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PROJECT 05-239

Stabilization and Preservation of DoD-owned Military Fortifications

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1.0 Introduction

This study has been funded as Project 05-239 by the Department of Defense (DoD) Legacy Resource Management Program. In 1990, Congress passed legislation establishing the Legacy Resource Management Program to provide financial assistance to DoD efforts to preserve our natural and cultural heritage. This study was funded by the Legacy program to develop a military fortifications preservation and stabilization guidance document (including fact sheets) that can be used throughout DoD.

1.1 Study Objectives

Numerous DoD installations contain historic military fortifications. These fortifications have been constructed through a large number of historic periods, and vary considerably in size, complexity, and materials. These fortifications include relatively simple Native American archaeological sites; through 18th century and 19th century field fortifications; to grandiose 19th century coastal defense fortifications such as Fort Monroe, Virginia; to the massive concrete gun emplacements of the late 19th and early 20th century; and include even relatively modest World War I and World War II fighting positions constructed to help train the large American armies of these two wars. These fortifications are constructed of various materials, including earth, sod, wood, dry-laid stone, mortared masonry (brick and granite), concrete, and various combinations of materials. These fortifications were constructed to support active military operations such as the American Revolution, War of 1812, or Civil War (the field fortifications constructed at West Point during the American Revolution being an example); to support military training (such as World War I earthworks located at Fort Belvoir, Virginia); or as coastal defensive structures to guard against an invasion that never came. These military fortifications are important historical resources that can be used to support military training and education. For example, the Revolutionary War fortifications at West Point directly support historic academic instruction and military training of the U.S. Military Academy Corps of Cadets.

Many of these materials, particularly natural materials including earth, wood, and sod, are extremely vulnerable to erosion and deterioration. The National Park Service has been active in developing strategies to manage and preserve military field fortifications that are constructed of earth and sod under their stewardship. Preservation approaches have been developed, implemented, and evaluated by the National Park Service, and guidance manuals have been developed and distributed.[1] The National Park Service has also made significant contributions to the management and preservation of more traditional architectural materials frequently used in permanent military fortifications such as mortared masonry (brick and stone) and concrete.

The DoD is responsible for the management of military fortifications that have been constructed during different historic eras, of a range of materials (e.g. dry-laid stone, concrete, or mortared

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[1] For examples, refer to the American Battlefield Protection Program website at http://www2.cr.nps.gov/hli/currents/earhtworks/index.htm).

masonry integrated with earth in various combinations), and for different purposes. Currently, the DoD does not have an integrated approach to preserve and manage the full range of military fortifications for which it is responsible. The purpose of this study is to expand the previous accomplishments of the National Park Service by evaluating different materials (such as dry-laid stone) for which comprehensive guidance has not been previously prepared, and particular conditions created by military fortifications where a range of different materials are often integrated, causing challenging preservation scenarios.

This project will initially review existing literature including previously prepared earthwork management studies by the National Park Service; fortification management studies previously prepared for the U.S. Military Academy and U.S. Army Kwajalein Atoll, Republic of the Marshall Islands; and a recently developed Seacoast Fortifications Preservation Guide developed by the National Park Service for concrete fortifications in the vicinity of San Francisco, California. Preservation strategies will then be developed for two American Revolution field fortifications at West Point consisting of integrated dry-stacked stone and earth (Redoubt No. 2 and its detached Battery constructed in 1778); and integrated dry-stacked stone, brick, granite masonry, and earth (1775 Romans' Powder Magazine, West Point); 19th century permanent fortifications constructed at Fort Monroe, Virginia consisting of mortared brick, granite and earth (Chaplain's Casemate, Building 21); and an integrated poured concrete and earth Endicott series coastal defense artillery battery at Fort Monroe, Virginia (DeRussy battery). Demonstration projects will then be performed at these four historic properties at these two installations. Finally, this project will prepare a military fortifications preservation and stabilization guidance document (including fact sheets) that can be used throughout DoD.

