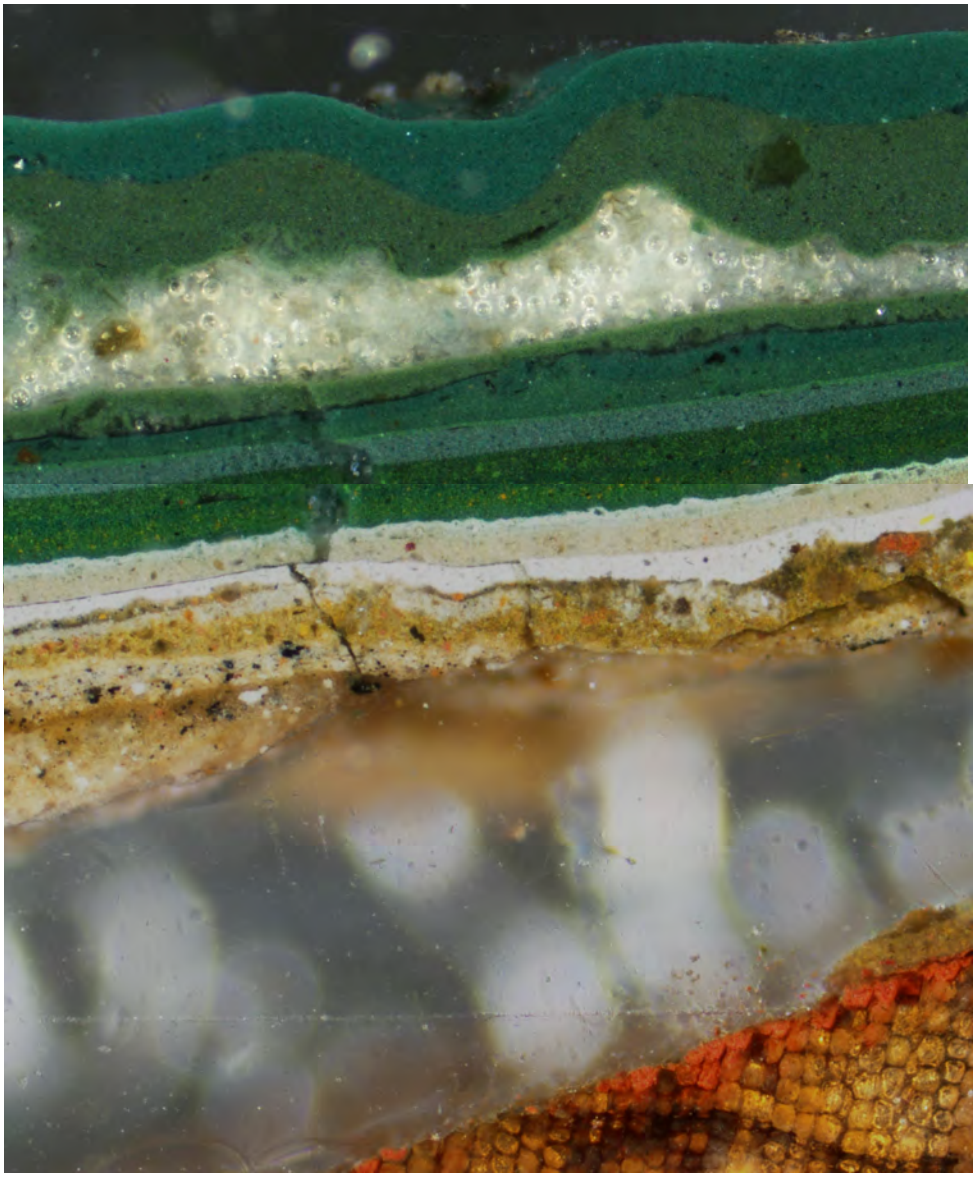


Figure 34. A montage of two photomicrographs of Sample F.1, removed from the wood frame of the south curtain ground floor passage. The red wood filler is visible at the bottom of the photograph as is the original yellow-brown finish. Note this element's earliest finish is the same as one of the much later yellow-brown paint layers visible in the photomicrograph of Sample F.2 in Figure 32 above. Visible light, 40x magnification.



Figure 35. The beaded floor joist on the ceiling of Room 12, where Sample F.4 was removed from. The pale gray finish applied to this wood element is clearly visible.

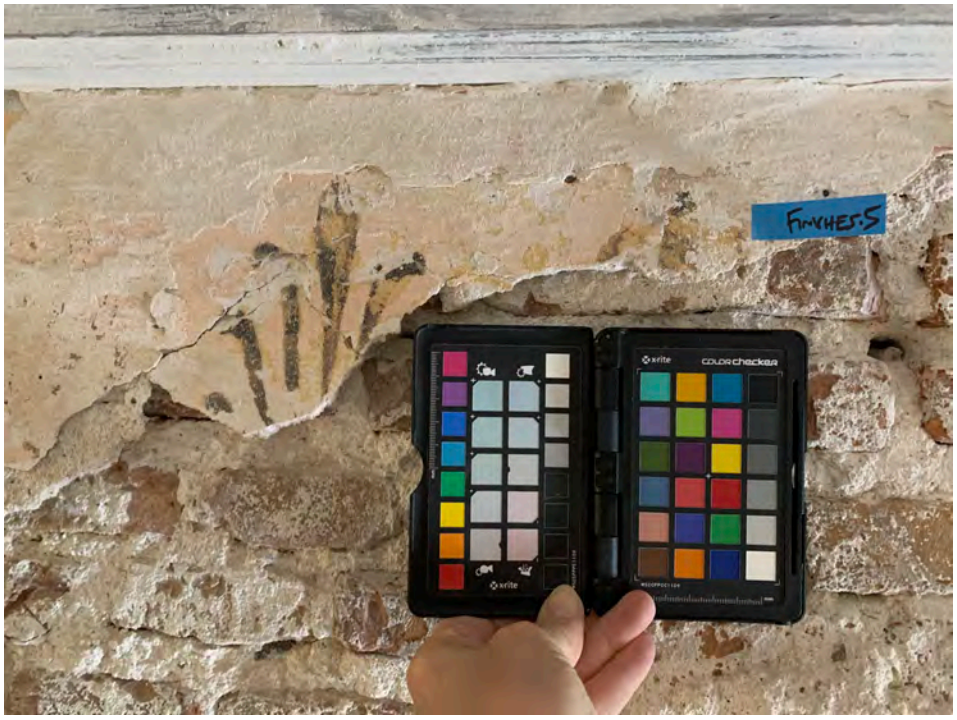


Figure 36. The area of stenciling on the east wall of Room 12, where Sample F.5 was removed from.

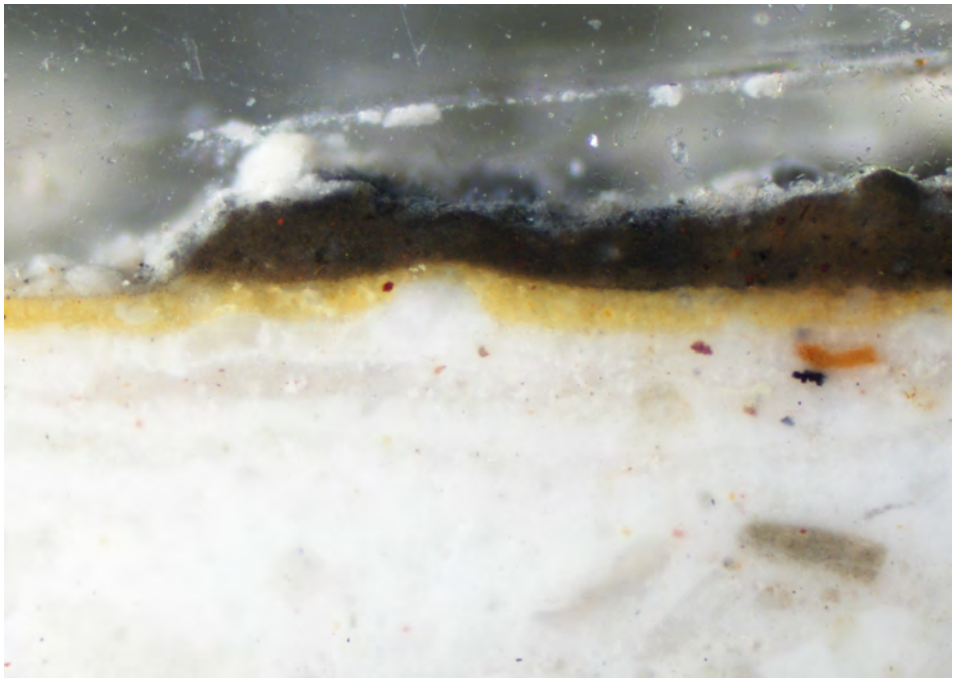


Figure 37. A photomicrograph of Sample F.5, removed from the area of stenciling. Note yellow ochre colored first layer with black/dark gray stencil design layer on top. These finishes appear to be limewashes. Visible light, 40x magnification.

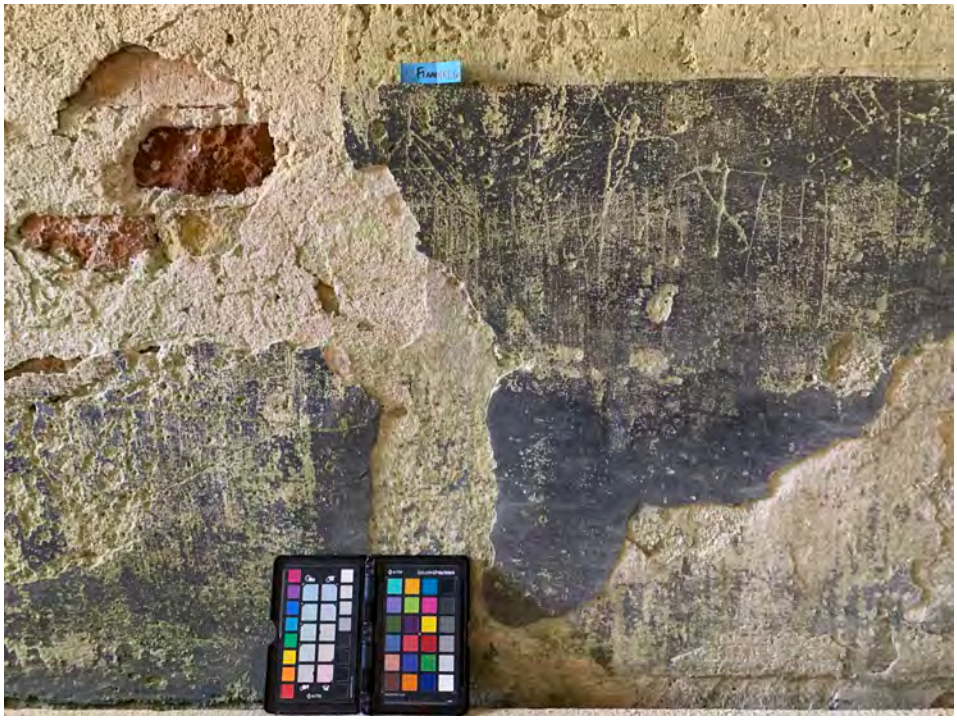


Figure 38. The gray dado of the west wall of Room 12, the location of Sample F.6. Note the lighter-colored, narrower band of gray at the bottom of the wall (arrow), which appears to be an earlier gray dado treatment for the wall.

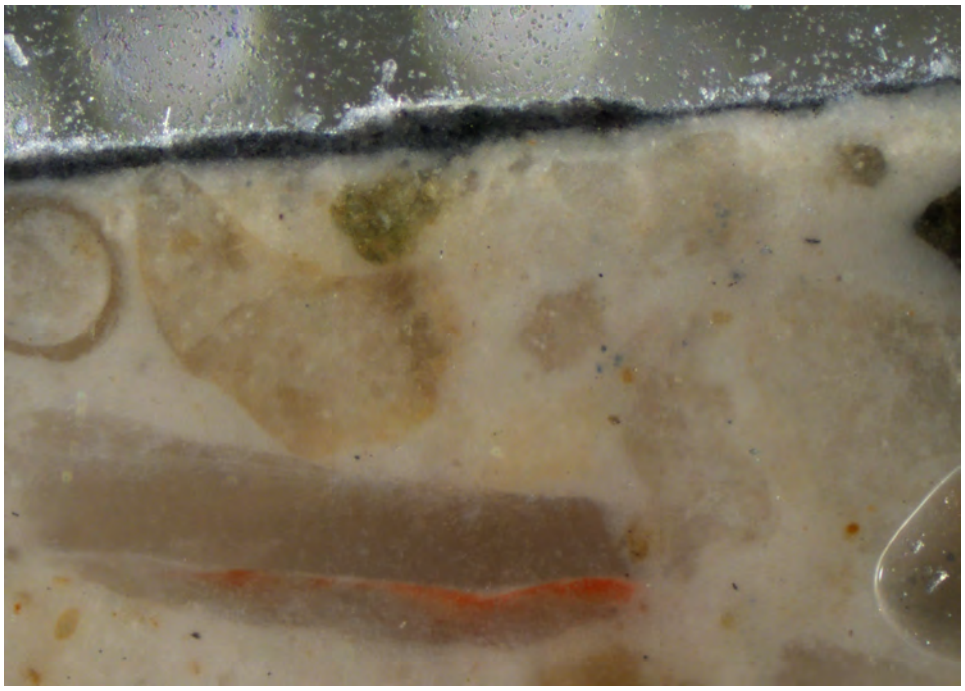


Figure 39. A photomicrograph of Sample F.6 showing a gray paint (most likely limewash) applied over white plaster. Visible light, 40x magnification. F.6



Figure 40. The north wall of Room 12 also has traces of black/dark gray stenciling applied over a yellow ochre finish, which only partially remains. An earlier band of gray paint immediately adjacent to the door opening is also visible (arrow).

6.0 CONCLUSIONS AND RECOMMENDATIONS

The current materials analysis was able to uncover and document significant information about the fort's historic materials, both its mortars and its paint finishes. Although the study was somewhat limited in terms of scope, it nonetheless revealed information about the fort's earliest appearance and the materials used to create it. The fort contains numerous unique mortar materials and finishes, and this study was only able to analyze select materials believed to be the most representative. Additional study and testing will be required to understand and document the full breadth of the fort's construction materials.

One of the most significant discoveries of the materials analysis was the presence of limewashed brick masonry walls during the earliest years of the fort's history, at least on the interior elevations (the exterior elevations were not included in this study). This brickwork had a tooled mortar joint and several limewashes ranging from red to brown in color. This evidence indicates that the brick was meant to be exposed and that it pre-dated the application of any stucco. BCA's research suggests that the exposed, limewashed brick was present from 1734-1779 and may have adorned the interior of the fort until as late as 1839, when the arched openings of the second-floor level of the south curtain were purportedly enclosed, covering one of the locations of the red limewashed brickwork. None of the previous reports on the fort discuss the limewashed brick that appears to be an original feature of the fort. Clearly, more research is required on this topic, as it could have broader implications for the interpretation of the fort.

Other early paint finishes were also documented in this report and color matches for significant layers are provided below.

In terms of the mortar materials, three distinct but similar early mortars were documented as part of the current materials analysis. The mortar appears to date to the earliest periods of construction for the fort, ca. 1734-1837. They are all non-hydraulic, high calcium lime-based mortars mixed with natural coralline sand; and they are all highly water permeable. Lime-based mortars such as these are typical of the 18th and early 19th centuries, as well as Caribbean masonry structures of the period. The mortars examined are also all in good condition. Recommendations for replication mortar mixes for the three mortar types that were analyzed are included below.

Additional study of the fort's masonry materials beyond what was accomplished in the current study is also recommended. There are numerous stuccos, mortars and plasters present at the fort and this study was only able to focus on a select few. More investigation and analysis to confirm the findings of this report, as well as document the characteristics of later masonry materials would be helpful for gaining a more comprehensive understanding of the fort's materials and physical evolution over time.

Masonry Materials

Because the historic high-calcium, non-hydraulic lime mortars examined as part of this study have performed adequately over their life, a replication mortar mix based on their composition is recommended. Therefore, a high calcium lime putty-based mortar is recommended for masonry repair work in the locations where the samples were removed, as well as other locations in the fort where the same mortar types were observed.

As a reminder, here are the three mortar types documented in this report, as well as the sample numbers associated with each type. The locations from which the samples were removed are identified in *Appendix C*.

- Mortar Type A. Earliest Existing Mortar (possibly ca. 1739-50)
  (Samples Mortar.4, Mortar.19, Mortar.20, Mortar.21B)

- Mortar Type B. Second Oldest Mortar/Plaster (possibly ca. 1779)
  (Samples Mortar.1, Mortar.3, Mortar.14B)

- Mortar Type C. Third Oldest Mortar/Plaster (possibly ca. 1817-18 or ca. 1834-37)
  (Samples Mortar.2, Mortar.8, Mortar.9, Mortar.21C, Mortar.22, Mortar.23)

As indicated below, a single mortar mix is recommended, even though there was some variation in terms of sand type and amounts in the three historic mortars. A single mix is being recommended primarily because the ingredients and proportions of the three historic mortars were generally the same (high calcium lime-based mortars with natural coralline sand). In addition, using a single mix proportion for these replication mortars will be more practical for repair work. The original proportions of lime putty to sand (1 : 1.7, 1 : 1.09, 1 : 0.5) have also been modified for the recommended replication mix to be more in line with current industry standards.

<u>Recommended Replication Mortar Mix for Mortar Types A, B and C</u>

- 1 part high-calcium, slaked lime putty
- 2 parts sand, selected to match the color and approximate grain size and gradation of the existing sands *of each mortar type* while conforming to the requirements of ASTM C144 – Standard Specification for Aggregate for Masonry Mortar.

  NOTE: Different sands will need to be used to replicate each historic mortar type (Types A, B and C) in order to provide a good visual match to the original. Information on each sand (color, gradation) is provided in Highbridge's report located in *Appendix E*. In addition, the extracted sand from each of the three mortars will be provided with this report. All of this information can be used for matching purposes.

  NOTE: Compared to ASTM C144, the modern standard for masonry sands, the aggregates in Samples Mortar.2 and Mortar.4 comply with the permissible gradation limits, while the aggregate in Sample Mortar.3 is too coarse.

Lime putty mortars require special precautions to ensure the proper installation and long-term durability. Because lime putty mortars take longer to cure and carbonate than lime-cement hybrid or hydraulic lime mortars (full carbonation of non-hydraulic lime can take years), it is important to protect the mortar during its initial cure. In order to ensure a proper cure, we recommend that the following precautions be taken when using lime putty mortars:

- Install at least 28 days prior to expected freezing temperatures to prevent the mortar from freezing. This should not be an issue on St. Croix; however, it is important to note.
- Do not install during the hottest summer months when mortar may dry out prematurely.
- Do not install in areas of perpetual dampness.
- Protect from sun, wind, and rain for at least 14 days.
- Moisten mortar and allow to dry in regular cycles during the initial cure to allow for carbonation.
- Best results will be obtained from a mason who is familiar with lime putty mortars, as their workability and working time differ from that of cement-lime hybrid mortars.

The lime putty manufacturer's precautions and recommended installation procedures should be consulted before beginning work.

With any replication mix, samples should be created to evaluate the appearance of the new pointing mortar to ensure it matches the original in terms of overall appearance.

Finishes

The following table documents the colors of select historic finishes observed in this materials analysis. The finishes selected for color matching are those that have some type of significance or relevance for the discussion included in this report. They tend to be finishes on wood, plaster and brick that are associated with the earliest part of the fort's history.

For the color matches included in the following table, it is important that *physical* color samples for each color be reviewed, as the printed or electronic version of the color swatches included below vary from the actual colors. Any attempt to reproduce these pages, including printing from the electronic version of the report, will distort the color of the provided chip. Only the actual color chip or the color notation should be used for paint replication purposes.

Element	Location	Possible Date	Finish Description	Color Match
Originally Exposed Brick Masonry Wall/Column	South Curtain, Ground Floor, Slave Cells	ca. 1734-1779	Brown Limewash	 Munsell 5YR 5/4 B. Moore 1162 Wooden Vista
Originally Exposed Brick Masonry Wall	South Curtain, Second Floor, East Exterior Wall South Curtain, Second Floor, Gallery, Jamb of Current Window Opening	ca. 1734-1779	Dark Pink/Red Limewash Note: Actual color may be more saturated and darker, color of finish varies in samples	 Munsell 7.5R 5/6 B. Moore 1201 Spiced Apple Cider
Wood Door Frame	South Curtain, Corridor, Door into Room 12 South Curtain, Room 12, Door to Corridor	ca. 1734-1779	Dark Gray Paint	 Munsell N3.25 B. Moore 2118-20 Toucan Black

Element	Location	Possible Date	Finish Description	Color Match
Beaded Wood Joist	South Curtain, Room 12, Ceiling	Unknown, possibly mid 19th c.	Yellow Brown Paint	Munsell 10YR 6/6-7/6 B. Moore 188 Eye of the Tiger
Plaster Wall, Painted Dado	South Curtain, Room 12, West Wall	1830s-40s	Medium Gray Limewash	Munsell N4.75 B. Moore HC-178 Charcoal Slate
Plaster Wall, Stencil Design (Background)	South Curtain, Room 12, East Wall	1830s-40s	Ochre-colored Limewash	Munsell 10YR 8/6 B. Moore 180 Beverly Hills
Plaster Wall, Stencil Design (Stencil)	South Curtain, Room 12, East Wall	1830s-40s	Dark Gray Limewash	Munsell N3.75 B. Moore CW 685 Ambler Slate

Appendix A.
Previous Materials Analyses Reports

FINAL DRAFT

NARRATIVE REPORT ON THE FINDINGS OF HISTORIC STRUCTURE EXAMINATION, CONCLUSIONS, AND RECOMMENDATIONS.

NAME OF SITE:

Fort Christiansvärn , Commandant's Quarters, 2nd floor, south elevation, windows 114-122*

LOCATION OF SITE:

Christiansted, St. Croix, U.S. Virgin Islands, Christiansted National Historic Site

INSPECTION OF SITE BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

EXAMINATION REPORT FILED BY:

Benjamin Nistal-Moret

DATE OF INSPECTION:

11 January 1983

TIME OF INSPECTION:

1300 - 1700 hrs.

SCOPE OF WORK:

Determine historic color finishes for exterior windows

EXAMINATION OF FINISHES:

All openings of the hall were examined -interior and exteriors- where windows 114-122 are located. The hall is positioned above the sally port . Windows open into the main elevation facing the main entrance. Besides windows 114-122, the following doors, including hardware, were examined: doors 54-56, 58-63, and 65.

METHODOLOGY:

Selective scrapping, cratering, and polishing prior to sample retrieval were conducted in order to determine -under field conditions- paint stratigraphy and possible historic finish.

FINISHES' CONDITIONS:

Windows 114-122 were examined (shutters, jambs, heads, and sills) including their hardware. It was found that due to extensive stripping, alterations, modifications, and introduction of later window types, original finishes apparently have been lost. Examination of existing

hardware supports this finding.

EXTENSION OF RESEARCH AND RETRIEVAL OF PAINT SAMPLES:

Doors 54-65 were examined and similar conditions were found. Door 62 diverted form this pattern. Based on door style, design, nailing, screws, harware, and multi-coat finish stratigraphic pattern, it appears to be original to the structure. Scrapping and cratering tended to confirm this finding. For research purposes and duplication of color paint it was concluded that Door 62 is probably the oldest existing door in the corridor at the Commandant's Quarters. Door 62 opens to said corridor on the second floor, north elevation, main courtyard. Doors 54-56, 58, 60, and 65 also open to the same corridor. All these openings are perpendicularly located to windows 116-122. The latter were the primary objective of the research and Scope of Work. Three paint samples were retrieved from Door 62: exterior (P.01), interior (P0.2), and jamb (P.03).

PRELIMINARY CONCLUSIONS:

No original paint was found in windows 114-122. Similar conditions seem to prevail in most other openings in the same area. Door 62 is an exception to prevailing conditions.

ANALYSIS OF EXTENDED RESEARCH AND PRELIMINARY CONCLUSIONS:

Overall conditions concerning preservation of original finishes seems to be considerably limited. Stripping, alterations, and insertion of new door and window types substantially changed the original design of Commandant's Quarters. Nevertheless, considering that windows 116-122 are located in the same space as doors 54-56, 58, 60, 62, and 65, that they were functionally related (for cross-ventilation purposes) within the same architectural space and as parts of a larger structure, that the treatment of all wooden members, hardware, and overall design seem to have been the same (even the additions at the ends of the building), it can be concluded -with certain reservations- that there is no major reason to suspect that windows 114-122 did not receive a similar treatment. It can be accepted -with reservations- that the treatment given to door 62 could have been the same as that given to the rest of the doors and windows.

PRELIMINARY RECOMMENDATION:

Considering previous findings and preliminary conclusions it is recommended that windows 116-122 be painted in a finish to be determined by

the historic colors of door 62. Upon microscopic examination of samples retrieved from said door, a final recommendation concerning color will be made.

This recommendation is based on an extrapolation - based on a known series of facts which allows to establish a parallelism with what is given or known. That is, the recommendation is an approximate conjectured based on a continuity of surroounding elements.

Furthermore, the Historic Structure Report for this site clearly states that

> The earliest ... accounts indicate that the masonry walls of the fort were stuccoued with lime mortar and limewashed with a combination of yellow-ochre and brown-red until 1829. All woodwork was painted "gray" or "stonecolor" during this era. The color of the walls was altered to a blue-gray in 1829. All exterior woodwork was apparently painted a light yellow color until 1836 and thereafter a dark green color. All hardware was painted black. Once again in 1839 the walls were limewashed with a yellow-brown stonecolor, and all exterior woodwork was painted green. The practice of limewashing the walls was apparently not begun until early in the 20th century**

Finally, and in order to gather further confirming information, the paint examination conducted at door 52 (fanlight and muntin), door 6 of room 106, and door 1 of room 102, should be compared with the findings from door 62 in order to gain a better understanding of exterior color patterns for the period 1827-1848, the Von Scholten Era. This is the historic period being used for preservation intervention in the site.