An integrated, proven set of procedures will be developed that are applicable to the range of this type of cultural resource. This will permit DoD installations to implement preservation and stabilization projects without having to individually review existing documentation, prepare procedures, and similarly duplicate efforts. Additionally, this would permit DoD installations to utilize previously proven techniques, rather than expending resources on techniques that are unproven, and might not be successful.

1.2 Historic Context

1.2.1 18th Century Field Fortifications

By the middle part of the 18th Century, when the thirteen colonies of the United States declared their independence from Great Britain, military art and science was an advanced field of study.[2] At the start of the War of American Independence, a healthy interest in military art and science was well-founded in the fourteen colonies, and a large number of military treatises were readily available for purchase.[3] At the early Battle of Bunker Hill, the cornerstone of the American defenses on Breed's Hill was a large, square earth redoubt that the American had constructed in a

[2] This section is derived from Douglas R. Cubbison, "Historic Structures Report- The Redoubts of West Point" (West Point, New York: Directorate of Housing and Public Works, U.S. Military Academy, January 2004); and Cubbison, "Historic Structures Report- The Hudson River Defenses at Fortress West Point, 1778-1783" (West Point, New York: Directorate of Housing and Public Works, U.S. Military Academy, January 2005).

[3] Among the few studies of this topic are John Henry Stanley, *Preliminary Investigation of Military Manuals of American Imprint Prior to 1800* (M.A. Thesis: Brown University, 1964); and Joseph R. Riling, *The Art and Science of War in America, A Bibliography of American Military Imprints, 1690-1800* (Alexandria Bay, New York: Museum Restoration Service, 1990).

single night of prodigious labor. This redoubt was approximately 136 feet square, contained a redan (salient angle) facing to the south (in the presumed direction of British attack), and an entrance to the north (reverse). The devastating casualties inflicted upon the British Army when it attacked this redoubt served as a demonstration of how effectively such works could be defended.[4] Given this early success, the Americans almost immediately began to utilize fortifications as an integral component of their military plans. Redoubts and artillery batteries were incorporated with great regularity into American defensive positions constructed between 1776 and 1777. Literally miles of fortifications were constructed under the supervision of General George Washington to defend New York City during 1776. As an example of the extent of this massive fortification effort, eighteen redoubts have been documented in association with the defense of Fort Washington on Manhattan Island alone. [5]

With the onset of armed hostilities, American political and military leaders recognized the need to fortify the Hudson River to deny British naval and land forces unconstrained access to this crucial river corridor. Early evaluations of the Hudson River identified Martelaer's Rock and West Point, along with Anthony's Nose to the south, as preferred locations for fortifications to impede the river. The Martelaer's Rock and West Point location was particularly well suited, for here the river is at its narrowest, and makes two right angle turns. Sail-driven boats must slow and make numerous changes of tack to negotiate these turns, a job exacerbated by shifting winds and currents in the narrow river gorge. In September 1775 Bernard Romans', a self-styled military engineer, arrived at Martelaer's Rock to supervise construction of "Fort Constitution." Work progressed slowly, obstructed by chronic shortages of money, men and materials; poor engineering design on Romans' part; and jurisdictional arguments between various revolutionary leaders.

Although Romans' proved to be a poor choice as Engineer for Fort Constitution, he managed to construct several campsites and barracks, support facilities such as storehouses and blacksmith shops, several artillery batteries, and one large powder magazine. Among the military fortifications constructed by Romans' at Constitution Island was a powder magazine, located at the northern end of his battery. This powder magazine was completely excavated by renowned archaeologist J.C. Harrington in 1973. Harrington's report provides a comprehensive discussion of this important historic resource.[6] Romans' Powder Magazine (and the other portions of Romans' military fortifications) comprises the earliest construction projects still in existence that was performed by the U.S. Army.