(Paint analysis for doors 1, 6, and 52 is attached)

* NPS/SERO/OCR drawings, "Preservation of Fort Christiansvaern", sheet 3

**Herbert Olsen, Historic Structure Report, Part I, p.47.

FINAL DRAFT

PAINT ANALYSIS REPORT

NAME OF SITE:

Fort Christiansvaern, Door 62 (Commandant's Quarters)

LOCATION OF SITE:

Christiansted, St. Croix, U.S. Virgin Islands, Christiansted National Historic Site

ANALYSIS BY :

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

ANALYSIS FILED BY:

Benjamin Nistal-Moret

SCOPE OF WORK:

Determine historic colors for preservation painting

METHODOLOGY:

The methodology used is the one followed by NPS/NARO Preservation Center.

Microscopic examination was performed at SERO/OCR. Color matching performed with Munsell color system.

ANALYSES:

P.01 (door 62, exterior)

wood
varnish, oil, or shellac
dark gray
dark green 2.5G 2/4 - 2.5G 3/4
varnish/brown
dark green
varnish/brown
gray
gray
tan (greenish)
tan/light yellow
tan/light yellow
tan/light yellow
tan/light yellow
tan/light yellow

light yellow
white
light green
light yellow
tan
light yellow
white
white
white

P.02 (Door 62, interior)

wood
cream
brown/tan
tan
cream
dark green 2.5G 2/4 - 2.5G 3/4
varnish/brown
dark green
gray
light gray
light yellow
light yellow
white
white
white
tan
white
white
white

P.03 (Door 62, jamb)

wood
red (possibly a red oxide used as preservative)
cream
tan

cream

tan

cream

tan

cream

tan

cream

tan

dark green 2.5G 2/4 - 2.5G 3/4

varnish/brown

(from hereafter stratigraphy closely follows that found in P.01).

RECOMMENDATION:

The color range of dark greens -mentioned in the HSR as "dark green" for the 1839 period (Von Scholten era)- vary, as in the case of the ones found in doors 1, 6, and, 52, between Munsell 2.5G 2/4, 2.5G 3/4, and 5G 3/4. Considering weathering, yellowing, and pigment light fastness, it is recommended that all exterior woodwork be painted 2.5G 2/4. It is important for historic preservation reasons that historic color findings at the Commandant's Quarters, the interior openings of the Fort, and the HSR findings so clearly coincide. → Note: check colors' similarity for Steeple Bldg. exterior woodwork; and Old Customs House exterior woodwork

communal color selected

Pratt & Lambert

G 6014 (A)

Deep Jungle

gloss



FINAL DRAFT

PAINT ANALYSIS REPORT

NAME OF SITE:

Fort Christiansvaern, Doors 1, 6, and 52 (exterior and interior)

LOCATION OF SITE:

Christiansted, St. Crois, U.S. Virgin Islands, Christiansted National Historic Site

ANALYSIS BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

ANALYSIS FILED BY:

Benjamin Nistal-Moret

SCOPE OF WORK:

Determine historic colors for preservation painting

METHODOLOGY:

The methodology used is the one followed by NPS/NERO/ Preservation Center.

Microscopic examination was performed in SERO/OCR. Color matching performed with Munsell color system.

ANALYSES:

P.01 (door 52, fanligth frame, under hinge)

wood
dark green 5G 3/4 - 5G 4/4
white/cream
tan
(the rest of the sample crumbled)

P.02 (door 52, fanlight muntin)

wood
white (possible primer)
dark green (grayish) 5G 3/2 - 5G 4/2
red
light green-gray
brown
white
white

white

white

P.03 (fanlight frame, ~~unidentified~~, sample retrieved while fanlight was being stripped)

wood

red 7.5R 3/6

brown 2.5YR 3/2

white

white

white (light tan)

white

white

P.04 (door 6, room 107, exterior)

wood

oil, shellac, or varnish

dark gray

dark green 2.5G 3/4 - 2.5G 2/4

dark green

varnish or shellac

tan

brown

light gray

tan

light yellow

tan/light yellow

tan/light yellow

tan/light yellow

tan/light yellow

light gray

light yellow

light green

dark green

P.05 (door 1, room 102, interior)

(evidence of stripping)

light yellow

gray

light yellow

light yellow

dark green

P.06 (door 1, room 102, butt)

same stratigraphy as P.05

RECOMMENDATION:

The color range of dark greens vary between 2,5G 2/4, 5G 3/4, and 2.5G 3/4. Considering ~~the possibility of~~ weathering, yellowing,and pigment light fastness, it is recommended that all exterior woodwork be painted 2.5G 2/4.

NARRATIVE REPORT ON THE FINDINGS OF HISTORIC STRUCTURE INSPECTION
CONCLUSIONS AND RECOMMENDATIONS

LOCATION OF SITE:

Christiansted, St. Croix, U.S. Virgin Islands
Christiansted National Historic Site

NAME OF STRUCTURE:

Old Customs House (1st floor, exterior and interior)

INSPECTION OF STRUCTURE BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

INSPECTION REPORT FILED BY:

Benjamin Nistal-Moret

DATE OF INSPECTION:

10 - 11 January 1983

TIME OF INSPECTION:

1000 - 1700 hrs. (10 January 1983)
0900 - 1300 hrs. (11 January 1983)

ENVIRONMENTAL CONDITIONS:

Relatively dry considering tropical conditions; no rain in days; mid-70's to low 80's F; clear skies; breezy.

GEO-TOPOGRAPHICAL CONDITIONS:

Structure is located approximately 200 mts. from shoreline in a gentle slope; northwest, west, and southwest corners of structure, appear to be in the lowest point of the slope while at the same time these are the closest points to a main road gutter; large trees are located 20 to 25 mts. shading the structure on the south, east, and north elevations; phreatic level is said to be approximately less than 50 cms. from ground surface; soil conditions appear to be different in the west elevation-sandy and gravel-from those around the structure-compact sand and earth-. Foundations' depth and building materials were not determined.

SAMPLING OF BUILDING MATERIALS:

Ten samples were retrieved from: (1) Southwest corner, exterior, plaster; (4) west elevation, exterior, plaster/paint; (1) door B, exterior, paint; door C, interior, jamb; (1 room I, west wall, paint/plaster; and (1) room II, west wall, paint/plaster.

PHOTOGRAPHIC RECORDING:

Fortythree color transparencies (general and details).

BUILDING MATERIALS' CONDITIONS: (EXTERIOR):

The purpose of this research was to sample existing fabric in order to determine original architectural finishes in the first floor of the structure (interior and exterior spaces). Sampling and analysis were to cover plaster, stucco, openings (including wooden members), and hardware. Assessment of overall finishes and wall conditions were to be performed. Particular attention was to be given to raising damp, and possible roof filtrations. As far as possible, performance examination of previous preservation work done by NPS/SERO/OCR was also to be carried out.

Visual inspection of site was suplemented with selective borings 1/2" in diameter, 1" to 2" deep into the wall fabric, intended to determine surface and subsurface conditions. Detached sections of plaster-which left exposed subsurface conditions-in interior as well as exterior areas were examined and, when necessary, carefully enlarged to increase examination of subsurface and collection of fresh samples.

Inspection of main elevation (north) revealed an uneven subsurface condition. After 6 examination borings were perforated, it was determined that at least three types of plaster exist under present finish coat: soft white, hard white, and hard grayish layers. One boring revealed a more complex substrate: yellow paint (actual finish coat), followed by a hard plaster, yellow paint, a yellowish transparent coat (possibly a sealant or a masonry adhesive), white wash (possibly cementitious), yellow paint, and a soft white stucco (possibly cementitious). Other borings demonstrated that a hard grayish Portland cement stucco covered a soft lime stucco. In other areas a hard grayish Portland cement stucco had been directly applied to the brick (or rubble) masonry wall. Examination of actual wall finish strongly suggested that it is a latex base paint

(highly plastic, rubbery and impervious to moisture). Visible signs of decay were observed about 30 to 50 cms, above grade (blistering and detachment).

All borings did not indicate existènce of original paint. It is probable that previous removal of historic fabric from surface by mechanical, abrasive, or chemical means destroyed historic fabric. It was impossible to establish the most elementary finish stratigraphy as a result of probable absence of historic paint residues. It is possible, though, that paint remains might exist in the north elevation of the second floor. Finally, it was observed that soft and hard stuccoes were different in composition, color, and texture.

Four examination borings were perforated in the south elevation where similar conditions were found although soft and hard white stuccoes tended to predominate throughout the elevation. Furthermore, it was found that repair work done in gray Portland cement around window 10-finished in a yellow paint, probably latex base-was in advanced state of deterioration (scaling and detachment). Decayed cement, already detached from the wall, was held in place by a paint pocket formed by deteriorated and detached yellow latex paint. This condition extended all over the repair work done in gray Portland cement. It was also noted that such advanced deterioration of building materials was not extensive to non-repaired surfaces which appear sounder and holding better than surrounding repaired surfaces.

The northwest corner revealed critical detachment of surface materials. Almost identical conditions were observed in the southwest pier of the arcade opposite north main elevation.

The east elevation presented similar pathological conditions, although it appears to be the soundest of all the walls in the first floor. The west elevation is the one with the most critical conditions of all exterior walls. As a result of complete detachment and collapse of stuccoes-repairs done in gray Portland cement-it was possible to observe the wall substrate (brick wall). Careful examination of repair work demonstrated that during the replastering of the wall with a high Portland cement content scratch coat, the wall joints were apparently raked to create keys. Thus, replastering "sealed in" the soft lime historic mortars. The scratch coat was covered with a blue masonry film (an adhesive or

sealant) upon which a white Portland cement was applied. In other areas, the same blue film was directly applied to the historic brick wall. The finished surface was painted with a yellow pigmented latex base film. In some areas it was found that a yellowish transparent coat was applied before the yellow latex paint. It was not possible to determine if this coat was a sealant or an adhesive to either establish impermeability or paint adhesion. It was also observed that the interface between Portland cement and brick wall had become detached and the Portland cement shearing several mms. of brick skin. Adjacent to this condition, it was found that bricks were covered with crystalized soluble salts. It is highly probable that this condition is a result of sulphate attack on the historic brick work which might be taking place as a consequence of the interaction between the Portland cement's tricalcium aluminate, soluble sulphates in the bricks, and moisture penetrating the wall. If this is the case, it is safe to assume that most repaired work done with Portland cement is progressively deteriorating and causing severe damage to the historic fabric.

COMMENTS AND CONCLUSIONS (EXTERIOR):

No evidence of historic finishes in exterior walls was found. Repair work done with Portland cement and subsequently painted with a latex base paint is directly associated with exterior deterioration processes. These are associated with the presence of moisture in the walls. Furthermore, the presence of extensive accumulation of crystilized soluble salts in the interface of Portland cement stucco and brick substrate is a significant sign of built-in deterioration mechanisms which origins are not clear yet. Deterioration of Portland cement stucco-scaling, flaking, detachment, and collapse-might be related to corrosive forces generated by sulphates in direct contact with moisture. Sulphates and chlorides might be related to the use of sea water, presence of salts in sands, or a related situation at the time of replastering. Other possible deterioration process might have been originated in the construction stages of the structure when seawater, unwashed sands, or materials containing salts were originally used in the fabric. These, in association with moisture-as raising damp, atmospheric moisture, sea spray, rain, or water blastering-

triggered an internal degenerating process. Therefore, two possible deterioration mechanisms might be acting against the structure. Notwithstanding this situation, replastering with Portland cement and painting with latex base paint have aggravated and, thus, speed-up deterioration.

Portland cement stucco is a very hard rendering while, at the same time is highly impervious to moisture penetration. That is, it does not allow a breathing capability to develop in the rubble/brick masonry substrate. Furthermore, its expansion-contraction coefficient is substantially difference from lime base mortars which, on their own, are soft and flexible thus allowing "natural" breathing of the wall. In this sense, Portland cement stucco acts against surrounding building materials in two different manners: contracts and expands at a different rate and, second, does not allow the fabric to "breath". In other words, it traps moisture inside the wall and displaces surrounding softer materials. This being the case, and considering that sulphates might be present in the historic fabric, serious decaying processes might be taking place inside the wall.

Depth of foundations and type(s) of building materials have not been determined. Considering that the building is located in a slope, its proximity to shoreline, and a section being in contact with a main road gutter, it is safe to assume that raising damp might be a pervasive problem, particularly in the west elevation. If this is the case:

> Water drawn from the soil usually contains a low concentration of soluble salts and the rising water will also generally dissolve salts from the bricks or the mortar. These salts tend to increase the surface tension of the water which increases the upward pull but this will be partially offset by the increase in density of the solution and the consequent increased downward pull of gravity. When evaporation occurs the salt solution becomes more concentrated at the surface and finally salts will crystallize out. This tends to block the pores

reducing evaporation and hence raises the level of dampness. These salts may also be hygroscopic and will absorb moisture from the air above some critical value of relative humidity so that the surface appears wet during wet weather although this dampness seems to disappear when the air becomes drier again.*

*Building Research Establishment Digest #245, Rising Damp in Walls: Diagnosis and Treatment, p.1 (London: HMSO, BRE, 1982).

Previous stated conditions were detected primarily in the west elevation where, as described, an entire replastered section of the wall is collapsing (which allowed collection of salts). If to these facts are added the impermeability of latex base paints-acting as rubberized skin in the exterior elevations-a serious built-in deterioration mechanism is acting against the life expectancy of the building in question.

The paint's adhesion loss and blistering-forming pouches in the wall-is a supporting element which confirms critical accumulation of moisture behind the paint film. Considering also that the stuccoes are lime base and/or cementitious, it can be suspected that alkali attack is taking place behind the paint film. (This might be one explanation which accounts for the yellowish membrane that appears as a runny drip at the bottom of the walls, particularly on the west elevation.) In order to support visual inspection, a conductivity meter was used. The test was performed in the west elevation 7' to 8' above grade in an area without visual deterioration. The reading indicated very high moisture contents in the wall (the needle reached the red zone). More reliable determinations could be achieved with an hygrometer and color indicator papers.

BUILDING MATERIALS' CONDITIONS (INTERIOR):

Rooms I, II, III, and IV were examined following the same methodology already applied to the exterior surfaces. Examination borings were not necessary as extensive sections of stucco and

substrate had already been exposed as a result of paint and plaster failure and collapse. As a general pattern, two types of plaster were identified: a white cementitious strata and a light pink lime base coat under the first. The light pink stucco surface is considered to be historic. It was located directly above two color washes directly applied to brick surface, and directly behind a second-an later-coat of similar characteristics. In-between these coats, Portland cement replastering and other architectural finishes form a well defined stratigraphy. Architectural finishes in Room I and IV were considered to be the same after scrapping and cratering was performed and samples retrieved. For example, in Room I, east wall, under wooden member (is part of an old stair removed in the 1970's) the following stratigraphy was found: brick, whitewash, yellow (almost a raw Sienna), gray, cream, light purple, stucco, blue, light yellow, white, thick whitewash (almost a stucco), several coats of cream/light yellow, and yellow latex base paint.

All first floor walls are severely deteriorated. Deterioration was associated with moisture in the walls. A conductivity meter test gave readings in the red zone in a section 4' above grade in all the walls of Room IV. In Room I the same readings were obtained approximately 7' above grade. Stuccoes are severely deteriorated in Room I especially in the west elevation.

Room II is a bathroom that has been replastered in gray Portland cement and painted with a white latex base paint. Tiles were installed up to 4' above grade. Both, stucco and paint are in an advanced state of deterioration (blistering, popping, and pitting). Conductivity meter readings reached the red zone above tiled wall.

COMMENTS AND CONCLUSIONS (INTERIOR):

If the exterior conditions are considered, it is highly probable that internal deterioration conditions are related to impermeability of external membranes (Portland cement stuccoes and latex base paints). That is, visible deterioration of internal walls is probably caused by massive moisture transmission which cannot escape through the exterior skin of the structure. Thus, it moves through the least point of resistance which, in this case,

are the interior walls where less Portland cement appears to have been used. Subsequently, finishes have deteriorated at a faster rate (higher index of moisture and alkali soluble salts attack have desintegrated paint film adhesiveness and binder's qualities).
It was also observed, particularly in Room IV, that rain water had entered the building through a possible roof leak. Moisture marks are visible in ceiling beams and 2nd floor beams.

FINISHES' CONDITIONS (EXTERIOR & INTERIOR) and SAMPLING:

NPS/SERO/OCR drawings for the 1976 Customs House conservation work were used to select the windows and doors to be sampled for paint analyses. Windows 1 & 9 were considered to be the best examples as they retained considerable amount of historic fabric. In location, and after scrapping, cratering, and polishing samples, were retrieved from doors B & C. Windows 1 & 9 showed similar stratigraphy for which reason were not sampled.
Microscopic examination of these samples will determine original color finish for first floor openings.

RECOMMENDATIONS (EXTERIOR & INTERIOR):

The following recommendations for the treatment of the interior and exterior elevations of the first floor of the Customs House are subject to change and modification depending on future research and findings.

Recommendations:

1. Establish depth of foundation & type of building materials used.
2. Establish nature of gradient and sub-soil conditions; these include determining type of soil, permeability, and bearing capacity.
3. Establish phreatic levels and/or oscillating waterable including determination of salinity contents of underground water.
4. Determine moisture contents of rubble/brick wall by the most suitable means, preferably by weighing cores or measurements taken with a hygrometer.
5. Assess thoroughly the 1976 NPS/SERO/OCR intervention in the structure (interior and exterior).

6. Remove exterior paint-walnut blasting, 60 psi - 100 psi - to find replastering patterns and determine soundness of materials and possible incompatibility between historic and non-historic materials.
7. Carefully assess all findings.
8. Remove deteriorated non-historic material and consolidate historic stuccoes.
9. Assess conditions.
10. Allow a reasonable amount of time to trespass to permit the wall to reach an equilibrium in moisture content and carefully monitor proces..
11. Assess conditions.
12. Concurrently repeat steps 6 - 11 in all interior spaces.
13. Consider alternatives to damproof structure at ground level with:
    a. Installation of weep-holes
    b. Electro-osmotic system
    c. chemical grouting (waterproofing resin, latex silicon, (polyester resin or Massari method).
14. Carefully monitor results.
15. Plaster and stucco structure with compatible mixture with historic fabric.
16. Paint or wash--search for historic evidence--exteriors and interiors with a sympathetic finish to the historic fabric.

REPORT ON

ARCHITECTURAL FINISHES AT FORT CHRISTIANSVAERN: THE VON SCHOLTEN PERIOD: 1827-1848

* * *

The problem under study is the establishment of a significant relationship between the historic exterior polychromy of Fort Christiansvaern and the highest level of architectural development of the structure, in order to substantiate a process by which it will be possible to approximately regain that finish appearance through a systematic preservation/restoration treatment.

*

The Historic Structure Report for Fort Christiansvaern states[1]

> Exterior Paints and Finishes.-- Numerous bills exist for frequent pointing, stuccoing, and limewashing of the exterior walls of the south curtain and the entire fort. The earliest of these accounts indicate that the masonry walls of the fort were stuccoed with lime mortar and limewashed with a combination of yellow-ocher and brown-red color until 1825 (47). All woodwork was painted "gray" or "stonecolor" during this era (48).
> The color of the walls was altered to a blue-gray in 1829 (49). All exterior woodwork was apparently a light yellow color until 1836 and thereafter a dark green color (50). All hardware was painted black.
> Once again in 1839 the walls were limewashed with a yellow-brown stonecolor, and all exterior woodwork was painted green (51). The practice of limewashing the walls was apparently not begun until early in the 20th century (52).

Structuraly, Mr. Herbert Olsen argued in his Foreword (p.iii) that

> The principal conclusion resulting from this study is that Forth Christianvaern is essentially an 18th century structure with some important additions and alterations from the 19th century era of 1834-1857. No major structural changes or additions have been made to the fort since the latter year

> despite its conversion into a police station and courthouse in 1878.
> From the standpoint of preservation and restoration, it is most fortunate that the existing structure and its period of greatest historical significance coincide so closely. If Fort Christiansvaern had been nothing more than a police station and courthouse throughout its existence, it would hardly by worthy of preservation by the Federal Government. But as a citadel for the early and first successful colonization of St. Croix and a fortification for the defense of the harbor and town of Christiansted, it is of a considerable historic significance.

During the administration of Governor Von Scholten, the Fort acquired its final and present form. This period, also known as the Von Scholten Era (1827-1848), "was the last effort to maintain the grandeur of the late 18th and early 19th centuries in the face of a severe decline in St. Croix's sugar economy." (p.34) One of the period's most lasting time impressions was its dynamic building construction, modifications or reconstructions of existing structures and, in the case of the old Fort, it was "significantly altered and added to during his administration." (p.27).

The research conducted by Mr. Herbert Olsen also considered a relatively detailed analysis of interior architectural finishes. For example, most rooms at the Fort had their walls whitewashed and ceilings, including trim, were painted white. Evidence of wallpaper was found in some rooms. Those in the west curtain were treated somewhat differently, though

> All documentary references to this subject indicate that the rooms of the west curtain were simply plastered and limewashed. Room No. (17) was limewashed in yellow in 1839, as was Room No. (21) in 1846. The kitchen was also limewashed yellow in 1838, and in 1840 the ceiling was whitewashed and the walls were yellow washed.

The 1835-1836 renovation of the northeast bastion resulted in a space which had "The ceiling beams and laths ... painted a pearl color, the walls plastered and limewashed, and window and door blinds...painted green." The officers latrine door "and all woodwork was painted green" also. Its walls "were plastered and whitewashed, and a strip about a foot wide was usually painted blue or black at the base of the walls."(p.49-52,62,67,73,80,89,92).

One final example of interior color treatment is worth mentioning. The Field Artillery Shed, built during the 1790's, was altered in the 1830's. Traditionally, the exterior was treated with tar to which a mix of red-brown

colors were added. The author added that "In the 1830's, at least, the interior was apparently limewashed with the same yellow color used on the exterior walls of the fort." (p.92)

The author included two important pieces of information regarding the use of color. One, footnote 48 (p.138) is a recipe for "stonecolor" in 1823. The mix called for

> 5/16 pound "light" and 19/48 lb. white lead in oil, an insignificant amount of black oil color (about 25 lb. for 485½ windows), turpentine, boiled linseed oil, and some litharge and "kobberrog"

which was applied to all exterior woodwork, jointly with gray. The other significant information is footnote 52 (p.139) and refers to exterior color in the 20th century

> The first entry in the accounts for the purchase of red ocher occurs in 1909...Proposed painting of the jalousies and windows of the south curtain facing on the courtyard in 1910 included the following quantities of paints: 100 lbs. white lead, 14 lbs chrome green, 7 lbs. yellow ocher,and an unspecified quantity of lampblack and paint oil.

As a general conclusion it can be safely stated, based on the HSR, that by the 1830's (1st) the predominant exterior architectural finish was a yellow-ocher color, (2nd) some interior spaces were also treated with the same finish, (3rd) dark green color was consistently used as a finish for exterior woodwork in the same way that black was for exterior hardware, and (4th) a band of gray color was used for lower sections of walls. This polichromy, as far as the HSR is concerned, is related to the period when the Fort assumed its present form as the greatest and last stage of development.

* * *

Current research of the Fort's building materials conducted by National Park Service, Southeast Regional Office, Division of Cultural Resources (Technical Unit) on its exterior historic architectural finishes reveals that historic paint characteristics radically differ from present ones. Field examination of finishes conducted at the site and followed by mycroscopic analyses of retrieved samples demonstrate that as a general characteristic, or

stratigraphic sequences manifested as patterns of color usage, yellow pigmentation was recurrently used for a long period of time prior to the present use of red. ocher or red oxide on exterior masonry surfaces.

Similar analyses carried out on exterior woodwork reveal that dark green color, besides gray and light creams and browns, were also used on most openings for a long period of time.

The scientific identification of the historic yellow pigment used at the Fort has not yet been definitively established. Sections of the samples retrieved from the site are presently under analysis at National Park Service North Atlantic Regional Office (Preservation Center). The samples are being tested microchemically and, if needed, by x-ray diffraction.

Microscopic color matching was done at NPS/SERO/OCR (Technical Unit) by Architecture Technician Benjamin Nistal-Moret. The results are attached to this report (Appendix A). It concludes, after examining five samples extracted from the exterior elevation of the northeast bastion (southeast corner), the east curtain (northeast section of wall), and the north wall of the stables (below in situ window sill) that a chrome or oxide yellow color was extensively used throughout exterior masonry surfaces. The Munsell System of Color Notation was used as color reference. The readings obtained ranged between 10YR 6/8, 10YR 7/8, and 10YR 6/7. A significant finding was made when a gray color was identified in the watertable. The Munsell notation was N 4.5 --15.6%R--. Finally, all exterior trim was found to have been painted white or very light values of yellow.

Critical analysis of field notes in conjunction with microscopic observations provide a better perspective of the problem under consideration. As the samples from the northeast bastion were retrieved it was noted that superficial masonry fabric was rubble (its depth was undetermined). It was covered with a plaster coat similar in texture and color to the wall rubble mortar, although the plaster lacked very small roundish black particles in the sand. A very white and brittle coat, possibly a lime whitewash was found as an intermediate layer between the plaster and a yellow wash. The latter was subsequently covered by another white and brittle coat. This white brittle wash had some gray tonalities produced, possibly, by lampblack applied to its surface when the wash was still wet. All the previous finishes were covered with a plaster finish coat. Above this one, at least three or four coats of color ranging from very light red to deep rich red were found. The darkest reds being the latest and most recents finishes.

In summary, the stratification of finishes found on the northeast bastion --extensively modified during the Von Scholten era-- was the following: (1) rubble (substrate), (2) plaster, (3) whitewash, (4) yellow wash, (5) whitewash (6) plaster, (7) several coats of red.

Those yellow washes which were "protected" by the whitewashes remained considerably well preserved. Sections exposed to environmental weathering or lacking a whitewash protective coat tended to be darker in color value and had a certain bubbly appearance. The darker qualities were due to possible contamination of red washes.

The red washes had interesting characteristics. Early ones found over the second plaster appeared as a reddish wash with a high contents of yellow granules which provided a red-orange or light red-yellowish finish. Subsequent washes seem to have had some sand in the mix. Curiously, these red finishes became deeper and richer in color as they became more recent in their application. The last coats, as the ones presently in the wall, are latex paints.

One problem which made this research challenging was that of color intrusions through cracks in the plaster. It appears that early applications of red washes done in a very thin consistency slipped through fissures in the plasters. Rain might have helped in this process. This might explain, possibly, why the earliest plaster found over the rubble wall sometimes appears pinkish. with yellow intrusions. These conditions dictated the need to proceed with pigment identification.

Examination of exterior cornices, capitals, column shafts and bases, pilasters capitals and bases, opening surrounds and other types of masonry trim and decorative elements resulted in negative findings of pigmented washes or other finishes. Generally white or very light yellow shades of white characterized color stratigraphy of exterior masonry trim.

Field examination of exterior masonry finishes was extended to the exterior of the Commandant's Quarters. Those areas which were affected by Von Scholten expansions or alterations were easily identified due to the presence of yellow pigmented washes throughout the walls and a gray band of color at the base of the walls.

Further field observations were carried out into three interior spaces in the west curtain. Rooms 134, 135, and the kitchen were thoroughly examined Their polichromy coincided with that found in the northeast exterior bastion walls,east curtain, and north wall of laundry; yellow walls and a band of gray at the base of the wall. One distinction was evident, though. In the interior

spaces, at the interface of yellow and gray, a very dark band approximately 1 1/2" wide of gray --almost black-- emphasized color transition. This is important, as the HSR for the structure states that some of the interior spaces were painted in yellow and gray, and a band of gray between the two was applied.

Further evidence which corroborates the use of yellow in exterior masonry walls is provided by contemporary graphic representations of the Fort (mid 1830's). This evidence supports historic and scientific analyses of materials and finishes. Furthermore, it reinforces and validates the data on the use of green on exterior woodwork. Mr. Herbert Olsen in his HSR (figs. 22-26, p.190-195) extensively studied these graphic sources located at the Royal Library and Rigsarkive at Copenhagen (Denmark), and at the Trade and Shipping Museum at Kronberg Clastle, Helsingor (Denmark). Color reproductions of the originals appear in Gunnar Olsen et.al, Vore Gamle Tropekolonier, Vol.II: Dansk Vestindien (Copenhagen: Westermann, 1953), p.261, 283, 323, 327. Detailed analysis of these graphic sources demonstrate that other major Christiansted public buildings were also painted yellow as the Old Danish Customs House, the Scale House, and the Steeple Building.

The question which remains unanswered is why red ocher pigment was purchased in 1909 and the Fort painted red c. 1910 for the first time in the history of the structure. Although the main purpose of this report is not to enter into speculative arguments but to assess factual findings, it is possible to shed some light on this issue from a technical point of view. It is known, as a given fact, that the 1830's yellow wash mix contained a red-brown additional pigment which identity is unknown. The color mix formula is also another unknown fact. Thus, and considering historic development of paints and pigments use, it is save to assume that the mix formula might have been an on site preparation. Most paints and washes were concocted that way as commercially available ready paints were not available at that period. Therefore, the values of yellow might have changed according to mixing conditions, craftmanship, availability of pigments and expertise in pigment mixing. Considering these circumstances a yellow chip (Munsell 10YR 6/7) which approximates the color readings for exterior masonry walls of the Fort was provided to Mr. Tom DiPalma a chemist for Pittsburgh Paints (Atlanta, Ga.) with the purpose of identifying the pigmentation present in the chip. Mr. DiPalma determined that in 10YR 6/7 the following pigments were present: yellow oxide, red oxide, and permanent yellow. The yellow oxide being the principal pigments of the three in the chip.

It is important to point out that the Fort went through a period of almost complete abscence of maintenance for a period of thirty or forty years. In the HSR it is stated, for example, that "Throughout the period from 1849 to 1877 Fort Christiansvaern received little more than routine maintenance, and even that was deferred at times for reasons of economy". (p.34). Therefore, deterioration of architectural finishes certainly ocurred. Thus, in the abscence of predetermined formulas for paint, deteriorated surfaces, reliable sources of technical information, etc. it is possible that word-of-mouth information, approximate imitations of paint remains in the walls, and other similar frames of reference might have been used as sources or rules for "professional" color schemes and their application.

Finally, it is interesting to clarify that yellow pigmentation was extensively used in fortifications throughout the period, particularly in Spanish fortifications. Current research sponsored by NPS on "Plasters, mortars, and architectural finishes in Spanish public buildings in the Caribbean" prove this point. It has been determined, for example that early and mid-19th century San Cristobal (San Juan fortifications) architectural finishes were yellow for the walls, white for trim, and emerald green for woodwork. Renderings for this structure in the 1850's demonstrate this fact. Furthermore, a band of gray was painted at the bottom of the walls obviously for cleaning and maintenance purposes.

In view of all these considerations and findings and considering that NPS is preserving/restoring Fort Christiansvaern (II stage) to its historically appropiate qualities, it has been recommended that said structure be painted in the following manner: all its exterior walls yellow oxide, all its exterior trim white, all its exterior hardware black, all its exterior wood work dark green, and its walls base boards dark gray.

Benjamin Nistal-Moret, Architecture Technician
National Park Service
Southeast Regional Office
Cultural Resources Management
(Technical Unit)
20 June 1983

APPENDIX A

NARRATIVE REPORT ON THE FINDINGS OF HISTORIC STRUCTURE EXAMINATION
CONCLUSIONS AND RECOMMENDATIONS
Fort Christiansvaern Commandant's Quarters
Christiansted National Historic Site

NAME OF SITE:

Fort Christiansvaern, Commandant's Quarters, 2nd floor, south elevation, windows 114-122*

LOCATION OF SITE:

Christiansted, St. Croix, U.S. Virgin Islands, Christiansted National Historic Site

INSPECTION OF SITE BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

EXAMINATION REPORT FILED BY:

Benjamin Nistal-Moret

DATE OF INSPECTION:

11 January 1983

TIME OF INSPECTION:

1300 - 1700 hrs.

SCOPE OF WORK:

Determine historic color finishes for exterior windows.

EXAMINATION OF FINISHES:

All openings of the hall were examined-interior and exteriors-where windows 114-122 are located. The hall is positioned above the sally port. Windows open into the main elevation facing the main entrance. Besides windows 114-122, the following doors, including hardware, were examined: doors 54-56, 58-63, and 65.

METHODOLOGY:

Selective scraping cratering, and polishing prior to sample retrieval were conducted in order to determine-under field conditions-paint stratigraphy and possible historic finish.

FINISHES' CONDITIONS:

Windows 114-122 were examined (shutters, jambs, heads, and sills) including their hardware. It was found that due to extensive stripping, alterations, modifications, and introduction of later window types, original finishes apparently have been lost. Examination of existing hardware supports this finding.

EXTENSION OF RESEARCH AND RETRIEVAL OF PAINT SAMPLES:

Doors 54-65 were examined and similar conditions were found. Door 62 diverted from this pattern. Based on door style, design, nailing, screws, hardware, and multi-coat finish stratigraphic patterns, it appears to be original to the structure. Scrapping and cratering tended to confirm this finding. For research purposes and duplication of color paint it was concluded that Door 62 is probably the oldest existing door in the corridor at the Commandant's Quarters, Door 62 opens to said corridor on the second floor, north elevation, main courtyard. Doors 54-56, 58, 60, and 65 also open to the same corridor. All these openings are perpendicularly located to windows 116-122. The latter were the primary objective of the research and Scope of Work. Three paint samples were retrieved from Door 62: exterior (P.01), interior (PO.2), and jamb (P.03).

PRELIMINARY CONCLUSIONS:

No original paint was found in windows 114-122. Similar conditions seem to prevail in most other openings in the same area. Door 62 is an exception to prevailing conditions.

ANALYSIS OF EXTENDED RESEARCH AND PRELIMINARY CONCLUSIONS:

Overall conditions concerning preservation of original finishes seems to be considerably limited. Stripping, alterations, and insertion of new door and window types substantially changed the original design of Commandant's Quarters. Nevertheless, considering that windows 116-122 are located in the same space as doors 54-56, 58, 60, 62, and 65, that they were functionally related (for cross-ventilation purposes) within the same architectural space and as parts of a larger structure, that the treatment of all wooden members, hardware, and overall design seem

to have been the same (even the additions at the ends of the building), it can be concluded-with certain reservations-that there is no major reason to suspect that windows 114-122 did not receive a similar treatment. It can be accepted-with reservations-that the treatment given to door 62 could have been the same as that given to the rest of the dors and windows.

PRELIMINARY RECOMMENDATION:

Considering previous findings and preliminary conclusions it is recommended that windows 116-122 be painted in a finish to be determined by the historic colors of door 62. Upon microscopic examination of samples retrieved from said door, a final recommendation concerning color will be made.

This recommendation is based on an extrapolation based on a known series of facts which allows to establish a parallelism with what is given or known. That is, the recommendation is an approximate conjectured based on a continuity of surrounding elements.

Furthermore, the Historic Structure Report for this site clearly states that

> The earliest...accounts indicate that the masonry walls of the fort were stuccoed with lime mortar and limewashed with a combination of yellow-ochre and brown-red until 1829. All woodwork was painted "gray" or stonecolor" during this era. The color of the walls was altered to a blue-gray in 1829. All exterior woodwork was apparently painted a light yellow color until 1836 and thereafter a dark green color. All hardware was painted black. Once again in 1839 the walls were limewashed with a yellow-brown stonecolor, and all exterior woodwork was painted green. The practice of limewashing the walls was apparently not begun until early in the 20th century**

Finally, and in order to gather further confirming information, the paint examination conducted at door 52 (fanlight and muntin),

door 6 of room 106, and door 1 of room 102, should be compared with the findings from door 62 in order to gain a better understanding of exterior color patterns for the period 1827-1848, the Von Scholten Era. This is the historic period being used for preservation intervention in the site.

(Paint analysis for doors 1, 6, and 52 is attached)

* NPS/SERO/OCR drawings, "Preservation of Fort Christiansvaern", sheet 3

** Herbert Olsen, Historic Structure Report, Part I, p.47.

PAINT ANALYSIS REPORT

NAME OF SITE:

Fort Christiansted, St. Croix, U.S. Virgin Islands, Christiansted National Historic Site

ANALYSIS BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

ANALYSIS FILED BY:

Benjamin Nistal-Moret

SCOPE OF WORK:

Determine historic colors for preservation painting

METHODOLOGY:

The methodology used is the one followed by NPS/NARO Preservation Center.

Microscopic examination was performed at SER/OCR. Color matching performed with Munsell color system.

ANALYSES:

P.01 (door 62, exterior)

wood
varnish, oil, or shellac
dark gray
dark green 2.5G 2/4 - 2.5G 3/4
varnish/brown
dark green
varnish/brown
gray
gray
tan (greenish)
tan/light yellow
tan/light yellow
tan/light yellow
tan/light yellow
tan/light yellow

light yellow
white
light green
light yellow
tan
light yellow
white
white
white

P.02 (Door 62, interior)

wood
cream
brown/tan
tan
cream
dark green 2.5G 2/4 - 2.5G 3/4
varnish/brown
dark green
gray
light gray
light yellow
light yellow
white
white
white
tan
white
white
white

P.03 (Door 62, jamb)

wood
red (possibly a red oxide used as preservative)
cream
tan
cream

tan
cream
tan
cream
tan
cream
tan
dark green 2.5G 2/4 - 2.5G 3/4
varnish/brown
(from hereafter stratigraphy closely follows that found in P.01).

RECOMMENDATION:

The color range of dark greens-mentioned in the HSR as "dark green" for the 1839 period (Von Scholten era)- vary, as in the case of the ones found in doors 1, 6, and, 52, between 2.5G 2/4, 2.5G 3/4, and 5G3/4. Considering weathering, yellowing, and pigment light fastness, it is recommended that all exterior woodwork be painted 2.5G 2/4. It is important for historic preservation reasons that historic color findings at the Commandant's Quarters, the interior openings of the Fort, and the HSR findings so clearly coincide.

Commercial color selected
Pratt & Lambert
G6014 (A)
Deep jungle

gloss

PAINT ANALYSIS REPORT

NAME OF SITE:

Fort Christiansvaern, Doors 1, 6 and 52 (exterior and interior)

LOCATION OF SITE:

Christiansted, St. Croix, U.S. Virgin Islands, Christiansted National Historic Site

ANALYSIS BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

ANALYSIS FILED BY:

Benjamin Nistal-Moret

SCOPE OF WORK:

Determine historic colors for preservation painting

METHODOLOGY:

The methodology used is the one followed by NPS/NERO/ Preservation Center.

Microscopic examination was performed in SERO/OCR. Color matching performed with Munsell color system.

ANALYSES:

P.01 (door 52, fanlight frame, under hinge)

wood
dark green 5G 3/4 - 5G 4/4
white/cream
tan
(the rest of the sample crumbled)

P.02 (door 52, fanlight muntin)

wood
white (possible primer)
dark green (grayish) 5G 3/2 - 5G 4/2
red
light green-gray
brown

white
white
white
white

P.03 (fanlight frame, unidentified, sample retrieved while fanlight was being stripped)
wood
red 7.5R 3/6
brown 2.5YR 3/2
white
white
white (light tan)
white
white

P.04 (door 6, room 107, exterior)
wood
oil, shellac, or varnish
dark gray
dark green 2.5G 3/4 - 2.5G 2/4
dark green
varnish or shellac
tan
brown
light gray
tan
light yellow
tan/light yellow
tan/light yellow
tan/light yellow
tan/light yellow
light gray
light yellow
light green
dark green

P.05 (door 1, room 102, interior)
(evidence of stripping)
light yellow
gray

light yellow
light yellow
dark green

P.06 (door 1, room 102, butt)
same stratigraphy as P.05

RECOMMENDATION:

The color range of dark greens vary between 2.5G 2/4, 5G 3/4, and 2.5G 3/4. Considering weathering, yellowing, and pigment light fastness, it is recommended that all exterior woodwork be painted 2.5G 2/4.

PAINT ANALYSIS REPORT
ON THE FINDINGS OF HISTORIC STRUCTURE INSPECTION.
CONCLUSIONS AND RECOMMENDATIONS

Fort Christiansvaern (exterior masonry paint colors)
Christiansted National Historic Site
Christiansted, St. Croix, U.S. Virgin Islands

PAINT ANALYSIS BY:

Benjamin Nistal-Moret, Architecture Technician, NPS/SERO/OCR

PAINT ANALYSIS REPORT FILED BY:

Benjamin Nistal-Moret

DATES OF INSPECTION AND SAMPLE RETRIEVAL:

10-11 January 1983

18-20 April 1983

PAINT ANALYSIS METHODOLOGY:

As developed by National Park Service, North Atlantic Regional Office, Preservation Center (see enclosed article "Techniques Employed At The North Atlantic Preservation Center For The Sampling And Analysis of Historic Architectural Paints and Finishes", APT, Vol.X, No. 2, 1978)

ANALYSES:

P.01 (northeast bastion, southeast exterior wall, approx. 2'-6" from grade)

substrate (rubble, lime/sand base plaster)
pink wash
yellow wash (samples range 10YR 6/8, 10YR 7/8, 10YR 6/7; considering color/pigment light fastness, 10YR 7/8 might be the most approximate color. Yellow oxide is identified in the Munsell system --using the Liquitex Acrylic and Oil Color Map and Mixing guide-- as 9.7YR 5.9/7)

white wash
red
red
red

P.02 (northeast bastion, southeast exterior wall including upper section of watertable)
substrate (pinkish plaster)
yellow wash (same as p.01)
gray
yellow wash
yellow wash
white wash
red
red
red

P.03 (northeas bastion, southeast exterior wall including upper and lower section of watertable)
substrate (pinkish plaster)
gray
white wash
yellow wash (same as P.01)
yellow wash
gray (corresponds to lower section of watertable)
N4.5 15.6%
white plaster
pinkish red wash
red
red

P.04 (east curtain, notheast section of wall including upper and lower sections of watertable)
identical stratigraphy to P.03

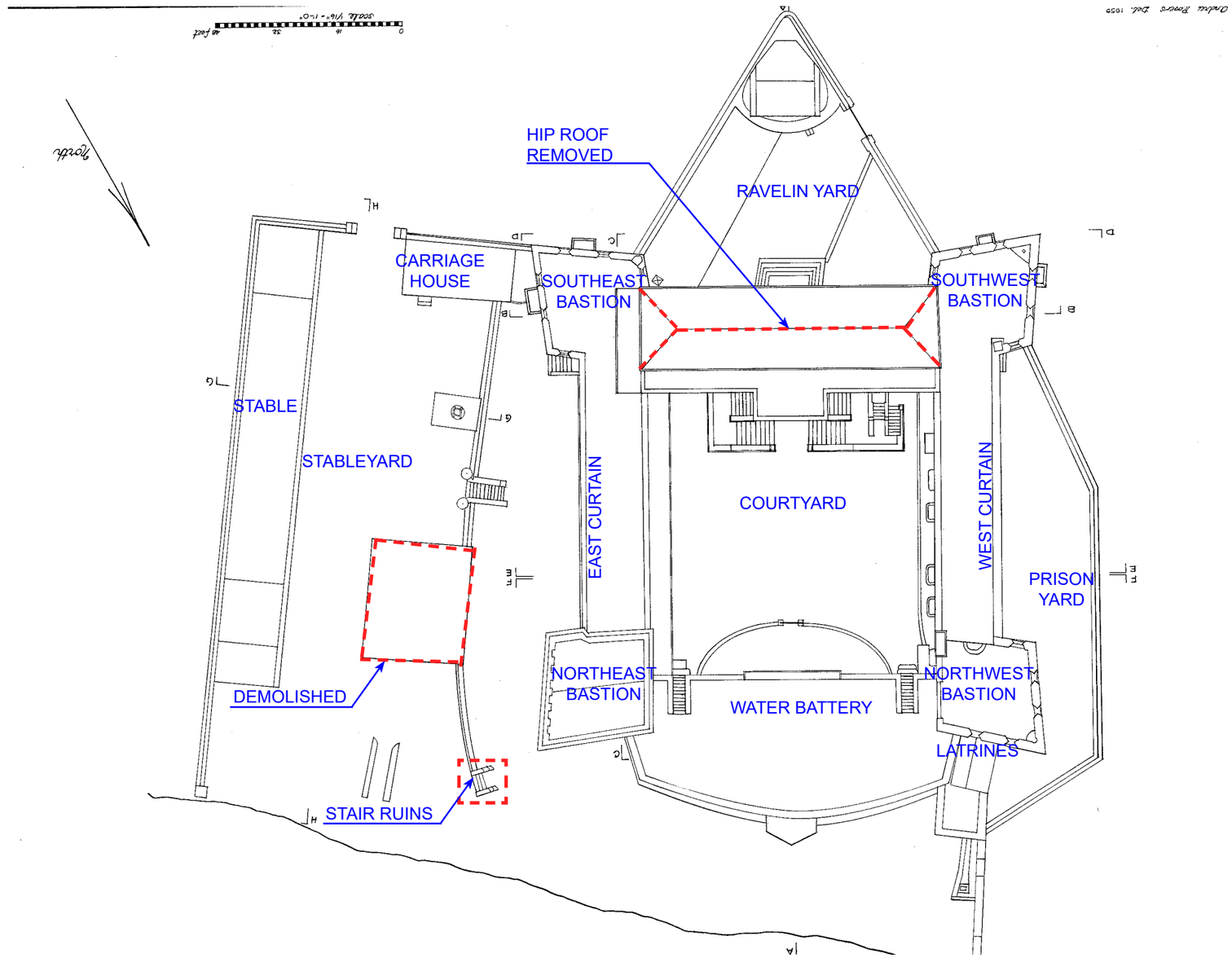
P.05 (stable, north wall facing bay, below sill)
substrate (pinkish plaster)
yellow wash (same as P.01)
white
gray (similar to gray in watertable)

pinkish red wash
red
red
red

RECOMMENDATIONS:

1. All exterior masonry walls at Fort Christiansvaern be painted with a lime base wash color yellow (Munsell 10YR 7/8)
2. All exterior masonry walls (lower sections) be painted with a lime base wash color gray (Munsell N4.5 15.6R)
3. All exterior masonry trim be painted white
4. These recommendations are based on factual, historic, and analytical study as reported on Architectural Finishes At Fort Christiansvaern The Von Scholten Period: 1827-1848.

Appendix B.
Existing Floor Plans with Room Names/Numbers Used by BCA



CONTEXT PLAN
SCALE: 1/32” = 1’-0”

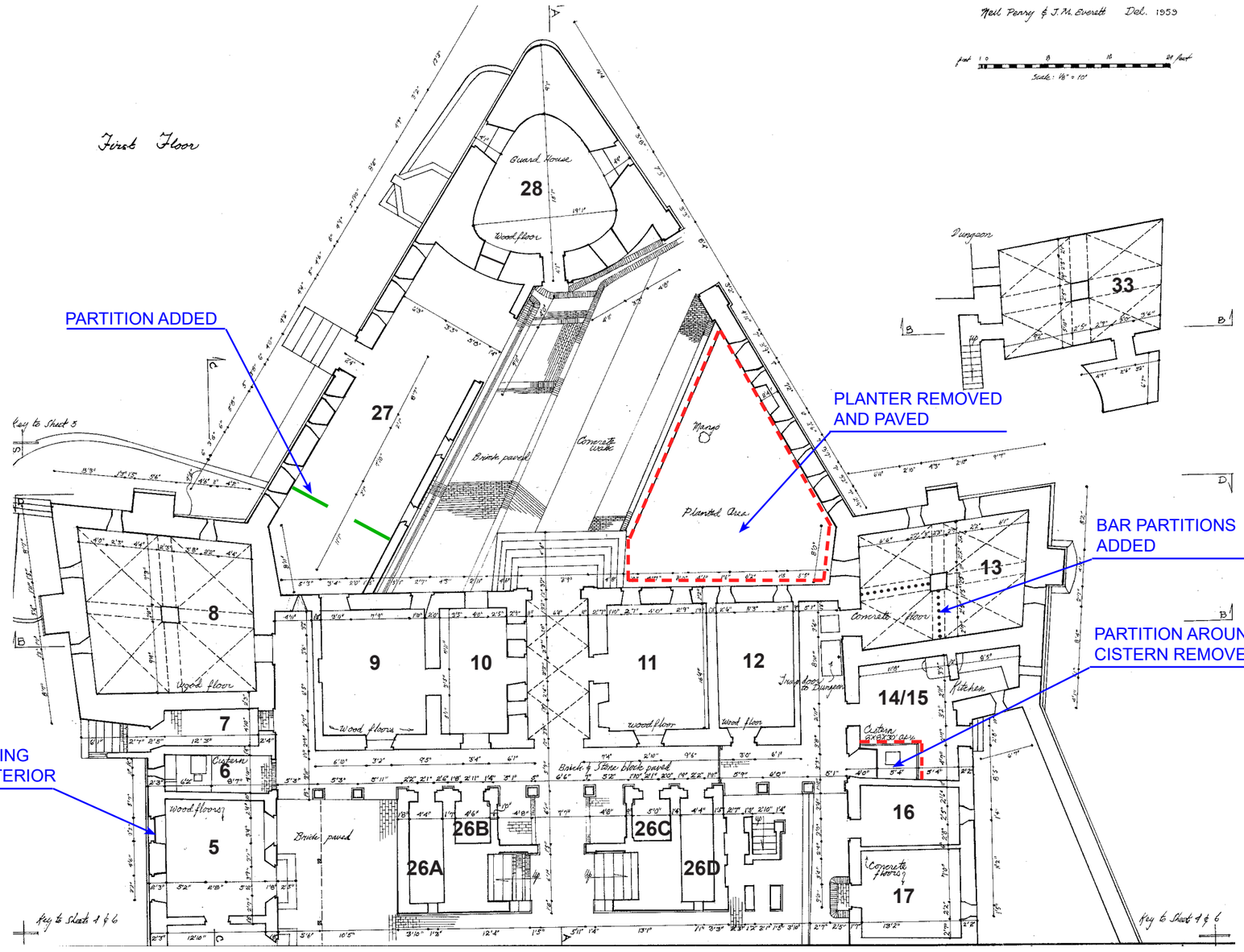
PLAN
NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN

CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE: 07.01.2021
RECORDED BY: JKO, RJH, JPA
SCALE: 1/32” =1’-0”
HSR APPENDIX C: SHEET 1



FIRST-FLOOR PLAN (SOUTH)
SCALE: 1/16” = 1’-0”