For various reasons, primarily Romans' failures, the Americans transferred the major defensive effort in the Hudson Highlands from Fort Constitution to Fort Montgomery, located on the west bank of the Hudson River immediately north of Popolopen Creek, where Anthony's Nose

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4 Richard M. Ketchum, *Decisive Day, The Battle for Bunker Hill* (Garden City, New York: Doubleday and Company, 1974), 111; and Christopher Ward, *The War of the Revolution* (New York: The Macmillan Company, 1952), 1:78-79.

5 Reginald P. Bolton, *Fort Washington, An Account of the Identification of the Site…with a History of the Defense and Reduction of Mount Washington* (New York: Empire State Society of The Sons of the American Revolution, 1902), 41-65.

6 J.C. and Virginia S. Harrington, *Excavation of The Powder Magazine, Romans' Battery, Constitution Island.* (West Point, New York: The West Point Fund, United States Military Academy, 1973); and J.C. Harrington, "Romans' Battery: Early Revolutionary War Fortification." *Pennsylvania Archaeologist* 49, no. 3 (September 1979), 31-41.

constricts the river. Work began at Fort Montgomery in March 1776. Initially, a single battery was sited to fire across the Hudson; supporting facilities such as barracks, storehouses, a guardhouse and a powder magazine were constructed to its rear; the whole enclosed by three redoubts connected by a lengthy breastworks. It soon became obvious that the site of Fort Montgomery was commanded by high ground immediately to the south, across Popolopen Creek. Fort Clinton was therefore constructed on this site beginning in August 1776. Communications were maintained between Forts Montgomery and Clinton by a pontoon bridge across Popolopen Creek. Fort Clinton also consisted of a series of breastworks with one large integrated redoubt serving as the heart of the fortification. One additional redoubt was constructed to the southwest of Fort Clinton, to control an avenue of approach from this direction (considered to be the rear of the fort, that is, the face of the fort away from the Hudson River). The American defensive position contained a number of fatal flaws, one of which was that both forts were served by a single powder magazine located at Fort Montgomery, and that the sole line of communications between the two forts (the pontoon bridge across Popolopen Creek) was not protected by fortifications.

Although a well-considered position, both Fort Montgomery and Fort Clinton were too extensive for their small garrisons, and when actually attacked by the British the available American force was only one tenth of the force necessary to adequately defend the two forts. The Americans retreated into the redoubts, and these subsequently bore the brunt of the fighting. Fort Clinton fell in part when ammunition ran out after the Popolopen Creek pontoon bridge was interdicted by British forces.[7] Fort Montgomery was eventually over-run by superior numbers. Still, the redoubts at the two forts had enabled the small and heavily out-numbered American defenders to present a credible defense.

During the early years of the War, the American forces displayed an alarming tendency to construct fortifications that were too extensive, and could not be held by the number of forces reasonably anticipated to be present for their defense. Additionally, the rambling nature of these works effectively tied down the American forces, rather than permitting them to maneuver. As the American Army prepared defensive positions across the Delaware River, they constructed a series of fortifications at Fort Billingsport on the New Jersey (east) side of the river, at Fort Mercer at Red Bank on the Pennsylvania (west) side of the river, and Fort Mifflin on Mud Island in the Delaware. All three forts were poorly designed. Fort Billingsport was originally designed as an earth fort with four bastions, seven hundred feet per side, which would have required approximately two thousand men to defend. Washington recognized this, and had it reduced in size. Still, the French Engineer DuCoudray again reduced the fort, essentially to a single redoubt. This fort was never assaulted, as an adequate force could not be mustered for its defense, and it was abandoned upon British approach. Fort Mercer had also been designed to be too large, and under the supervision of French Engineer Chevalier Thomas Antoine Mauduit du Plessis, it was substantially reduced in size, essentially to a large redoubt that could be defended by five hundred men. The success of this re-design was made apparent when a large Hessian force assaulted the work on October 25, 1776 and was repulsed with crushing losses. The attacking force lost 151 killed, 263 wounded and twenty captured. Eighty of the attackers were so demoralized by the experience that they deserted to the Americans the next day. American casualties were light, being fourteen killed and twenty three wounded. Fort Mifflin was similarly too large, being designed for 1,500 men instead of the five hundred that were actually available. Still, its location in the middle of the Delaware River enabled it to put up a stout defense in the fall of 1777. The

[7] Dave R. Palmer, *The River and the Rock* (New York: Greenwood Publishing Corporation, 1969), 113-114.