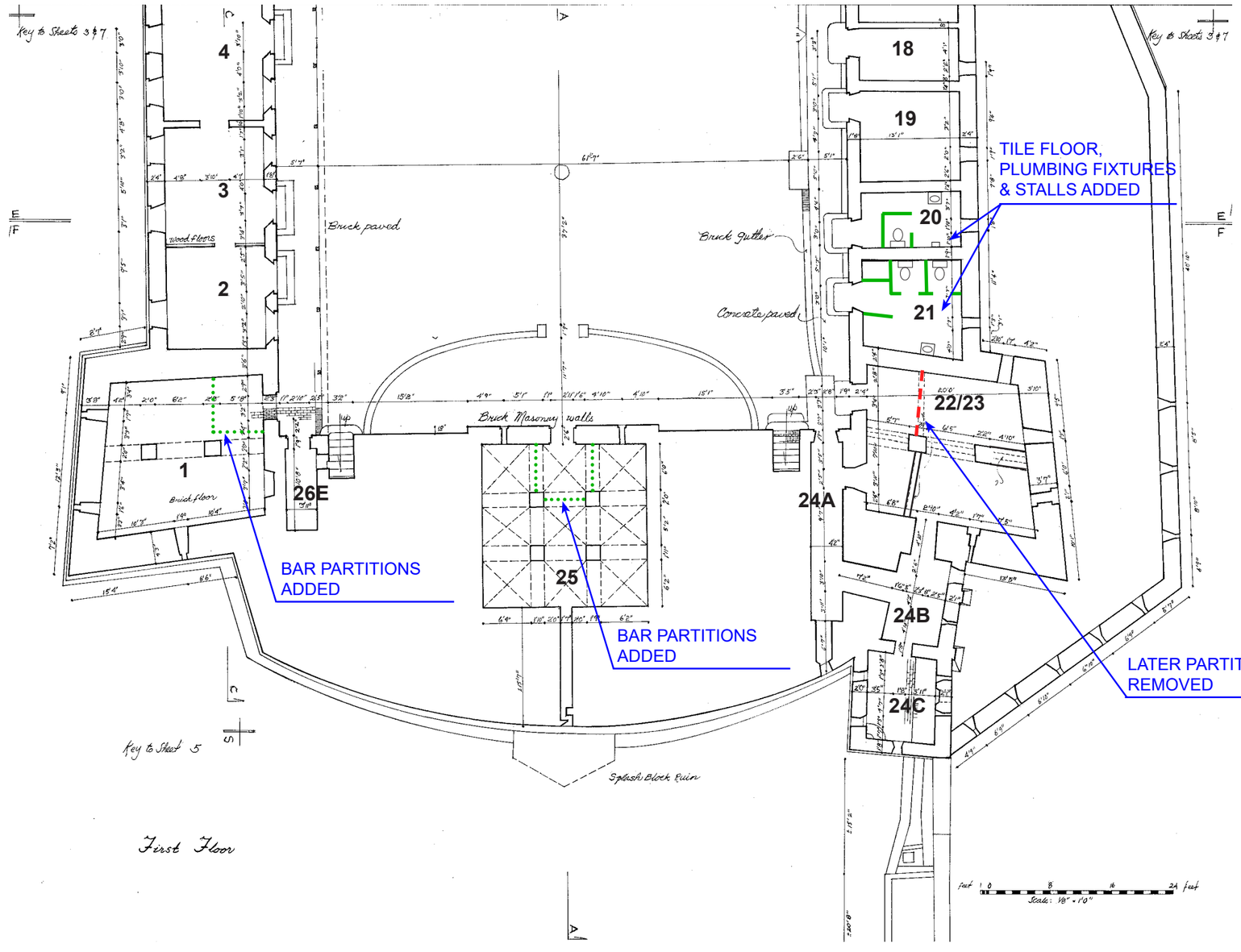
PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN

CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE: 07.01.2021
RECORDED BY: JKO, RJH, JPA
SCALE: 1/16” =1’-0”
HSR APPENDIX C: SHEET 2



First Floor

FIRST-FLOOR PLAN (NORTH)
SCALE: 1/16” = 1’-0”

PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

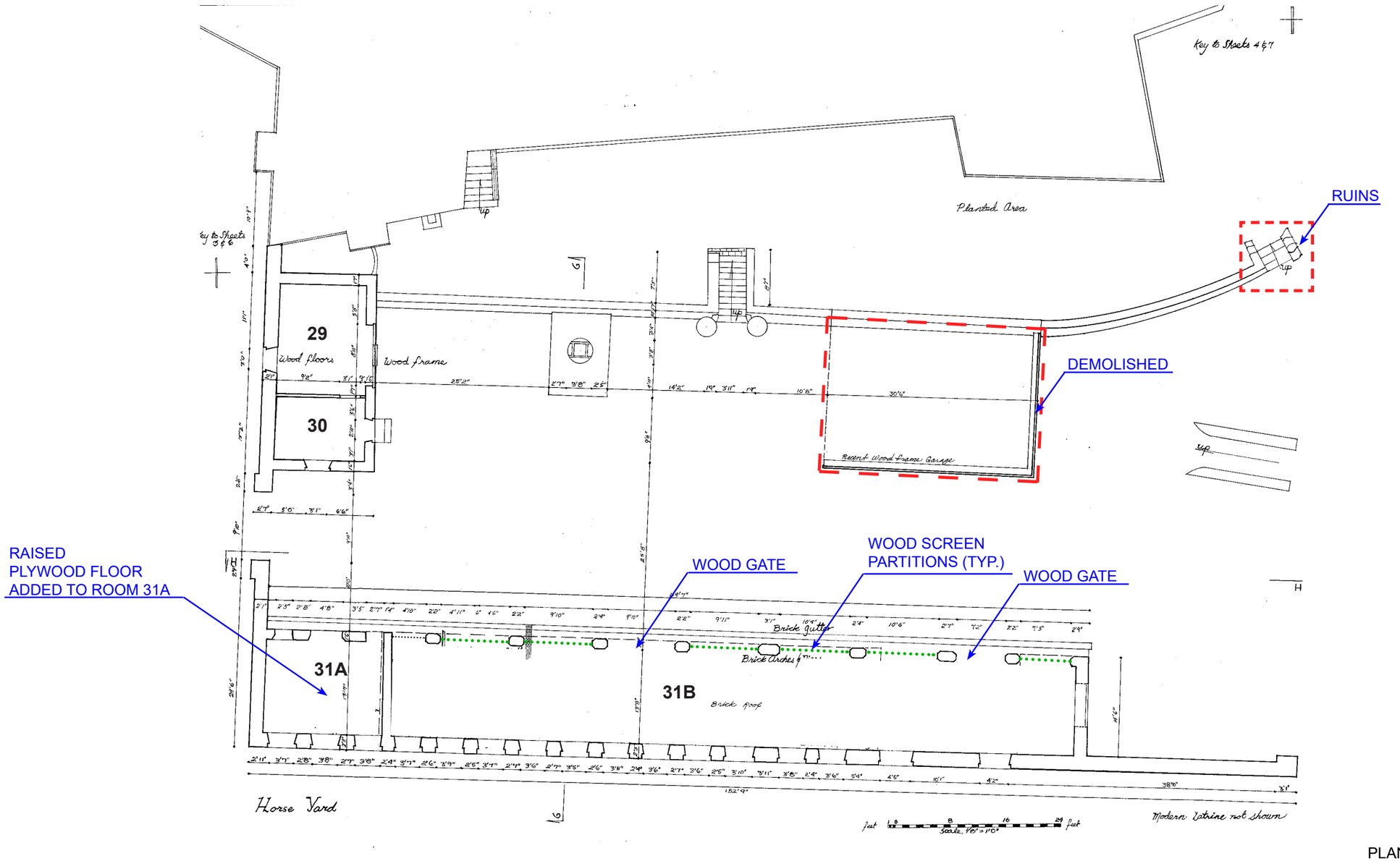
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR APPENDIX C: SHEET
3



STABLEYARD PLAN
SCALE: 1/16” = 1’-0”

PLAN
NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN

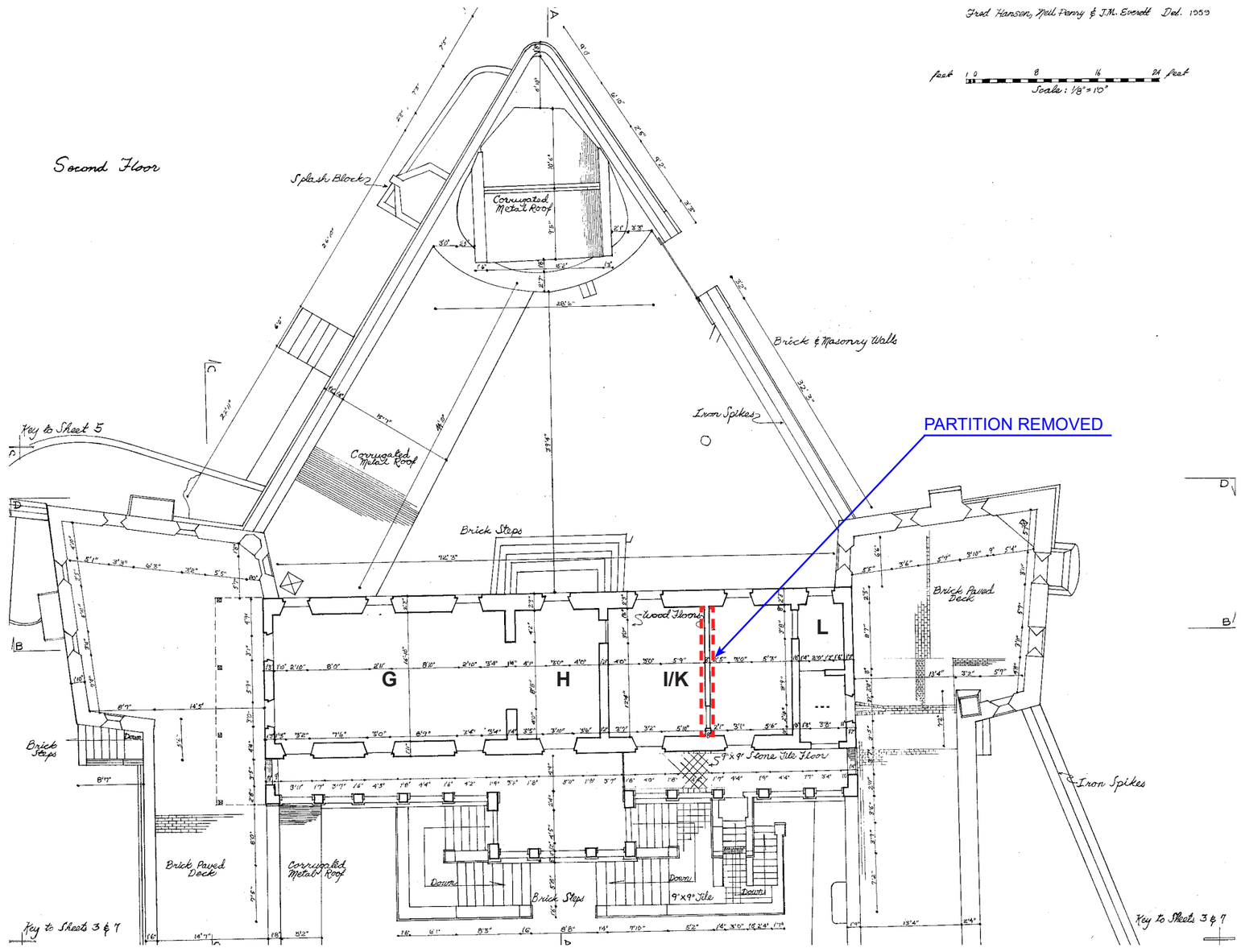
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE: 07.01.2021
RECORDED BY: JKO, RJH, JPA
SCALE: 1/16” =1’-0”
HSR APPENDIX C: SHEET 4

Fred Hansen, Will Penny & J.M. Everett Del. 1953

feet 1 0 8 16 24 feet

Scale: 1/8" = 1'0"



PARTITION REMOVED

SECOND-FLOOR PLAN (SOUTH)

SCALE: 1/16" = 1'-0"

PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

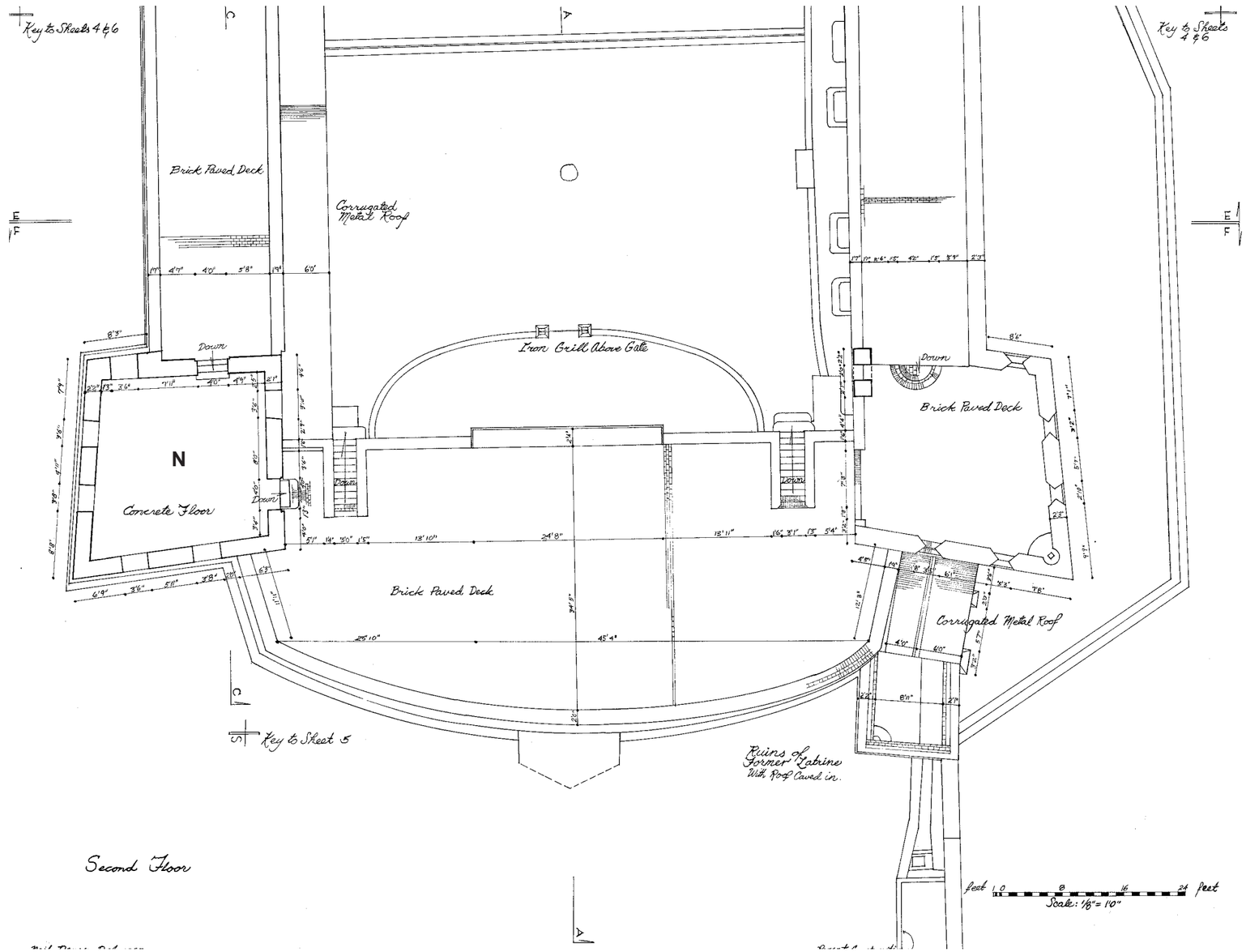
FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16" =1'-0"

HSR APPENDIX C: SHEET
5



SECOND-FLOOR PLAN (NORTH)
SCALE: 1/16” = 1’-0”

PLAN NORTH

JOSEPH K. OPPERMANN - ARCHITECT, P.A.
WINSTON-SALEM, NORTH CAROLINA

FORT CHRISTIANSVAERN
CHRISTIANSTED NATIONAL HISTORIC SITE
CHRISTIANSTED, VI

RECORDATION DATE:
07.01.2021

RECORDED BY:
JKO, RJH, JPA

SCALE:
1/16” =1’-0”

HSR APPENDIX C: SHEET
6

Appendix C.
List of Sample Locations

Fort Christiansvaern
List of Sample Locations
Removed June 2021

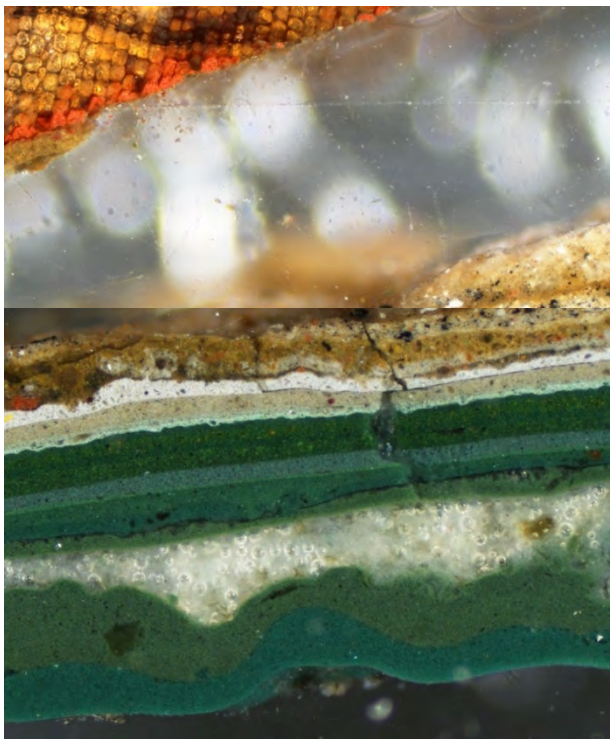
Masonry Materials

Mortar.1	First Floor, South Curtain. Room 12, west wall, mortar.
Mortar.2	First Floor, South Curtain. Room 12, west wall, plaster.
Mortar.3	First Floor, South Curtain. Room 26C, slave cell, east wall, mortar.
Mortar.4	First Floor, South Curtain. Room 26C, slave cell, northeast column, mortar.
Mortar.5	First Floor, South Curtain. Room 26C, slave cell, northeast column, stucco.
Mortar.6	First Floor, South Curtain. Room 26D, slave cell, mortar.
Mortar.7	First Floor. Room 6, south wall (area of existing penetrations), mortar. Three mortars present: 7A, 7B, 7C.
Mortar.8	First Floor. Room 26E, east wall, mortar.
Mortar.9	First Floor. Room 24A, north wall, embrasure, plaster/stucco.
Mortar.10	First Floor. Room 24B, west wall, embrasure with iron bars, plaster/stucco. Sample removed from interior.
Mortar.11	First Floor. Room 24B, west wall, embrasure with iron bars, plaster/stucco. Sample removed from exterior.
Mortar.12	First Floor, Exterior. West wall, stucco. Sample taken from prison yard adjacent to embrasure of samples Mortar.11 and Mortar.12.
Mortar.13	First Floor, Exterior. West wall, stucco. Sample taken at rectangular opening in west wall of latrine.
Mortar.14	First Floor. Room 24B, north wall. Two samples: plaster (14A) and mortar (14B).
Mortar.15	First Floor. Room 16, south wall, mortar/plaster of brick-between-post construction.
Mortar.16	First Floor. Kitchen, south wall, mortar.
Mortar.17	First Floor. Room E, south return of east window (behind wood frame), stucco.
Mortar.18	First Floor. Room E, west return of south window, stucco.
Mortar.19	Second Floor, South Curtain. East half of gallery, north wall, window opening, mortar.
Mortar.20	Second Floor, South Curtain. East half of gallery, north wall, window opening, mortar.
Mortar.21	Second Floor, East Elevation (exterior wall of south curtain). Multiple pieces of sample: brick substrate (21A), mortar (21B), white stucco (21C), gray stucco (21D).
Mortar.22	First Floor, South Curtain. Underside of west stair, stucco.
Mortar.23	First Floor, South Curtain. Wall surrounding door into Room 12, stucco.

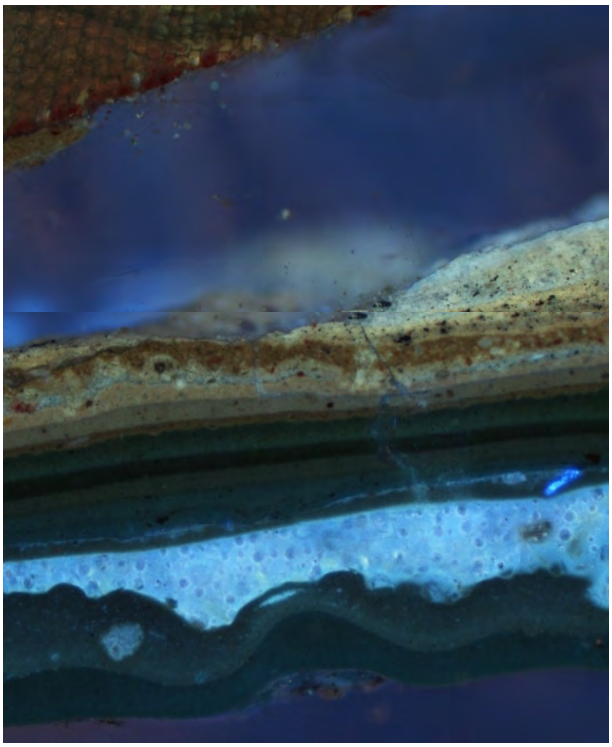
Paint Finishes

F.1	First Floor, South Curtain. West half of corridor, wood frame of corridor opening.
F.2	First Floor, South Curtain. South wall of corridor, door to Room 12, casing.
F.3	First Floor, South Curtain. Room 12, north wall, door casing.
F.4	First Floor, South Curtain. Room 12, ceiling, underside of second floor joist (beaded), currently covered by tongue-and-groove board ceiling.
F.5	First Floor, South Curtain. Room 12, east wall, stencil.
F.6	First Floor, South Curtain. Room 12, west wall, dado (currently gray).
F.7	First Floor, South Curtain. Room 26C, northeast column, painted brick.
F.8	First Floor. Room 24A, north wall, embrasure, plaster/stucco.
F.9	First Floor. Room 24B, west wall, embrasure with iron bars, stucco.
F.10	First Floor. Room 24B, west wall, embrasure with iron bars, stucco.
F.11	Second Floor, South Curtain. East half of gallery, north wall, window opening, painted brick.
F.12	Second Floor, South Curtain. East half of gallery, north wall, window opening, painted brick/mortar.
F.13	Second Floor, East Elevation (exterior wall of south curtain). Painted brick under later stucco.
F.14	First Floor, South Curtain. Underside of west stair, stucco.
F.15	First Floor, South Curtain. Wall surrounding door into Room 12, stucco.

Appendix D.
Photomicrographs and Stratigraphy Charts of Finish Samples



Visible light, 40x



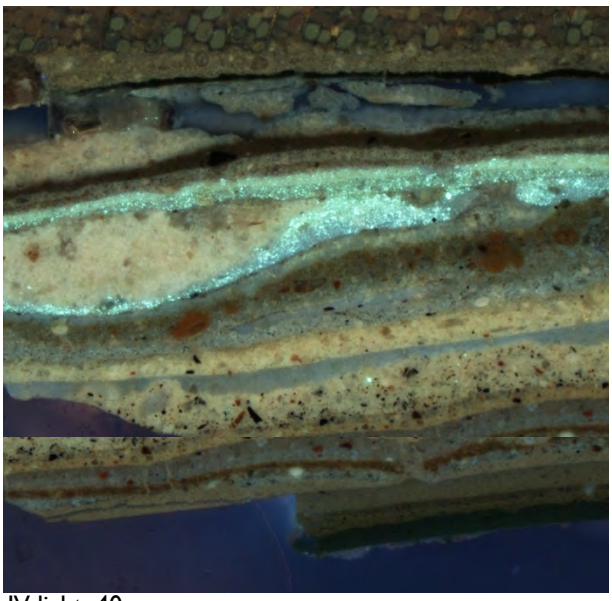
UV light, 40x

SAMPLE NO:	F.1
LOCATION:	First Floor, South Curtain. West half of corridor, wood frame of corridor opening.

LAYER	**COLOR**	**NOTES**
Substrate	wood	red-orange pigment/stain in pores of wood
1	pale brown	
2	gray	
3	yellow brown	
4	gray	
5	pale gray/white	
6	khaki	
7	pale green	
8	dark green	
9	dark green	
10	blue- green	
11	dark green	
12	dark green	
13	green	
14	white	spackle? plaster?
15	dark green	
16	dark green	



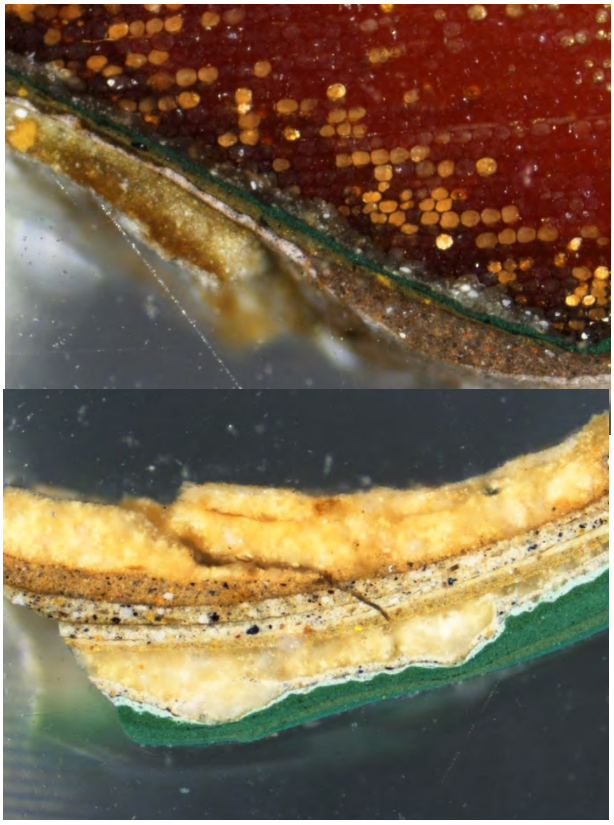
Visible light, 40x



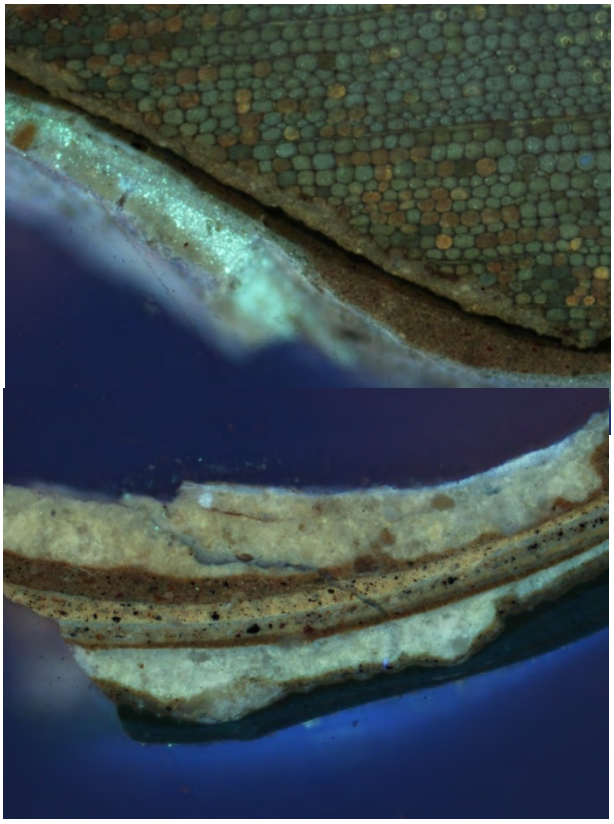
UV light, 40x

SAMPLE NO:	F.2
LOCATION:	First Floor, South Curtain. South wall of corridor, door to Room 12, casing.

LAYER	COLOR	NOTES
Substrate	wood	
1	dark gray	
2	dark green	
3	cream	
4	dark gray	
5	white	
6	olive green	
7	yellow brown	
8	olive-green	
9	brown	
10	tan	
11	tan	
12	tan	
13	tan	
14	tan	
15	tan	
16	tan	
17	khaki	
18	tan	
19	tan	
20	light gray	
21	khaki	
22	light green	
23	dark green	



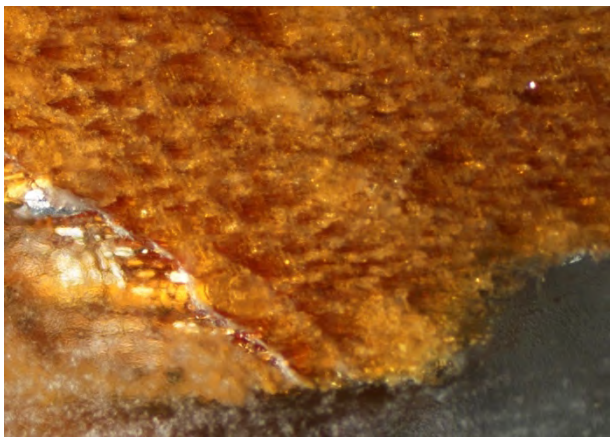
Visible light, 40x



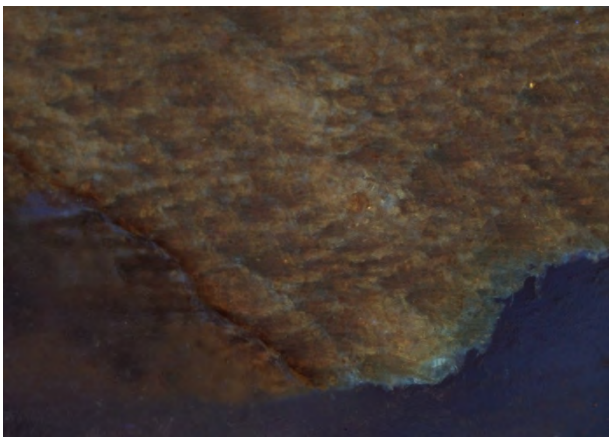
UV light, 40x

SAMPLE NO:	F.3
LOCATION:	First Floor, South Curtain. Room 12, north wall, door casing.

LAYER	COLOR	NOTES
Substrate	wood	
1	dark gray	
2	dark green	
3	olive green	
4	brown	
5	cream	
6	brown	
7	khaki	
8	pale gray	
9	cream	
10	white	
11	light green	
12	dark green	
13	dark green	
14	dark green	



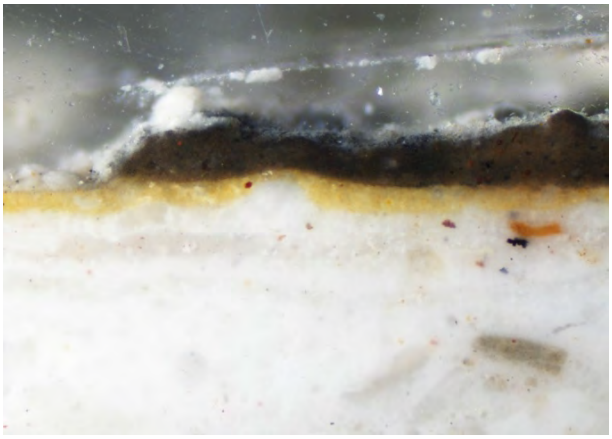
Visible light, 40x



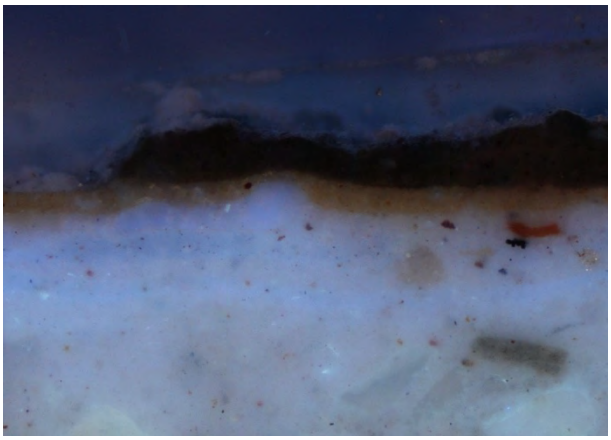
UV light, 40x

SAMPLE NO:	F.4
LOCATION:	First Floor, South Curtain. Room 12, ceiling, underside of second floor joist (beaded), currently covered by tongue-and-groove board ceiling.

LAYER	**COLOR**	**NOTES**
Substrate	wood	
1	yellow brown	not visible in photo
2	pale gray	not visible in photo



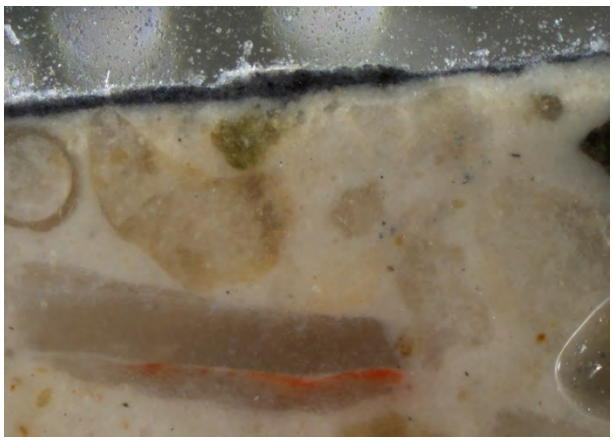
Visible light, 40x



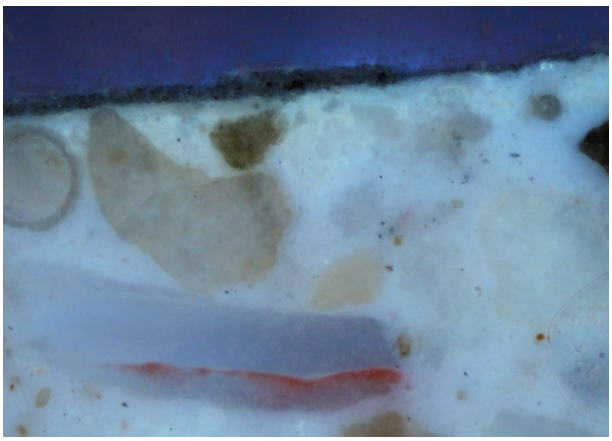
UV light, 40x

SAMPLE NO:	F.5
LOCATION:	First Floor, South Curtain. Room 12, east wall, stencil.

LAYER	**COLOR**	**NOTES**
Substrate	plaster	
1	ochre	limewash? stencil background
2	dark gray/black	limewash? stencil pattern



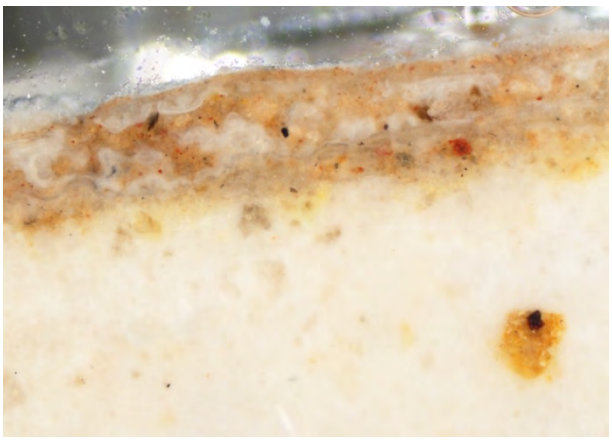
Visible light, 40x



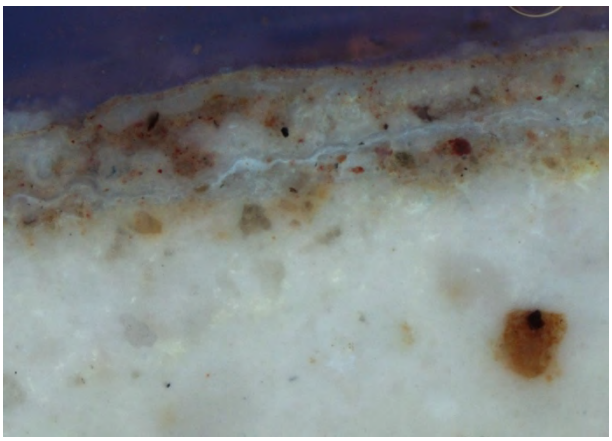
UV light, 40x

SAMPLE NO:	F.6
LOCATION:	First Floor, South Curtain. Room 12, west wall, dado (currently gray).

LAYER	**COLOR**	**NOTES**
Substrate	plaster	
1	dark gray	limewash?



Visible light, 40x



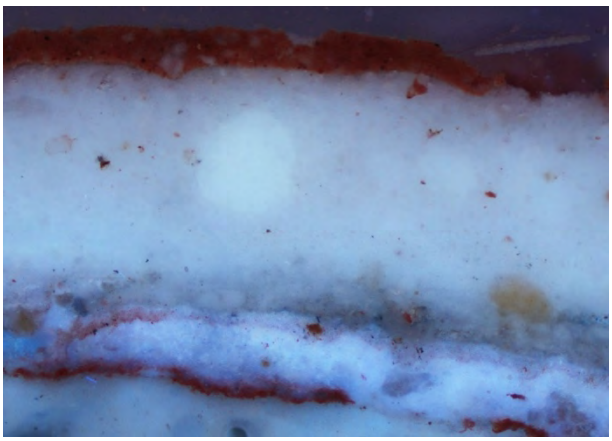
UV light, 40x

SAMPLE NO:	F.7
LOCATION:	First Floor, South Curtain. Room 26C, northeast column, painted brick.

LAYER	COLOR	NOTES
Substrate	brick	
1	brown	limewash
2	brown	limewash



Visible light, 40x



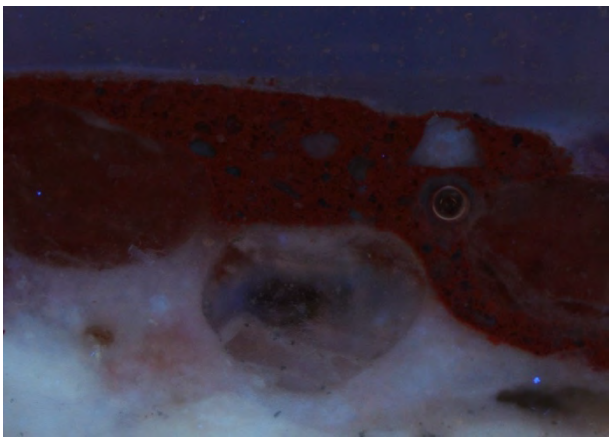
UV light, 40x

SAMPLE NO:	F.8
LOCATION:	First Floor. Room 24A, north wall, embrasure, plaster/stucco.

LAYER	**COLOR**	**NOTES**
Substrate	plaster/stucco	
1	white	
2	red	limewash?
3	white	
4	red	limewash?
5	white	
6	red	



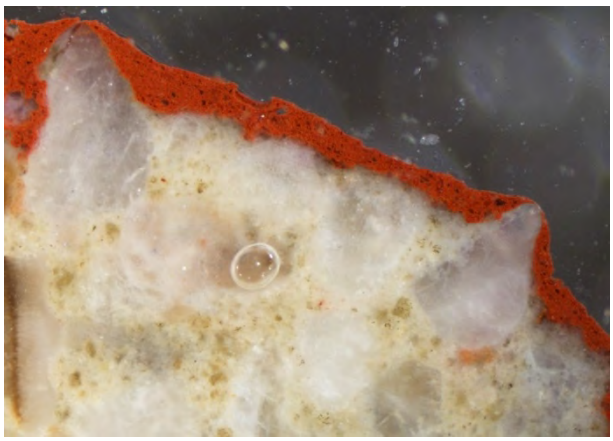
Visible light, 40x



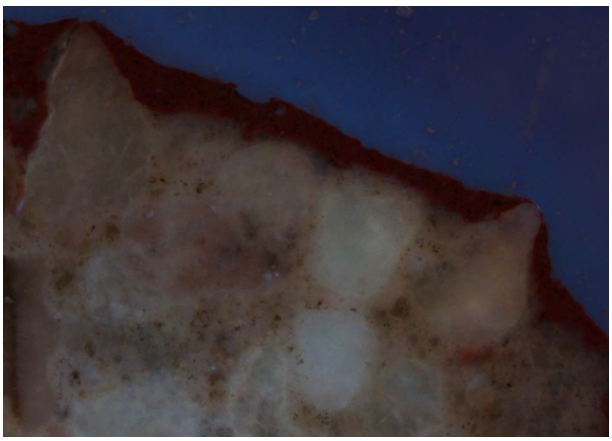
UV light, 40x

SAMPLE NO:	F.9
LOCATION:	First Floor. Room 24B, west wall, embrasure with iron bars, stucco.

LAYER	COLOR	NOTES
Substrate	stucco	
1	red	



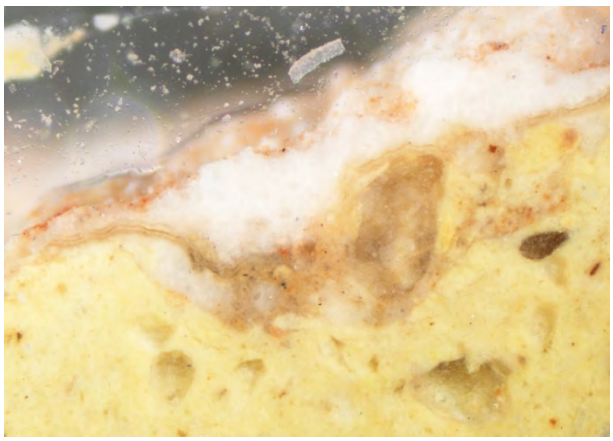
Visible light, 40x



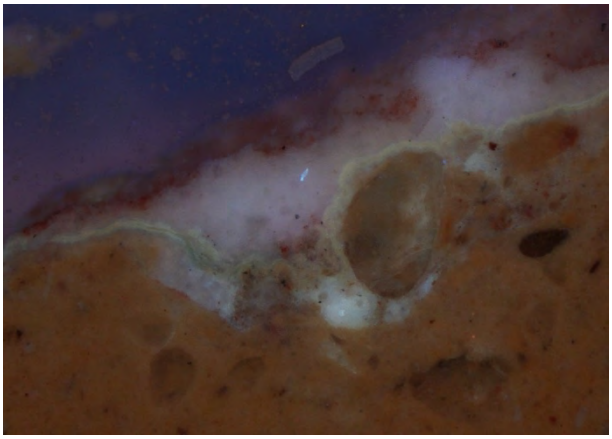
UV light, 40x

SAMPLE NO:	F.10
LOCATION:	First Floor. Room 24B, west wall, embrasure with iron bars, stucco.

LAYER	COLOR	NOTES
Substrate	stucco	
1	red	



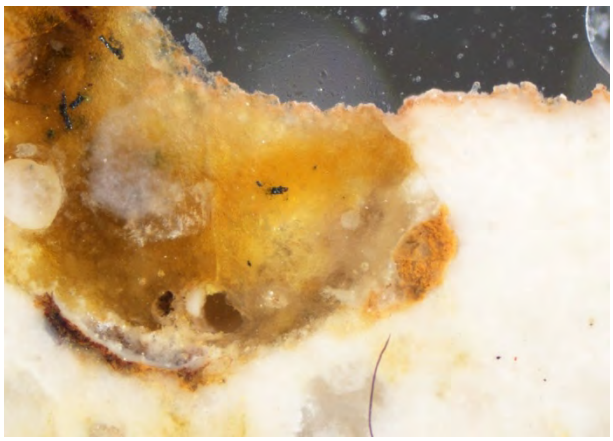
Visible light, 40x



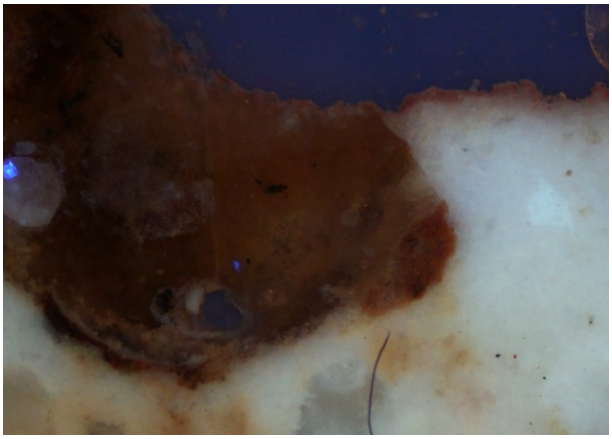
UV light, 40x

SAMPLE NO:	F.11
LOCATION:	Second Floor, South Curtain. East half of gallery, north wall, window opening, painted brick.

LAYER	**COLOR**	**NOTES**
Substrate	brick/mortar	
1	red/pink	limewash
2	white	mortar
3	red/pink	limewash



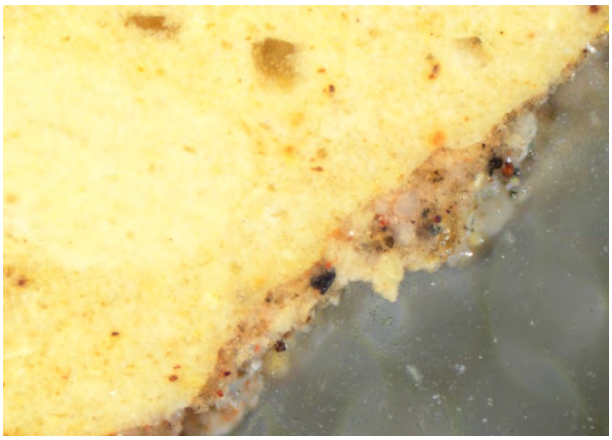
Visible light, 40x



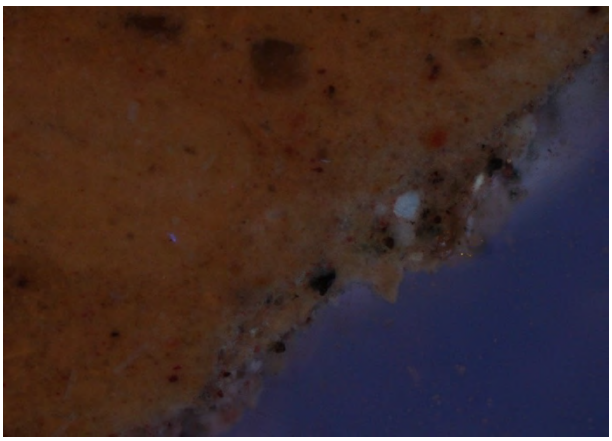
UV light, 40x

SAMPLE NO:	F.12
LOCATION:	Second Floor, South Curtain. East half of gallery, north wall, window opening, painted brick/mortar. Early layers only.

LAYER	**COLOR**	**NOTES**
Substrate	brick	
1	red/dark pink	limewash



Visible light, 40x



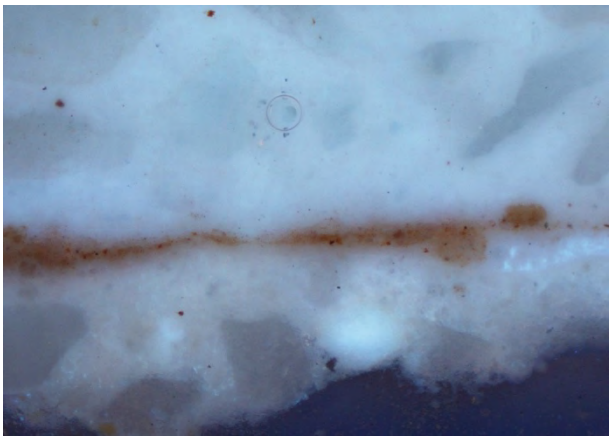
UV light, 40x

SAMPLE NO:	F.13
LOCATION:	Second Floor, East Elevation (exterior wall of south curtain). Painted brick under later stucco.

LAYER	**COLOR**	**NOTES**
Substrate	brick	
1	red/dark pink	limewash



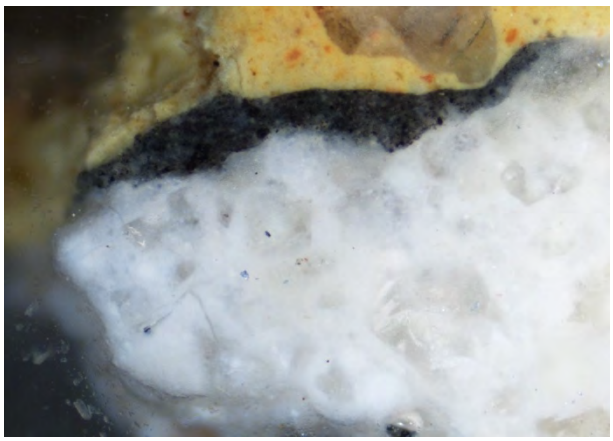
Visible light, 40x



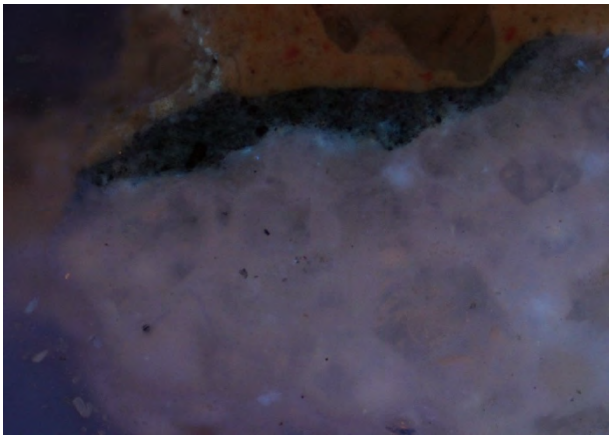
UV light, 40x

SAMPLE NO:	F.14
LOCATION:	First Floor, South Curtain. Underside of west stair, stucco. Early layers only.

LAYER	COLOR	NOTES
Substrate	stucco	
1	white	limewash?
2	ochre yellow	limewash?
3	white	stucco



Visible light, 40x



UV light, 40x

SAMPLE NO:	F.15
LOCATION:	First Floor, South Curtain. Wall surrounding door into Room 12, stucco.

LAYER	COLOR	NOTES
Substrate	stucco	
1	dark gray	
2	yellow	

Appendix E.
Mortar Analysis Report (Highbridge Materials Consulting)

Mortar Analysis Report

Fort Christiansvaern National Historic Site

Christiansted, Saint Croix, U.S. Virgin Islands



Prepared for
Building Conservation Associates, Inc.

Client ID
BUIL005

Report No.
SL1673-01R.1

Original Report Date
10/18/22

Revision Date
06/19/23

HIGHBRIDGE MATERIALS CONSULTING, INC.

404 Irvington Street, Pleasantville, NY 10570 | 914-502-0100 | www.highbridgematerials.com

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Cover Image

Photograph of Fort Christiansvaern, entrance at the east elevation. Image courtesy of Ms. Dorothy Krotzer of Building Conservation Associates, Inc.

Revision History

This revision supersedes Highbridge Report SL1816-01. The client has requested that two typographical errors in the figure captions be amended for this revised report. No substantive changes have been made to the text.

Respectfully submitted,

John J. Walsh
President/ Senior Petrographer
Highbridge Materials Consulting, Inc.

Heather Hartshorn
Chemist/ Staff Scientist
Highbridge Materials Consulting, Inc.

1. Executive Summary

Three mortar samples are examined petrographically and chemically for this report. The samples are reported to have been taken from masonry walls at Fort Christiansvaern, Saint Croix, U.S. Virgin Islands. The mixtures are generally similar though there are variations in sand compositions and gradations. This could indicate that the samples represent different construction eras. However, there are no materials present that would not have been available during the original eighteenth century construction.

All three mortars have a grainy to slightly pebbly texture and a light, warm-toned color. Samples M2 and M4 have a moderately soft binder paste but an overall cohesive and fairly indurate quality. Sample M3 is softer and more friable. All are highly water-permeable.