American experience along the Delaware River proved that military fortifications could be used with great success, when correctly sized and defended.[8]

Washington's Army spent that winter at the infamous encampment at Valley Forge. Although other elements of this camp have received considerable discussion, the fact that Washington had French Engineer Louis L. Duportail design a series of fortifications to protect the camp is frequently ignored. Duportail designed two lines of fortifications. The "outer line" consisted of a large square redoubt flanked by artillery redans, and a series of breastworks and lunettes. Behind this was a strong "inner line" consisting of a number of redoubts connected by breastworks.[9] When British commander William Howe sent spies to the Valley Forge, he learned that it was indeed "a strong point" and "having good information…that the enemy had strengthened his camp by additional works, I dropped all thoughts of attack."[10] By the sheer strength of a fortified camp, a British advance had been deterred.

In the Northern Theater, the American army used redoubts and military fortifications to great advantage at Fort Ticonderoga in 1776 and at Saratoga in 1777. Americans under Benedict Arnold and Ethan Allen had occupied the fortifications at Ticonderoga in May 1775, and Ticonderoga had served as the logistical base for American operations in Canada throughout 1775 and the first half of 1776. When the American invasion of Canada ended in defeat, the American army was removed to Fort Ticonderoga, where they established their main defensive position. Although American forces had been stationed at Ticonderoga for over a full year, they had apparently taken few (if any) steps to strengthen or repair the position there. When Major General Horatio Gates arrived at Ticonderoga to assume command of the American field army and main defensive position there, he immediately initiated the construction of a series of redoubts and batteries around the old French fort. The works at Ticonderoga were constructed under the supervision of Colonel Jeduthan Baldwin, the Chief Engineer of the American Northern Theater. Although Baldwin had never received any formal military engineering training, he had served under renowned British Engineer Captain William Eyre at the construction of Fort William Henry in 1755-1756.[11] Almost immediately upon the arrival of Gates and Baldwin at Ticonderoga on July 8, 1776 they began laying out the fortifications.[12] Baldwin and Gates occupied a strong position on the eastern side of Lake Champlain which they christened "Mount Independence," and established river batteries there to command the isthmus of Lake Champlain. They then laid out a series of redoubts to control the high ground around Fort Ticonderoga, and an entrenched line with integrated batteries to defend the rear of the Mount Independence batteries. At the same time, the old French breastworks on the commanding ridge to the west of the French fort were re-constructed. Strengthening the American defensive position at Ticonderoga were seven new redoubts, and two old French redoubts were re-constructed.

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[8] DuCoudray, "Du Coudray's Observations on the Forts Intended for the Defense of the Two Passages of the River Delaware, July 1777" *Pennsylvania Magazine of History and Biography* XXIV, No. 3 (1900), 343-347; Hugh M. Brackendridge, "The Siege of Fort Mifflin" *Pennsylvania Magazine of History and Biography* XI, No. 1 (1887), 82-88; Samuel S. Smith, *Fight for the Delaware, 1777* (Monmouth Beach, New Jersey: Philip Freneau Press, 1970); and Ward, *The War of the Revolution*, 1: 372-383.
[9] It should be noted that this is a classic use of redoubts, as specifically addressed by Lewis Lochlee, *Elements of Field Fortification* (London: 1783), 123-124.
[10] Ward, *The War of the Revolution*, 2: 544; and Gilbert S. Jones, *Valley Forge Park, An Historical Record and Guide Book* (Valley Forge Park Commission: 1947), 8-11.
[11] Colonel John H. Calef, Editor, "Extracts from the Diary of a Revolutionary Patriot." *Journal of the Military Service Institution of the United States* 39 (July-August 1906), 123-130.
[12] Thomas Williams Baldwin, Editor. *The Revolutionary Journal of Colonel Jeduthan Baldwin, 1775-1778* (Bangor: Printed for the DeBurians, 1906), 58-59.