The samples are identified as nonhydraulic lime mortars. There is evidence in Sample M3 to suggest that the lime was manufactured from fossil coral. All are high-calcium products. The mortars contain clean and well-graded natural coralline sands. Binder to sand ratios are estimated at 1 : 1.7 for Sample M2, 1 : 0.9 for M3, and 1 : 0.5 for Sample M4. The materials were mostly well-prepared though the mortar represented by Sample M3 is estimated to have been prepared with more mix water than necessary to yield good workability. This is likely responsible for the weaker character of this one sample.

All mortars are fully carbonated as expected for the long service life. The only other secondary chemical effects noted are present in Sample M4. This includes a thin carbonate scale below an overlying lime wash, and drusy chloride (?) salts within pores.

2. Introduction

Between August 27, and September 17, 2021, Highbridge received three mortar/stucco samples reported to have been sampled from Fort Christiansvaern in Saint Croix, U.S. Virgin Islands. The fort was constructed between 1738 and 1749 with significant repair and reconstruction occurring through to the present day. A summary of the received samples and descriptions provided by the client are given in Table 2.1. Highbridge has chosen a shorthand for the sample identifications as indicated in the table, and these are used throughout the remainder of the report.

Table 2.1: Summary of Samples Received

Client ID	HMC ID	Client description
CHRI.Mortar.1	M1	First floor level, "Room 12", interior, west wall, mortar/parging/plaster. Earliest existing mortar on this wall.
CHRI.Mortar.2	M2	First floor level, "Room 12", interior, west wall, brick mortar/plaster. Applied over CHRI.Mortar.1 and also found on several alterations to this room.
CHRI.Mortar.3	M3	Removed from a brick wall that appears to have been constructed before 1799, based on a review of historic building plans. The sample is believed to be the same as CHRI.Mortar.1.
CHRI.Mortar.4	M4	First floor level, "Room 26C", interior, east wall, brick mortar. Sample was removed from a brick column that was enclosed by 1799 (based on a review of historic building plans), indicating this area may represent a preserved, intact area of brick masonry dating from 1738-99. The mortar/stucco applied directly over this brick mortar is the same as CHRI.Mortar.1.

At the client's request, a compositional analysis is performed on three of the four samples (all but Sample M1). The testing includes a petrographic examination and chemical analysis to identify constituents, estimate proportions, and assess overall condition. Acid digestions to extract sand samples for description and gradation are also included.

3. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within ASTM C1324-20a. Data collection is performed or supervised by a degreed geologist who by nature of their education is qualified to operate the analytical equipment employed. Analysis and interpretation are performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 4 of ASTM C856/C856M-20.

Chemical analysis is performed in general accordance with the procedures outlined in ASTM C1324-20a. Water, carbon dioxide, and aggregate weight percentages are determined gravimetrically. Oxide weight percentages are determined by inductively coupled plasma - optical emission spectroscopy (ICP-OES). While ASTM classifies C1324 as a test method, it is intended to serve as a guideline for qualified practitioners with ample experience in the various materials under consideration. Section 10.2 indicates the need for discretion on the part of the laboratory to ensure that methods are tailored to specific mortar compositions. As such, Highbridge chooses specific digestion methods, supplementary tests, instrumentation protocols, and mathematical models to best characterize each individual mortar under consideration. Many of these are proprietary methods that have been researched internally.

The following personnel contributed to the examination:

Technician:	A. Ledwitch
Scientific Assistant:	J. Negron
Staff Scientist:	L. Rocha
Chemists:	H. Hartshorn
	M. Sinclair
Petrographer:	J. Walsh

4. Laboratory Findings and Discussion

4.1 - Materials

All three samples provided for examination have a light, warm-toned color and a somewhat grainy texture. The texture is notably coarser in Sample M3. The colors vary somewhat as summarized in Table 4.1a. The paste is soft in Sample M3 and the matrix appears a bit crumbly. The binder matrix is moderately soft in Samples M2 and M4 but these samples appear more cohesive. All mortars are permeable.

Table 4.1a: Mortar Color

Sample ID	Color	Munsell code
M2	Yellowish-white	2.5Y 8.75/1.25
M3	Very pale orange	10YR 8.5/2.5
M4	Very light buff	10YR 9/1.5

All three samples contain clean coralline sands that are generally similar in composition. Minor differences between the samples are highlighted in Table 4.1b. Much of the sand consists of the eroded skeletal remains of reef-building organisms and associated invertebrates. The biological fragments include those derived from algae, corals, and snails for the most part. Rock particles are also found in variable concentration. These include sand-sized grains of biomicritc limestone. Volcanic grains and other siliceous materials are also trace to minor components. Clay coatings or friable materials are negligible if not entirely absent. The organic remains often have an open porosity but particles these clearly have good mechanical strength.

Sand samples were extracted from all three mortars. The aggregates are mostly uniform with a semi-opaque visual character. Average colors are light buff with some minor to moderate color variegation in the coarser grains, particularly in Sample M3. The aggregate is soft-textured with grain shapes that are mostly subrounded and equidimensional. Gradation analyses were performed on all three sand samples and these results are presented in Section 6. Samples M2 and M4 with only traces of siliceous grain types have nominal top sizes at the No. 8 sieve and peak abundances near the No. 30 sieve. Sample M3 contains a higher quantity of volcanic particles. As most of these are coarser-grained, the nominal top size is found at the 3/8" sieve for this sample. The peak abundance for this sand is between the No. 16 and N0. 30 sieves. Though some minor amount of crystalline calcite fines is observed petrographically for all three samples, there is no significant clay or unwashed fine debris associated with the aggregate of any sample. Compared to ASTM C144, the modern standard for masonry sands, the aggregates in Samples M2 and M4 would comply with the permissible gradation limits while the aggregate in Sample M3 would be too coarse. Of course, these comments are only made for comparative purposes. The modern standard does not necessarily apply to historical lime-based mortars.

Table 4.1b: Differences in Sand Appearance and Composition
This table presents a summary of some more notable differences in the sand composition present in the three mortar samples. More complete descriptions of the sand components are provided in Tables 5.1 through 5.3.

Sample ID	Munsell color (average)	Biological forms	Biomicrite grains	Siliceous grains
M2	10YR 7.75/1.25	Halimeda dominant	Minor	Trace quartz and volcanics
M3	9YR 7/2	Coral dominant	Abundant	Minor feldspathic volcanics
M4	10YR 8/1.75	Biodiverse, coral with both aragonite and calcite	Abundant	Trace polycrystalline quartz

The binder in all three samples is a high-calcium, nonhydraulic lime. No cementitious materials or pozzolans are identified in any of the mixtures. The cured lime pastes have a high capillary porosity and this is typical of lime-based mortars. The microporosity is very high in Sample M3. The mortars lack the microscopic shrinkage cracks that are often observed in pure lime mixes. The hardened binders all have uniform microtextures though the paste in Sample M3 has a notable grainy character at the microscopic scale.

The chemical analysis was used to estimate the lime compositions and these results are presented in Table 7.4. Though the lime could have been prepared from the same source material, there is too much variation in the minor impurities to be able to make this determination. All are clearly high-calcium varieties with too few siliceous and aluminous impurities to have produced any meaningful hydraulicity. On a pre-slaked basis, the lime in Samples M2 and M4 have CaO contents greater than 95%. The measured CaO in Sample M3 is a little lower at 91%. However, it is suspected that some of the more soluble components of the volcanic aggregate have mobilized in service.

The lime was quite well dispersed and the putty may even have been screened before use. Discrete lime particles are fairly uncommon in all samples and most are nondescript. However, there are a few grains identified petrographically in Sample M3 that contain pore structures similar to those observed in the skeletons of scleractinian corals. It seems likely for this mortar that fossil coral was used to produce the lime. This may have also been true of the other samples though only one other scarce piece of petrographic evidence was observed in Sample M4.

4.2 - Component Proportions

The component proportions are estimated from the chemical analysis presented in Section 7. As summarized in Table 4.2a, the sand contents are lower than would be expected in a modern masonry mortar. However, pure lime mortars with lime to sand proportions of about 1 : 1 on average were typical in Colonial Era mortars of the Americas. Mixes with lower sand contents can be volume-stable and even more durable than sandier mixtures provided mix water contents are controlled.

Table 4.2a: Summary of Mixture Proportions
The ratios reported here calculate the lime in the form of a putty rather than a dry hydrate.

Sample ID	Lime : sand ratio
M2	1 : 1.7
M3	1 : 0.9
M4	1 : 0.5

4.3 - Condition and Service Performance

Based on the examined sample pieces, the constituents were well-blended in all three mortars. No streaks or clots of lime or sand are identified. In fact, undispersed lime particles are rarely coarser than 1 millimeter and there are relatively few of these overall. This suggests that the lime may have been screened before use. All mortars are compact and well-consolidated. The only evidence for a workmanship deficiency is in the particularly high capillary porosity and somewhat friable and crumbly matrix of Sample M3. This suggests a higher mix water content than necessary to produce a workable mix. Still, the qualities of the hardened product are not outside those typically observed in historical high-calcium lime mortars. Mix water contents are estimated to have been more appropriate in the other two samples. The more cohesive and somewhat indurate quality of these two mortars can probably be attributed to lower mix water contents. These two mortars were likely fatty though stiff when freshly-prepared. The sand gradations also likely contributed to greater cohesive strength where mix water contents were not excessive. All else being equal, mortars with coarser sand are stronger than those with finer sand. Regardless of any strength variation, all three mortars are highly water-permeable as expected for the design.

The lime paste is fully carbonated in all examined samples and this is a normal and desirable consequence of long-term curing. No microcracking is identified petrographically and there is no physical distress observed in any sample. Though there is some microscopic granularity in the carbonated lime of Sample M3, none of the lime paste is chemically altered or decomposed.

Secondary salt deposits are only identified in Sample M4 and none have been observed to have caused any physical damage. These include thin carbonate scale deposits between the original tooled face and one to two layers of lime wash. There are also fine salt deposits within pores and at the rear surfaces of some of the sample pieces. The optical isotropism, low relief, and occasional cubic character suggests a chloride salt. However, no further instrumental analysis was performed to confirm this identification. It should be noted that the lack of observed soluble salts in the other two samples is not necessarily an indication that they are absent. It is always possible for salt to be present in submicroscopic capillaries but not visible at the scale of the light microscope.

5. Petrographic Data

Table 5.1: Petrographic Data - Sample CHRI.Mortar.2

Sample ID	Chri.MORTAR.2
As-received description	
Description	The sample consists of several small to medium mortar fragments and a moderate abundance of granules and powder. The shapes of the larger pieces are mostly angular and irregular. The thickest piece is about 1". The total sample weighs 81 grams.
Surfaces	All surfaces are compact. No tooling or bed surfaces are obvious. However, there are several fresh, unsoiled, planar surfaces with a somewhat rough sandy texture that could represent masonry contacts.
Hardness/friability	The paste is soft to moderately soft. However, the mortar is indurate and nonfriable.
Appearance	Fresh surfaces have a dull luster and a yellowish-white color (Munsell code approximately 2.5Y 8.75/1.25).
Absorptivity	The mortar matrix is very rapidly water-absorptive.
Other details	No cracks or secondary mineralizations are visible in hand sample. White binder grains are very rare and are less than 1 millimeter in size.
Sand	
Lithology	The aggregate is primarily a coralline sand consisting of the eroded skeletal remains of reef-building organisms and associated marine invertebrates. The biological forms that have contributed to the aggregate include green algae (Halimeda), scleractinian coral, red algae, gastropods (snails), foraminifera, and echinoid spines. The latter two are minor. A minor amount of bioclastic limestone intraclasts are also observed. The major forms tend to be variably porous though all appear to be mechanically robust. There are also traces of quartz and undifferentiated volcanic particles.
Appearance	The sand is mostly uniform and opaque to semi-opaque. The overall color is light buff (Munsell color code approximately 10YR 7.75/1.25). Minor darker gray and reddish particles in the +No. 30 fraction provide some color variegation.
Gradation	The sand is medium-grained and broadly graded. The nominal top size is at the No. 8 sieve, the peak abundance near the No. 30 sieve, and the fines content is negligible.
Shape/aspect ratio	Sand shapes are subrounded on average. Aspect ratios are mostly equidimensional to subequant. There is some variability in grain texture due to the high diversity of fossil forms.
Clay coatings/friable materials	No significant clay coatings or friable materials are evident.
Other	None
Binder matrix	
Paste uniformity	The lime paste is uniformly-developed.
Capillary porosity	High
Microscopic shrinkage cracking	None significant
Residual calcium hydroxide	Depleted due to complete carbonation
Evidence for admixtures[1]	None
Binder residuals	
Binder type	High-calcium, nonhydraulic lime
Hydraulic cement	None identified
Lime	Undispersed lime grains are found in very low abundance as fine-grained particles that are internally nondescript and fully carbonated. Grains are always less than 1 millimeter in diameter.
Pozzolans/SCMs[2]	None detected
Other	Very fine-grained bits of wood cinder ash are found in exceedingly trace abundance throughout the lime paste.

Table 5.1 (cont'd.): Petrographic Data - Sample CHRI.Mortar.2

Sample ID	Chri.MORTAR.2
Pigment	
Concentration	None detected
Composition	n/a
Particle size	n/a
Color of extracted pigment	n/a
Other materials	
Details	None
Placement features	
Constituent distribution	The mortar constituents are well-dispersed.
Mix water	There is no variation in paste density that would suggest inconsistent distribution of mix water.
Compaction/consolidation	The mortar is compact and well consolidated.
Estimated air content/structure	The air content is estimated at less than 2% by volume. Voids are mostly spherical and very fine in diameter.
Paste-sand interfaces	Sand grains are well-coated with binder.
Other	None
Secondary effects	
Carbonation	The lime paste is fully carbonated throughout the thickness of the sample pieces provided.
Paste alteration	None detected
Cracking	None significant
Mineral deposits	None detected
Surface erosion/weathering	No obvious joint surfaces are included with the sample.
Other	None

Notes:
1. Organic admixtures or soluble inorganic additives cannot be detected petrographically, though their effects on paste microstructure can sometimes be discerned.
2. SCMs = supplementary cementitious materials.

Table 5.2: Petrographic Data - Sample CHRI.Mortar.3

Sample ID	Chri.MORTAR.3
As-received description	
Description	The sample consists of a mixture of small fragments, granules, and powder. Larger pieces have a lumpy texture due to the differential loss of paste around coarse sand grains. The sample weighs a total of 31 grams.
Surfaces	All surfaces are compact. No tooling or bed surfaces are obvious. There are also no weathered faces and all mortar appears fresh.
Hardness/friability	The paste is soft. The mortar can be handled gently though feels like it would crumble easily(possibly due to weak paste-aggregate interfaces). The mortar was not aggressively probed due to the limited sample size.
Appearance	Fresh surfaces have a dull luster and a very pale orange color (Munsell code approximately 10YR 8.5/2.5).
Absorptivity	The mortar matrix is very rapidly water-absorptive.
Other details	Cracking is not assessed due to the small sample size. No secondary mineralizations are visible. Only one white binder particle was noted visually at the millimeter-scale. Coarser sand is evident in hand sample including one pebble-sized orange volcanic particle.
Sand	
Lithology	The aggregate is primarily a coralline sand consisting of the eroded skeletal remains of reef-building organisms and associated marine invertebrates. The biological forms that have contributed to the aggregate mostly include scleractinian coral and gastropods (snails). A fairly significant component of the sand also includes grains of biomicritic limestone. Minor biological debris in the sand includes fragments of echinoids spines, green algae (Halimeda), red algae, and foraminifera. In addition to the coralline sand, there is a minor component of volcanic grains. These are generally feldspathic with a high content of undifferentiated groundmass and an absence of ferromagnesian phenocrysts. This, despite some heavy iron alteration in some grains. The volcanic grains tend to be found in the coarser grain sizes.
Appearance	The sand is uniform in the finer grain sizes but displays moderate color variegation in the coarser particles. The grains are opaque to semi-opaque. The overall color is buff (Munsell code approximately 9YR 7/2). The coarser particles have a variety of colors including rusts, reds, darker grays, and lighter greenish grays.
Gradation	The sand is coarse-grained and broadly graded. The nominal top size is at the 3/8" sieve, the peak abundance between the No. 16 and No. 30 sieves, and the fines content is negligible.
Shape/aspect ratio	Sand shapes are subrounded on average. Aspect ratios are mostly equidimensional to subequant. There is some variability in grain texture due to the high diversity of fossil forms.
Clay coatings/friable materials	No significant clay coatings or friable materials are evident. Porous clay lumps are present but very minor. These have mineral inclusions that associated these with the volcanic component of the aggregate.
Other	None
Binder matrix	
Paste uniformity	The lime paste is uniformly-developed. However, the cured binder is noticeably grainy in texture at the micron scale.
Capillary porosity	Very high
Microscopic shrinkage cracking	None significant
Residual calcium hydroxide	Depleted due to complete carbonation
Evidence for admixtures[1]	None
Binder residuals	
Binder type	High-calcium, nonhydraulic lime. Soluble impurities measured chemically may or may not be associated with the lime.
Hydraulic cement	None identified
Lime	Undispersed lime grains are found in moderately low abundance as fine-grained particles that are generally less than 1 millimeter in diameter and fully carbonated. Many of the grains are internally nondescript though some have the microgranular texture of the adjacent lime paste. More importantly, several lime grains contain internal pores that coincide with those found in scleractinian corals.

Table 5.2 (cont'd.): Petrographic Data - Sample CHRI.Mortar.3

Sample ID	Chri.MORTAR.3
Binder residuals (cont'd.)	
Pozzolans/SCMs[2]	None detected
Other	Very fine-grained bits of wood cinder ash are found in exceedingly trace abundance throughout the lime paste.
Pigment	
Concentration	None detected
Composition	n/a
Particle size	n/a
Color of extracted pigment	n/a
Other materials	
Details	None
Placement features	
Constituent distribution	The mortar constituents are well-dispersed.
Mix water	There is no variation in paste density that would suggest inconsistent distribution of mix water.
Compaction/consolidation	The mortar is compact and well consolidated.
Estimated air content/structure	The air content is estimated at about 2% to 3% by volume. Voids are mostly subspherical and fine in diameter.
Paste-sand interfaces	Sand grains are well-coated with binder.
Other	None
Secondary effects	
Carbonation	The lime paste is fully carbonated throughout the thickness of the sample pieces provided.
Paste alteration	None detected
Cracking	None significant
Mineral deposits	None detected
Surface erosion/weathering	No obvious joint surfaces are included with the sample.
Other	None

Notes:
1. Organic admixtures or soluble inorganic additives cannot be detected petrographically, though their effects on paste microstructure can sometimes be discerned.
2. SCMs = supplementary cementitious materials.

Table 5.3: Petrographic Data - Sample CHRI.Mortar.4

Sample ID	Chri.MORTAR.4
As-received description	
Description	The sample consists of several small joint mortar fragments along with a moderate abundance of pebble-sized pieces and minor loose granules and powder. The sample weighs a total of 31 grams. Joint heights are approximately 3/4" though possibly as much as 1". Depths are represented up to about 3/8".
Surfaces	The tooling has a grapevine profile with a 1/4" wide convex bead flanked by roughly planar surfaces flush with the top of the bead. There are some reddish stains on surfaces that are presumed to have been in contact with the masonry. These surfaces slope/taper inward from the joint face and the stains are possibly brick residues. The rear surfaces of the mortar samples appear to be fresh breaks although some of the surfaces are a little rounded and soft-textured.
Hardness/friability	The paste is soft to moderately soft. The mortar was not aggressively probed to avoid disaggregating the limited sample. Visually, the mortar appears moderately cohesive and nonfriable.
Appearance	Fresh surfaces have a dull luster. The freshest area has a very light buff color (Munsell code approximately 10YR 9/1.5) but most parts of the mortar are a bit more yellowed.
Absorptivity	The mortar matrix is very rapidly water-absorptive.
Other details	The sample pieces are small but there is no obvious cracking visible. One sample piece has a sugary semi-translucent scale deposit along the tooled face. Other sample pieces have tooled faces that are covered in an opaque white powdery coating with a slightly satiny luster. A couple of white lime grains are visible in hand sample at several millimeters in diameter.
Sand	
Lithology	The aggregate is primarily a coralline sand consisting of the eroded skeletal remains of reef-building organisms and associated marine invertebrates. The biological forms that have contributed most to the aggregate include green algae (Halimeda), gastropods (snails), and scleractinian coral. The corals exhibit one of two types of internal texture. Some contain original aragonite while others have recrystallized to an ultrafine-grained equigranular calcite. Other organisms observed in minor to trace quantity include red algae and foraminifera. Also fairly abundant in the sand are grains of biomicritic limestone. Finally, there are also traces of siliceous grains. Most of these consist of very fine-grained polycrystalline quartz.
Appearance	The sand is uniform and opaque to semi-opaque. The overall color is light buff (Munsell color code approximately 10YR 8/1.75). There are minor darker gray grains that provide some color variegation in most of the grain sizes. These are more visible above the No. 30 sieve.
Gradation	The sand is medium-grained and broadly graded. The nominal top size is at the No. 8 sieve, the peak abundance near the No. 30 sieve, and the fines content is negligible.
Shape/aspect ratio	Sand shapes are subrounded on average. Aspect ratios are mostly equidimensional to subequant. There is some variability in grain texture due to the high diversity of fossil forms.
Clay coatings/friable materials	No significant clay coatings or friable materials are evident.
Other	None
Binder matrix	
Paste uniformity	The lime paste is uniformly-developed. However, the cured binder is slightly grainy in texture at the micron scale.
Capillary porosity	High
Microscopic shrinkage cracking	None significant
Residual calcium hydroxide	Depleted due to complete carbonation
Evidence for admixtures[1]	None

Table 5.3 (cont'd.): Petrographic Data - Sample CHRI.Mortar.4

Sample ID	Chri.MORTAR.4
Binder residuals (cont'd.)	
Binder type	High-calcium, nonhydraulic lime
Hydraulic cement	None identified
Lime	Undispersed lime grains are found in very low abundance as fine-grained particles that are fully carbonated and usually about 1 millimeter in diameter give or take. Most are internally nondescript though the carbonated lime within lime grains is often sparser and more microgranular than the adjacent lime paste. A single grain is detected that has an internal texture similar to that of a coral. However, the evidence is not especially convincing.
Pozzolans/SCMs[2]	None detected
Other	None
Pigment	
Concentration	None detected
Composition	n/a
Particle size	n/a
Color of extracted pigment	n/a
Other materials	
Details	One to two coats of a thin lime wash coat most of the tooled surfaces. The wash has a maximum thickness of about 0.5 millimeters.
Placement features	
Constituent distribution	The mortar constituents are well-dispersed.
Mix water	There is no variation in paste density that would suggest inconsistent distribution of mix water.
Compaction/consolidation	The mortar is compact and well consolidated.
Estimated air content/structure	The air content is estimated at less than 2% by volume. Voids are mostly irregular and very fine in diameter.
Paste-sand interfaces	Sand grains are well-coated with binder.
Other	None
Secondary effects	
Carbonation	The lime paste is fully carbonated throughout the thickness of the sample pieces provided.
Paste alteration	None detected
Cracking	None significant
Mineral deposits	Calcium carbonate scale deposits are common along the joint surfaces. These are present as thin veneers below the lime wash when this is present. Cubic, isotropic salt deposits consistent with chloride salts are present within pores and along the rear surfaces of some of the sample pieces. The identification of these was not confirmed chemically or through x-ray diffraction analysis.
Surface erosion/weathering	Though there are carbonate deposits along the joint faces, there is no weathering or erosion.
Other	None

Notes:
1. Organic admixtures or soluble inorganic additives cannot be detected petrographically, though their effects on paste microstructure can sometimes be discerned.
2. SCMs = supplementary cementitious materials.

6. Aggregate Sieve Analysis

For each mortar sample, a single subsample was used to produce the chemistry aliquot and the extracted sand sample. The following procedure was used:

- A representative sample was taken and weighed analytically to represent the complete yield.
- These subsamples were disaggregated and macerated in hot water to loosen the binder fraction from the aggregate. The disaggregated samples were stirred to suspend the binder. The suspended binder was decanted into a separate beaker. The original sample was repeatedly rinsed and decanted until the water ran clear.
- The process yielded two subsamples in water. One is a finer-grained suspension of cured lime paste potentially with some minor silt derived from the aggregate. The other subsample consists of sand in which much but not all of the lime paste had been removed. Both beakers were placed in a low-temperature oven and evaporated to dryness. The lime binder sample was used for chemical analysis while the sand sample was used to extract the aggregate and help normalize the chemical weight percentages.
- The sand samples were each digested for several seconds in an acetic acid solution buffered at a pH of 4.5. The samples were flooded with water to arrest the reaction. The sample was dried and examined under a stereoscopic microscope to determine whether any remaining lime paste was sufficiently decomposed and rinsed away. It was necessary to repeat the mild acid digestion, rinsing, and drying several times for each of the samples.
- Once the sand was almost completely clean, the aggregate was described and graded through a standard sieve stack. The fraction passing a No. 200 sieve was observed in petrographic grain mount and the amount of remaining lime paste was estimated to the nearest 25% by volume. Assuming an equivalency between volume and weight, this fraction was excluded from the gradation profile below. An error in this estimate is negligible given the small amount of this component.

Table 6.1: Acid Digestion Data - Weight Retention (g)

Sieve size	M2	M3	M4
3/8"	0.00	0.00	0.00
No. 4	0.00	0.64	0.00
No. 8	0.19	0.34	0.04
No. 16	0.94	0.61	0.14
No. 30	6.39	1.59	1.55
No. 50	8.25	1.40	1.77
No. 100	1.67	0.37	0.24
No. 200	0.37	0.11	0.04
Pan	0.16	0.03	0.00

Table 6.2: Acid Digestion Data - Cumulative Passing (%)

Sieve size	M2	M3	M4
3/8"	100.0	100.0	100.0
No. 4	100.0	87.4	100.0
No. 8	98.9	80.8	98.9
No. 16	93.7	68.8	95.1
No. 30	58.1	37.6	54.2
No. 50	12.2	10.0	7.5
No. 100	2.9	2.7	1.3
No. 200	0.9	0.5	0.1
Pan	0.0	0.0	0.0

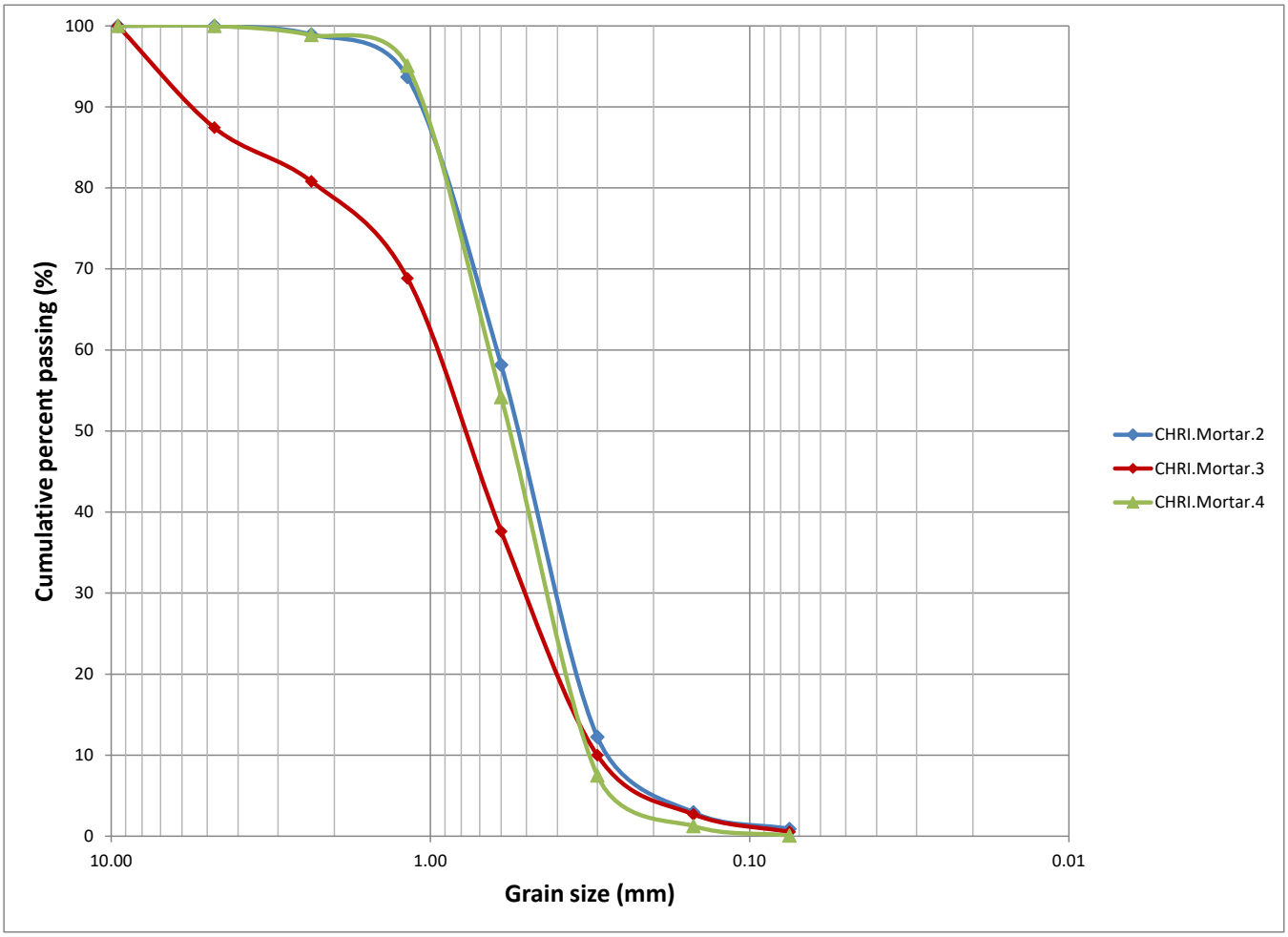
Table 6.3: Acid Digestion Data - Cumulative Retained (%)

Sieve size	M2	M3	M4
3/8"	0.0	0.0	0.0
No. 4	0.0	12.6	0.0
No. 8	1.1	19.2	1.1
No. 16	6.3	31.2	4.9
No. 30	41.9	62.4	45.8
No. 50	87.8	90.0	92.5
No. 100	97.1	97.3	98.7
No. 200	99.1	99.5	99.9
Pan	100.0	100.0	100.0
Fineness modulus	**2.34**	**3.13**	**2.43**

Chart 6.1: Aggregate Sieve Analysis

The following chart presents the particle size distribution curves for the extracted sand samples. The chart plots the data from the cumulative passing values in Table 6.2. The following should be noted:

- The fine end of the curve is terminated at the No. 200 sieve. Any silt and clay components are not graded beyond this point and these are simply combined as the minus No. 200 fraction.
- The curve for Sample M3 is somewhat irregular toward the coarse end. This is commonly observed when gradation curves are drawn from small samples and individual coarse particles represent a significant weight proportion of the whole.



7. Chemical Analysis

The challenge for these particular types of mortar is that the coralline sand is nearly as acid-soluble as the cured lime binder making it difficult to separate the two chemically for individual measurement. The laboratory has used a proprietary modification of ASTM C1324 to overcome this difficulty. While there may be some small errors, results should be considered within several percent of the true values. The following steps have been taken:

- A representative subsample of each mortar is taken.
- The mortar is mechanically disaggregated and a small aliquot of finer material that can be suspended in water is separated out and reserved for chemical analysis. This is assumed to represent an accurate subsample of the binder with some minor silt and clay derived from the sand.
- The remaining coarse material is mechanically disaggregated and washed in mild acid (Section 6). This removes any remaining binder that was not subsampled in the last step. This material is discarded. The coarse material represents the total percentage of aggregate relative to the original subsample (Table 7.2). All that is missing is any silt captured with the fine binder portion.
- Subtracting the aggregate percentage from 100% yields the percentage of binder plus any silt and clay.
- Since the binder matrix appears uniform, the smaller aliquot of fines separated out initially may be considered to be a compositionally accurate subsample. The chemical analysis in this section is performed on this smaller aliquot (Table 7.1). The measured chemical oxides plus any insoluble residue and losses on ignition are proportionally normalized to fill the difference between 100% and the measured aggregate.
- After this normalization, the insoluble residue measured with the binder is added back to the initial sand measurement to add back any silt and clay that was removed initially. The combined analysis (Table 7.3) can now be treated as any lime mortar analysis would be using the standard calculation methods of ASTM C1324 (Table 7.5).

Table 7.1: Chemical Analysis Results (Disaggregated Fines)

As described in Section 6, mechanical disaggregation of each mortar sample produced a coarse fraction used to determine a sand gradation, and a fine fraction mostly representing the lime binder. The latter was recovered as a fine powder decanted from the disaggregated mortar, suspended in water, and evaporated to dryness. The chemical analysis was performed on this recovered powder.

The powder was subjected to a typical chemical analysis procedure to determine soluble oxides, insoluble residue, and losses on ignition. The digestion procedure was modified from that in ASTM C1324 to account for the lime binder. The method includes a room temperature acid digestion and excludes the base digestion used for siliceous binders. The insoluble residue was taken from this same digestion rather than from the digestion of a separate aliquot.

Sample ID	M2	M3	M4
SiO_2	BDL	0.63	0.10
CaO	49.11	42.00	47.00
MgO	0.64	1.71	1.38
Al_2O_3	0.23	0.81	0.35
Fe_2O_3	0.07	0.39	0.08
Insoluble residue	2.73	11.82	3.94
LOI to110°C	0.22	0.49	0.40
LOI 110°C-550°C	3.03	4.18	3.54
LOI 550°C-950°C	40.24	34.49	38.83
Measured totals	**96.28**	**96.53**	**95.61**

Note:

1. For Sample M2, the measured SiO_2 is below the detection limit. In this analysis, the detection limit for SiO_2 is 0.001% for a 1-g sample of the concentrated binder.

Table 7.2: Chemical Analysis Results (Coarse Fraction)

The coarse fraction of the disaggregated mortar was further processed with mild acetic acid to clean surfaces of residual lime as described in Section 6. The table shown here reports the cleaned sand as weight as a percentage of the total sample.

Sample ID	M2	M3	M4
Component (wgt. %)			
Sand	64.66	44.44	32.57

Table 7.3: Chemical Analysis Results (Total Mortar)

The total chemistry is calculated by adding the measured aggregate residue from the coarse fraction (Table 7.2) and a normalized amount of all of the components from the fine fraction (Table 7.1). The lime binder and any intermixed silt is assumed to be uniform so that any fines washed from the sand surfaces can be assumed to have the same composition as that of the fine fraction measured chemically. As such, the soluble oxides, sand, and losses on ignition presented in the table below are proportionalized up to the difference between the coarse fraction and the initial sample weight. This is summed with the fine fraction to produce a complete analysis of the mortar.

Sample ID	M2	M3	M4
Component (wgt. %)			
SiO_2	BDL	0.36	0.07
CaO	18.03	24.17	33.15
MgO	0.24	0.99	0.98
Al_2O_3	0.09	0.47	0.24
Fe_2O_3	0.03	0.23	0.06
Sand	65.66	51.24	35.35
LOI 45°C-110°C	0.08	0.28	0.28
LOI 110°C-550°C	1.11	2.40	2.50
LOI 550°C-950°C	14.77	19.86	27.39
Measured totals	**100.00**	**100.00**	**100.00**

Note:

1. For Sample M2, the measured SiO_2 is below the detection limit. In this analysis, the detection limit for SiO_2 is 0.001% for a 1-g sample of the concentrated binder.

Table 7.4: Normalized Lime Compositions

The binder in each of the three mortar samples is interpreted to consist of a nonhydraulic lime with no other additives. As such, the lime chemistry is estimated from the chemical analysis presented in Table 7.1. The five major oxides in the binder are normalized to a 99% weight yield. This normalizes the lime to a dry weight basis and is equivalent to the pre-slaked condition. The residual 1% is assumed to represent trace unmeasured constituents. Important chemical indices are calculated as follows:

$$\text{Hydraulic index} = (SiO_2 + Al_2O_3) / CaO$$

$$\text{Cementation index} = (2.8 \cdot SiO_2 + 1.1 \cdot Al_2O_3 + 0.7 \cdot Fe_2O_3) / (CaO + 1.4 \cdot MgO)$$

The following features are worth noting:

- Samples M2 and M4 have CaO contents over 95% and are considered to be high-calcium products with very little impurity. These likely slaked readily and produced a higher volume of lime putty upon slaking.
- The high calcium contents would be consistent with lime burned from coral though not diagnostic of that source.
- The soluble chemistry in Sample M3 contains only 91% CaO and a modest amount of impurity. This includes almost 4% MgO. This sample is one in which a coral source for the lime is more certain based on petrographic evidence. This level of impurity would not be typical for this type of lime. Instead, it is suspected that portions of the volcanic sand had solubilized through reaction with the alkaline lime paste prior to carbonation, and is available for chemical measurement after acid digestion. While this type of reaction might be considered analogous to a pozzolanic reaction, there is no evidence to indicate any true hydraulicity.
- Hydraulic indices less than 0.1 and cementation indices less than 0.4 are generally taken to indicate an absence of any appreciable hydraulicity (Eckel, 169-173). None of the limes show any chemical sign of a hydraulic property.

Sample ID	M2	M3	M4
Component (wgt. %)			
SiO_2	0.0	1.4	0.2
CaO	97.1	91.3	95.1
MgO	1.3	3.7	2.8
Al_2O_3	0.5	1.8	0.7
Fe_2O_3	0.1	0.9	0.2
Other	1.0	1.0	1.0
CaO/MgO	76.5	24.5	34.0
Hydraulic index	**0.00**	**0.03**	**0.01**
Cementation index	**0.01**	**0.07**	**0.01**

Table 7.5: Calculated Components

Two separate volume estimates are given in the table below. One is given with the lime in the form of a dry hydrate despite the fact that the mortars examined for this report predate the commercial availability of prepackaged hydrated lime. Calculating the lime as a dry hydrate is convenient because it does not have to take into account the mix water used in a lime putty. It also allows for a more direct assessment of possible repair formulations using modern bagged masonry lime. Nonetheless, it is generally assumed that a volume of dry hydrate will lose approximately 20% of its volume when water is added to produce a putty of stiff consistency. This assumption is the basis for the volume estimate reported for lime putty. This ratio is derived from the dry hydrate calculation.

It should also be noted that where volume proportions are given, these are based on estimated original bulk densities of the materials. However, limes are subject to great variation in volume due to factors such as settling or "fluffing" in dry powders and mix water content in putties. The table also presents the weight percentages of the dry ingredients (dry hydrated lime and sand). These are more accurate as they represent direct measurements of material mass and are not based on assumptions of bulk density.

Of course, all of these discussions may be academic since it is usually desirable to modify the original design if modern materials will be used to replace their historic counterparts. The findings of a mortar analysis are best used to constrain possible repair designs rather than as a prescription for a specific formulation.

Sample ID	M2	M3	M4
Component			
Lime expressed as dry hydrate (wgt. %)	27	40	56
Sand (wgt. %)	73	60	44
Lime : sand ratio (by volume with lime as dry hydrate)	1 : 1.4	1 : 0.74	1 : 0.39
Lime : sand ratio (by volume with lime as putty)	1 : 1.7	1 : 0.93	1 : 0.48

Notes:

1. The component proportions are calculated from the total mortar chemical analysis presented in Table 7.3. The lime weight is calculated by mathematically converting the measured CaO and MgO to their respective hydroxides by molecular weight conversion. The three other measured oxides are assumed to represent minor impurities in the lime and are added directly to the calculated hydroxides. The total represents the lime in the form of a dry hydrate. The sand is taken directly from the weight of the sand presented in Table 7.3. The lime and sand weights are then normalized to 100% to return the materials to a dry weight basis.
2. Volumetric ratios are calculated assuming bulk densities for nonhydraulic lime and damp, loose sand of 40 lbs./ft.^{3} and 80 lbs./ft.^{3}, respectively. Another calculation is provided assuming the lime in putty form. This assumes a unit of dry lime hydrate will lose approximately 20% of its volume when mixed to the consistency of a stiff paste.

References

Eckel, Edwin C. *Cements, Limes, and Plasters. Their Materials, Manufacture, and Properties.* New York: Robert Drummond, 1905.

Appendix I: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and an Olympus SZ40 stereoscopic microscope. The polarized light microscope is fitted with a Tucsen MIchrome 5 Pro 5MP digital camera. The stereoscopic microscope is used for simple magnification. Sample types examined under this microscope include fractured surfaces, fine constituents extracted through chemical or physical means, or honed or polished cross sections. The polarized light microscope (PLM) magnifies but also employs principles of optical crystallography. The most common sample preparation for the PLM is the petrographic thin section. For this preparation, cross-sectioned samples are mounted to glass slides and are milled to a thickness sufficient to allow light to be transmitted through the material. These are usually prepared without water and with minimal heat to avoid altering minerals that are water or temperature-sensitive. In many cases, the samples are impregnated with a low-viscosity, blue-dyed epoxy. When so treated, blue areas represent some type of void space (e.g., air-voids, capillary pores, cracks, etc.). The polarized light photomicrographs are taken using a variety of optical settings chosen to best demonstrate the feature(s) of interest. These are distinguished as follows:

Plane polarized light (abbreviated as PPL)

This method uses the refractive power of different constituents to produce an artificial sense of surface relief. Otherwise, the method is the closest to a simple magnification of the material. The setting is often used to demonstrate granular relationships or microstructure. Pore spaces and cracks are observable with this setting if the blue-dyed epoxy is used.

Conoscopic polarized light (abbreviated as CPL)

In this setting, the transmitted light is condensed just before passing through the thin section. The method tends to bring colors or finer particulates into higher contrast at the expense of image sharpness. The setting is often used to image grain boundary failures in dimension stone, pigment particulates in binders, or gel phases in the micropores of cement pastes.

Cross polarized light (abbreviated as XPL)

The setting places the thin section between two pieces of polarizing film oriented at 90° to one another. In isotropic materials (e.g., glasses, simple salts), all light is absorbed and the materials appear black. In anisotropic crystals, two light rays traveling at different speeds are produced within the thin section and these offset waves interfere at the upper polarizing film. The interference produces a color that can be used to calculate properties of the crystal structure and aid in identification of mineral species. In essence, the colors are artificial. It should be noted that color is a function of orientation and color differences do not necessarily indicate material differences.

Compensator plates

When in XPL mode, full-wave or quarter-wave compensator plates may be inserted into the light path to add or subtract interference. Technically, these methods are used to calculate properties of the crystal structure. However, they can also be used to alter the image appearance to help improve contrast between different constituents. They can also reveal preferred orientations in some materials (e.g., oriented residual crystallinity in fired ceramics).

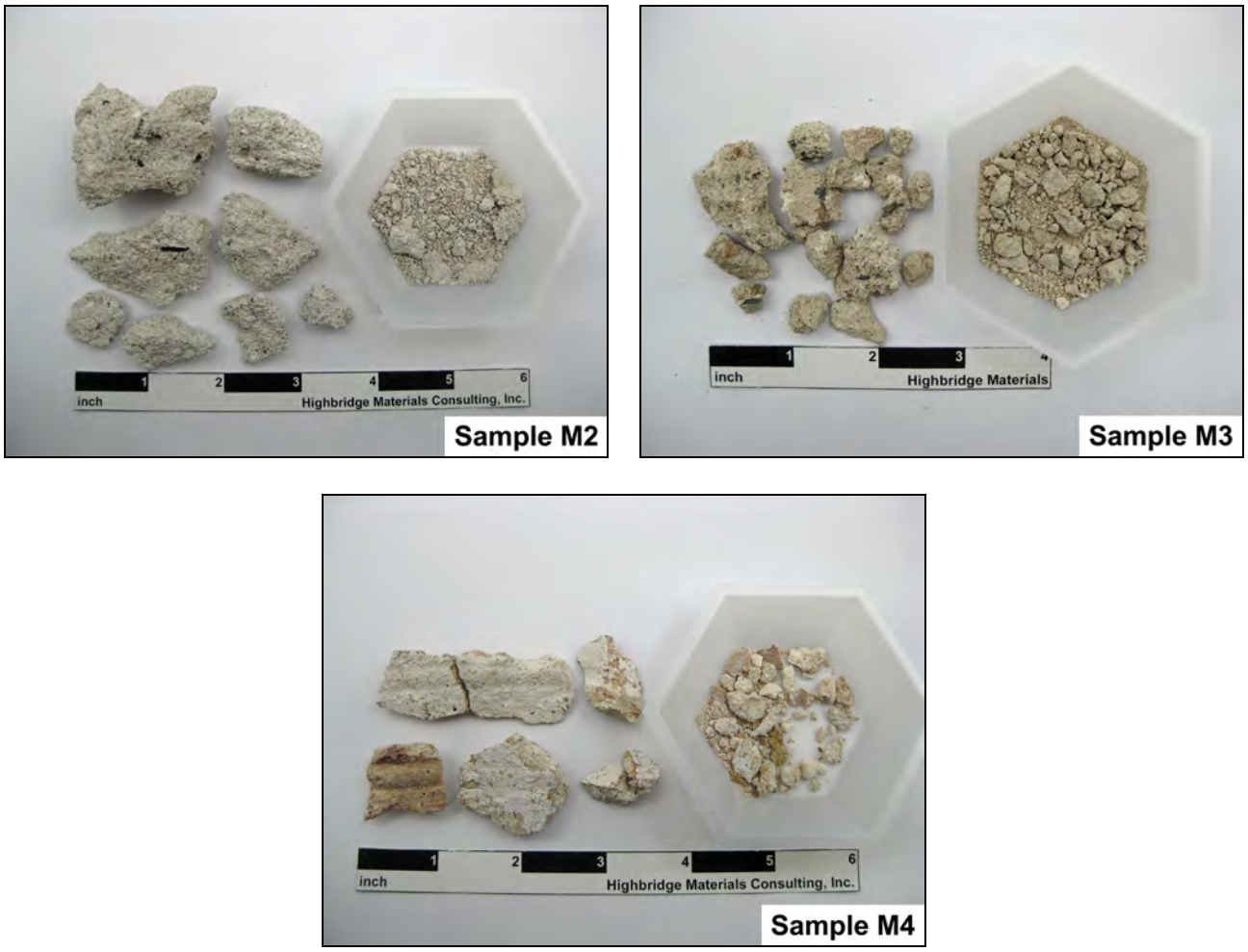


Figure 1: Photographs of the mortar samples provided to Highbridge for examination. All material is light-colored with a warm hue. More intact pieces are shown at left in each image. The weighing dishes contain finer granules and powder.

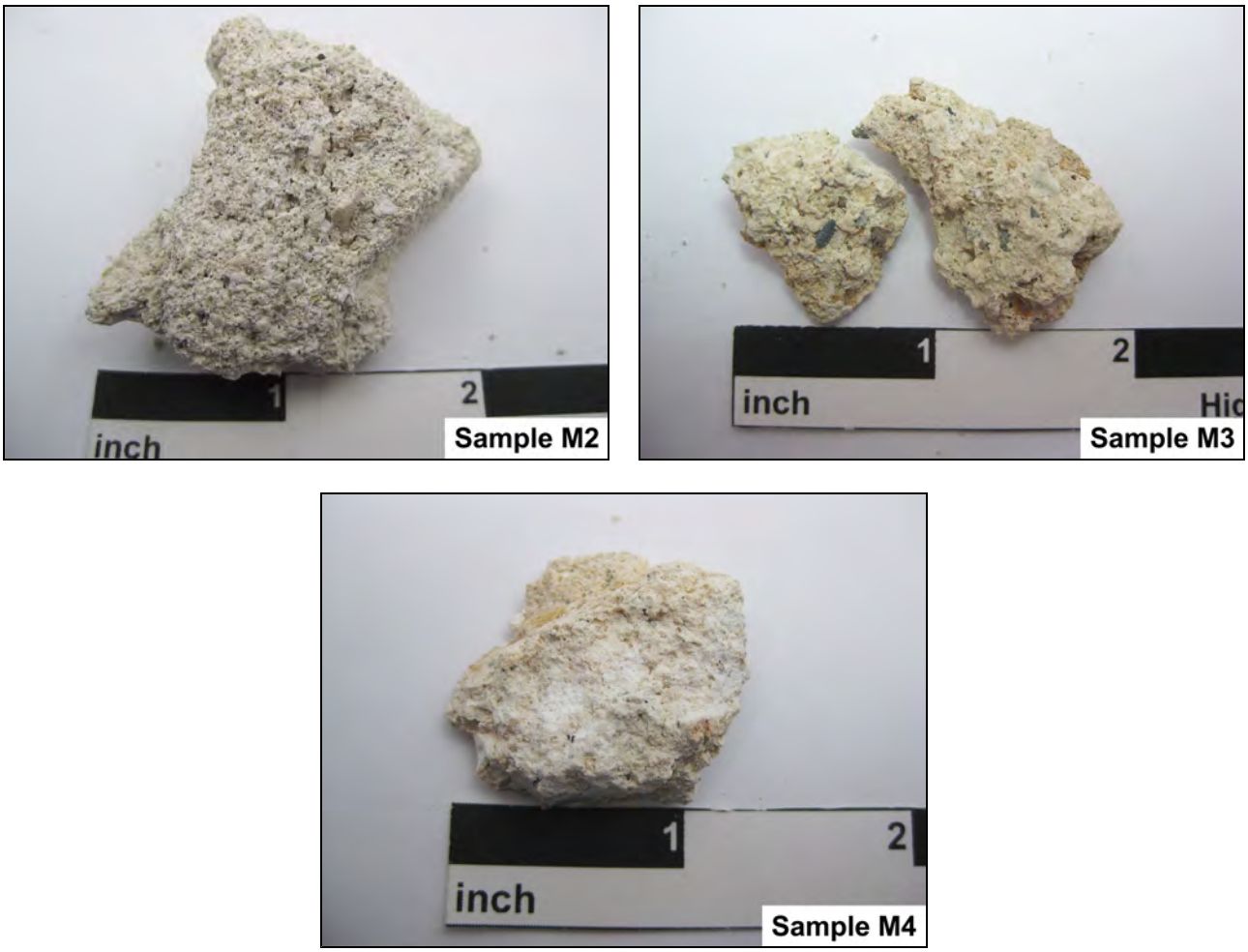


Figure 2: Close-up photographs of the mortar samples illustrate the grainy texture of the materials.