When combined with the works at Mount Independence, additional outer defensive works at Mount Hope, the reconstruction of the old French defensive breastworks, and the old French fort itself, Ticonderoga was an imposing fortification. Colonel John Trumbull, Adjutant to General Gates, describes the impression that Ticonderoga made upon the British Army when it advanced in late October 1776:

> Ticonderoga must have had a very imposing aspect that day, when viewed from the lake. The whole summit of cleared land, on both sides of the lake, was crowned with redoubts and batteries, all manned, with a splendid show of artillery and flags…. Our appearance was indeed so formidable, and the season so far advanced, that the enemy withdrew without making any attack….”[13]

Again, an American position had resisted attack merely through the presence of its fortifications, of which redoubts had played a prominent role. The use of redoubts at Ticonderoga had permitted the Americans to effectively control all of the militarily significant terrain around the old French fort with their available forces.

The British Army returned down Lake Champlain in 1777, and drove the Continental Army in retreat almost to Albany. Major General Horatio Gates returned to the Northern Theater to resume command of the army, and working in conjunction with a young Polish Engineer named Thaddeus Kosciusko, they laid out a strongly fortified position on a bluff immediately west of the Hudson River, near a local landmark “Bemis’ Tavern.” Although these works have received scant study or appreciation, in large part because they never figured in the heavy fighting that occurred at Saratoga in September and October 1777, they constituted an extensive and formidable position. Kosciusko, a professionally trained military engineer, may well have drawn upon a strong Polish military tradition of utilizing field fortifications and entrenched camps.[14] Constructed across the high ground of “Bemis’ Heights” were a series of artillery batteries and infantry redoubts, connected by lineal breastworks. Kosciusko cleverly designed these works to “refuse” the American right (eastern) flank, such that any British force moving south on the River Road would suddenly discover its advance blocked by heavy entrenchments, and outflanked to the west by strong artillery batteries guarded by redoubts.[15] The American works extended nearly 1¼ miles east to west (with a double line of fortifications guarding the west flank), and ¾ miles from north to south. Although the British Army never directly assaulted these works, their presence heavily influenced the British maneuvers and field tactics during September and October 1777. In large part, the strength of the field works at Saratoga enabled the American Army to re-establish a successful defense of the Hudson River, and contributed their full share to the British surrender at Saratoga.

By February 1778 when the Continental Army re-occupied the defensive position astride the Hudson River at West Point, fortifications were an integral component of the fledgling republic’s military tactics and strategies. Under the able direction of Continental Army Engineer Thaddeus Kosciusko, an experienced Polish soldier and a classically trained French Military Engineer, the

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[13] Theodore Sizer, Editor. *The Autobiography of Colonel John Trumbull, Patriot-Artist, 1756-1843* (1841: reprint edition New Haven: Yale University Press, 1953), 34.

[14] Robert I. Frost, *The Northern Wars, 1558-1721* (Essex, England: Pearson Education Limited, 2000), 106 110, 244-245, 247. The most current, and well-prepared, biography is Francis Casimir Kajencki, *Thaddeus Kosciuszko, Military Engineer of the American Revolution* (El Paso, Texas: Southwest Polonia Press, 1998).

[15] Kosciusko may well have been emulating the successful use of redoubts by the Russian Army in canalizing and subsequently crushing a Swedish Army at the Battle of Poltava on June 27, 1709 along the Vorskla River. Frost, *The Northern Wars*, 289-294.