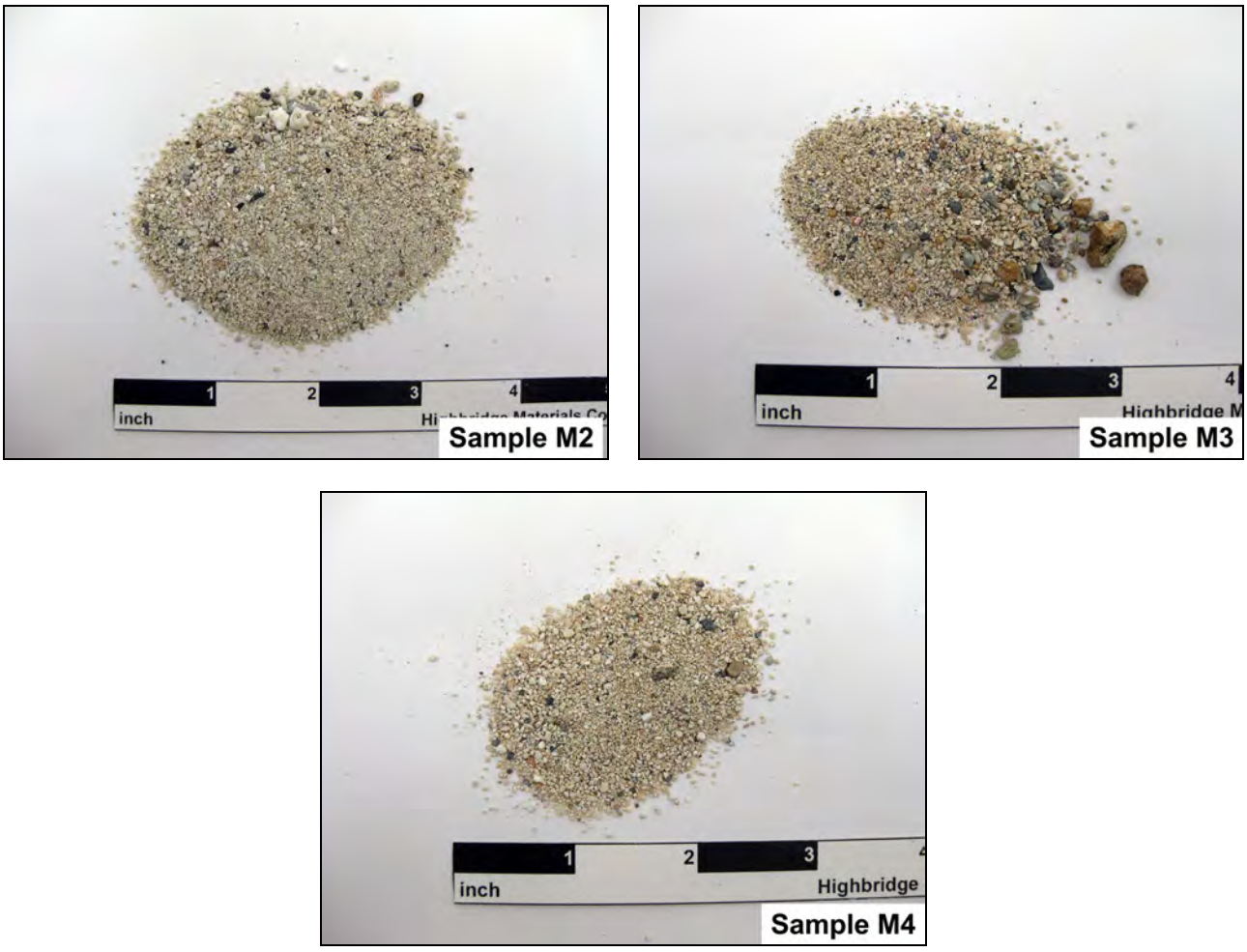


Figure 3: Photographs illustrating the sand samples extracted by mechanical disaggregation followed by mild acid-washing. The coralline sands are buff-colored and soft-textured.

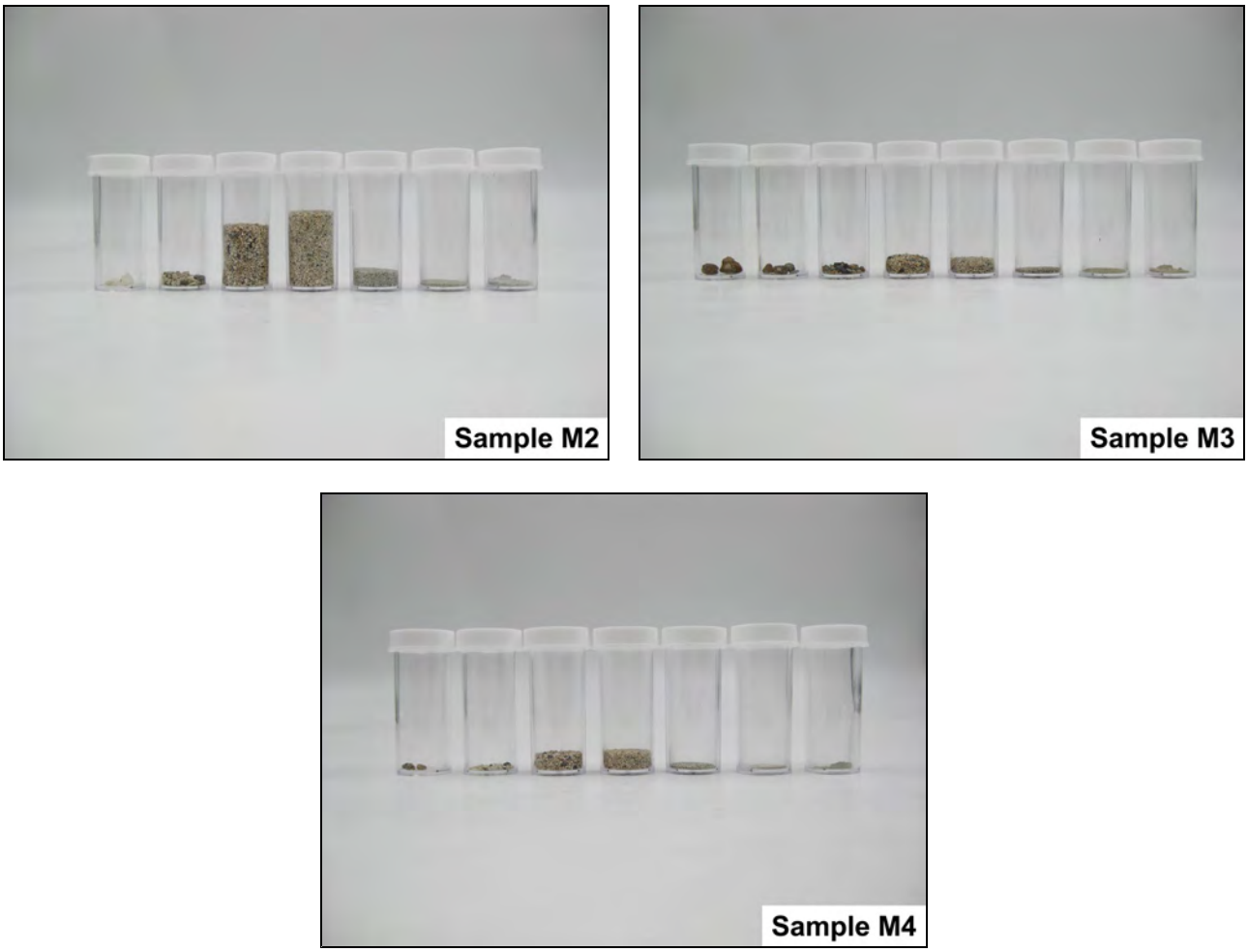


Figure 4: The sand samples are shown after gradation through a standard sieve stack. All have relatively broad particle size distributions.

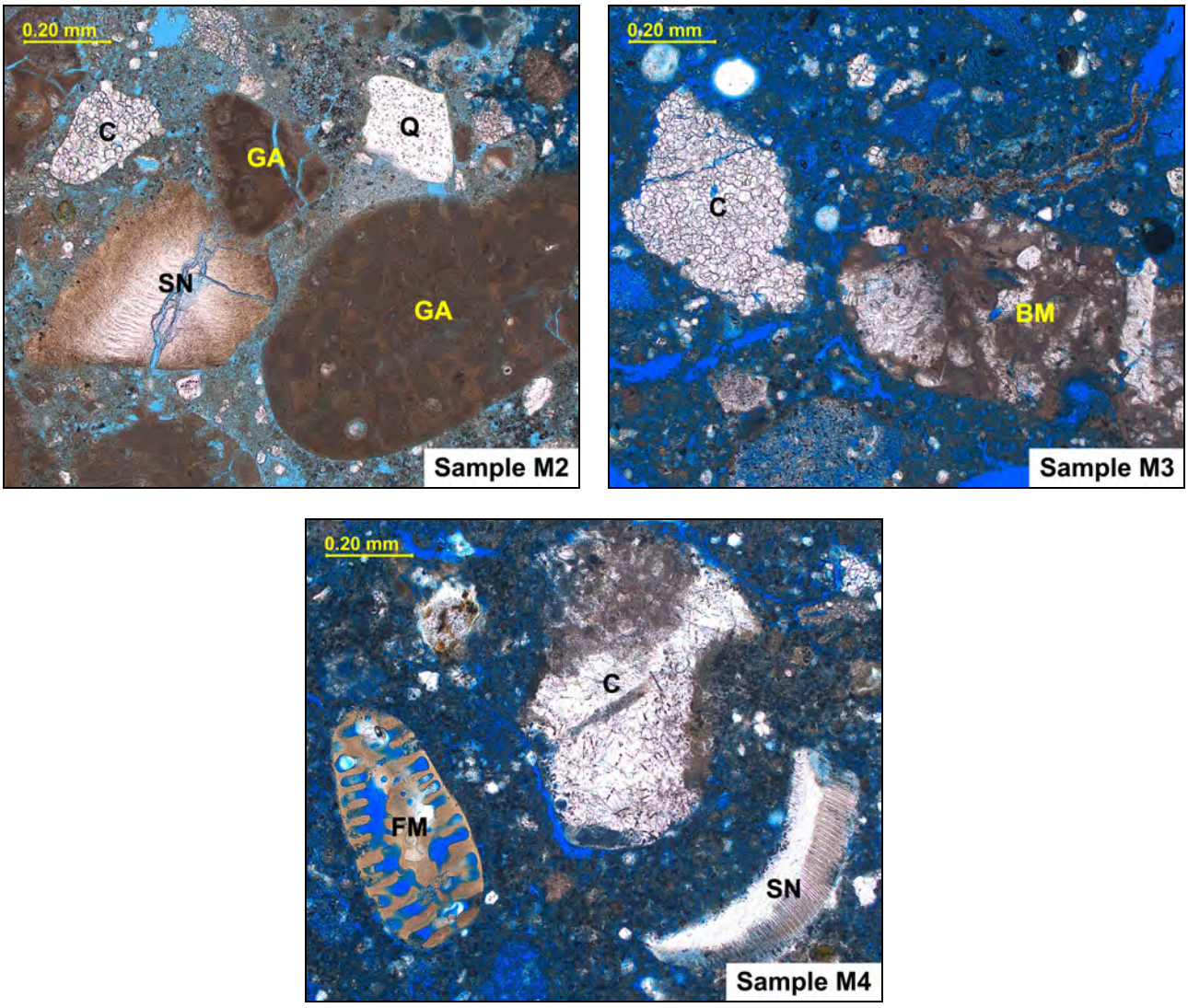


Figure 5: PPL photomicrographs illustrating the various components of the coralline sand including green algae skeletons (GA), coral grains (C), snail shell fragments (SN), foraminifera tests (FM), and biomicritic limestone particles (BM). Some quartz sand (Q) is also shown here.

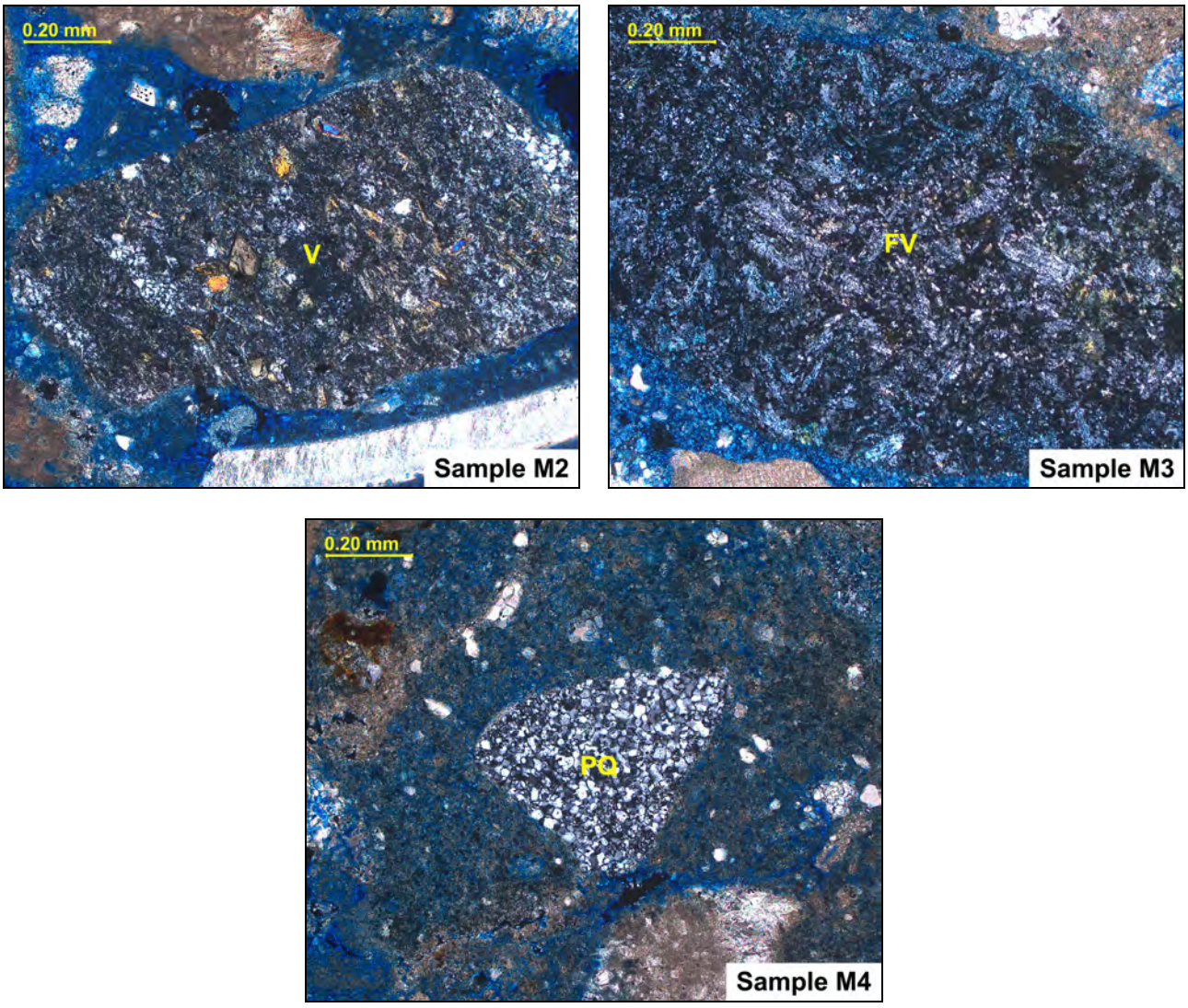


Figure 6: XPL photomicrographs. Minor to trace amounts of siliceous sand grains are also present. Shown here are examples of volcanic grains (V), feldspathic volcanics (FV), and polycrystalline quartz (PQ).

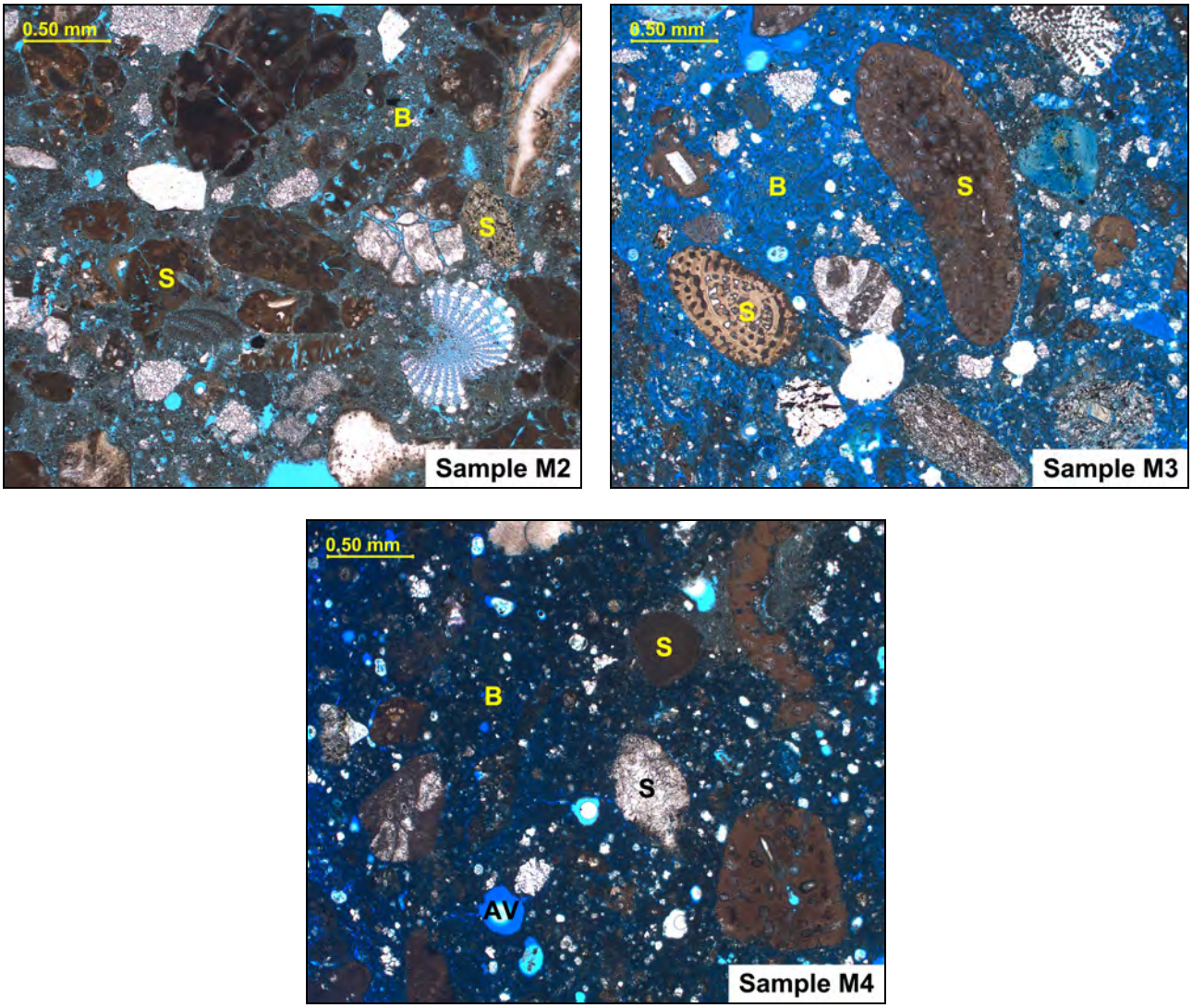


Figure 7: PPL photomicrographs illustrating the overall microtexture of the mortar samples. The absorption of blue-dyed epoxy indicates that the binder (B) has high microporosity as is typical for high lime mortars. Note that the intensity is higher for Sample M3. This mortar has a higher microporosity and a softer quality in hand sample. This is interpreted to be the result of a higher original mix water content. Sand grains (S) are uniformly distributed throughout all mortars. Varying packing densities correlate with the different binder to sand ratios calculated for each sample. All mortars are well-consolidated and air-voids (AV) are minimal. One is shown only for Sample M4.

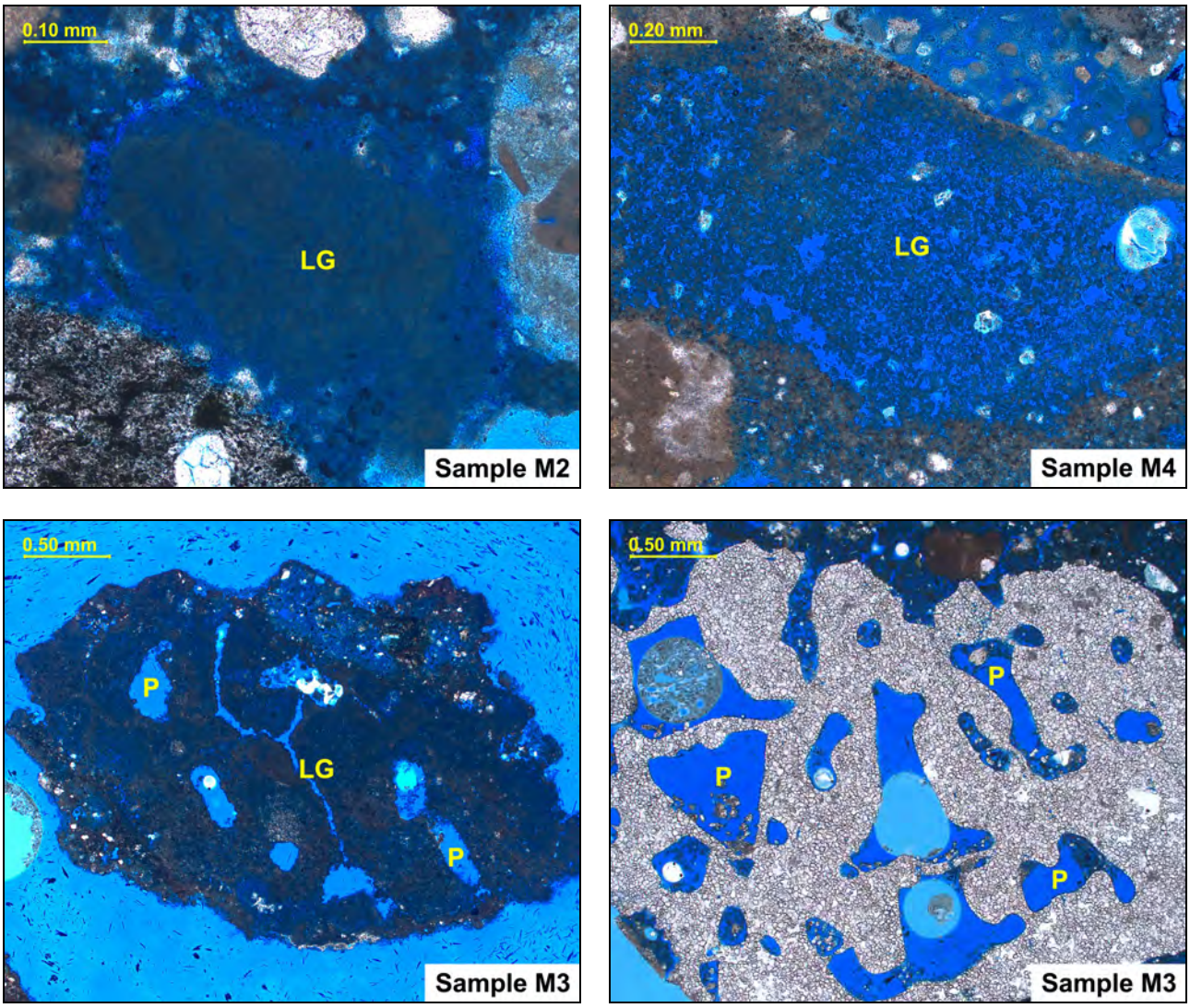


Figure 8: PPL photomicrographs illustrating the microtexture of undispersed lime grains (LG) in each sample. Those in Samples M2 and M4 are relatively nondescript (upper images). The one in Sample M4 has a somewhat grainy microtexture. A few lime grains in Sample M3 have an unusual distribution of pores (P) with elongate rounded shapes (lower left). Note that these are quite similar to the pores present in the scleractinian coral particle shown at lower right. This suggests that the lime was burned from fossil coral.

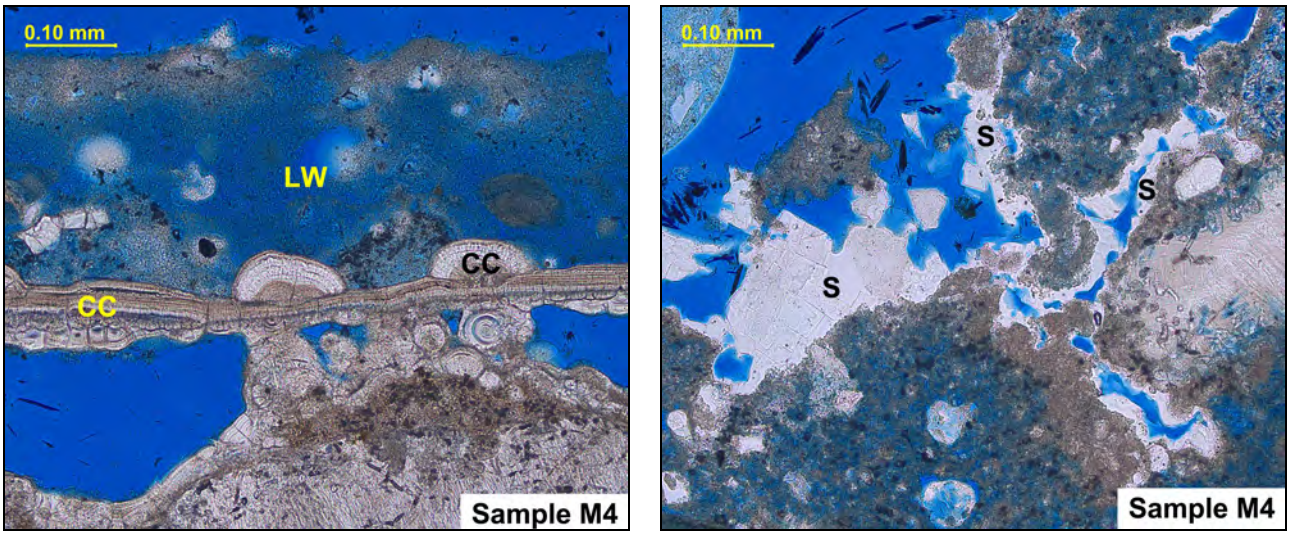


Figure 9: PPL photomicrographs. Salt deposits are only observed petrographically in Sample M4. (Left) Calcium carbonate scale (CC) directly overlies the original tooled joint face but lies below one to two coats of lime wash (LW). (Right) Isotropic salts in pores (S) are optically consistent with chloride salts.

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