West Point Fortress was established to prohibit English forces from again moving north from New York up the Hudson River. Fortress West Point subsequently played a key role in military operations on the Hudson River throughout the remainder of the War for American Independence.[16]

As American military commanders and their various supporting Engineering officers evaluated the terrain around the bend of the Hudson River at West Point, it became immediately obvious that West Point was controlled by ground that continually ascended nearly twenty miles to the west (essentially to Schunnemunk Mountain immediately west of Woodbury Creek). Thus, any successful defensive scenario at West Point would have to consist of two integrated elements:

- Obstructions and artillery batteries at the Hudson River; and
- Supporting fortifications to prevent the river batteries from being taken from ascending ground to their rear.

The anchor of Fortress West Point was a large, formal bastioned fortification, named Fort Arnold in honor of Major General Benedict Arnold, sited immediately above the river batteries. A single large hill overlooked Fort Arnold, and a large redoubt christened "Fort Putnam" was constructed to secure this ground. Fort Arnold and Fort Putnam were both large works possessing considerable strength, and were designed to require a formal siege for their reduction. To control ascending ground above and around Fort Putnam, a series of four redoubts were constructed. These redoubts were intended to be strong enough to be able to withstand a simple infantry assault, and to require a deliberate attack before they could be captured. They were intended to provide perimeter security for Fort Putnam in particular. As formally designated on July 27, 1779 the redoubts from east (closest to the river) to west (terminating at "Rocky Hill" above Fort Putnam) are numbered Redoubt No. 1, 2, 3 and 4.[17]

The great significance of Fortress West Point is that it was constructed on an already naturally strong position in such a manner that it enabled the American military command to defend the Hudson River corridor with a comparatively small force (what modern military tacticians refer to as "Economy of Force"). On several occasions during the War for American Independence the natural topographical strength of West Point, enhanced by the layers of military fortifications, permitted Washington to successfully defend the Hudson Valley corridor with a minimum expenditure of manpower (including usually unreliable militia) while still being able to aggressively maneuver his main field force from the Continental Army- in 1778 against the British garrison of Rhode Island; in 1779 against Native Americans supporting the British cause in western New York, and most significantly in 1781 against the British Army of Lord Cornwallis in Virginia. The use of West Point in this manner was entirely consistent with military art and science as practiced during the era of the American Revolution.

The American defensive position was anchored on the chain and boom across the Hudson River, defended by four well-sited artillery batteries, which in turn were defended by an interlocking series of fortified positions occupying key terrain. The use of the chain and boom, the design and construction of the river artillery batteries guarding it, and the positioning of Fort Arnold, Fort Putnam, and the numerous redoubts controlling the ground around West Point were all based

[16] For more complete information on Revolutionary War redoubts, refer to Cubbison "Historic Structures Report, The Redoubts of West Point" and Cubbison, "Historic Structures Report, The Hudson River Defenses at Fortress West Point, 1778-1783."
[17] "Orderly Book, West Point Garrison, July-August 1779 and August- December 1779" (WPA Transcript, Special Collections and Archives, U.S. Military Academy Library, West Point, New York), 31.

upon existing military engineering treatises of the 18th century. These defensive positions were derived from previous American experiences with similar military fortifications during the Seven Years Wars; from previous river defense successes (such as the Fort Ticonderoga-Mount Independence defense in 1776 and the Delaware River defense in 1777); and from previous river defense failures (such as the Hudson River defense in 1776-1777 and Fort Ticonderoga in 1777). Kosciusko and other engineers and officers designed a formidable string of interlocking fortifications that effectively controlled critical terrain around the river defenses. The great success of these works is that the efficient use of redoubts and batteries enabled the American garrison to fully command West Point, without becoming over-extended as had happened at Fort Montgomery and Fort Clinton. The American field force was never large, and had West Point been incorrectly designed and fortified, the entire American Continental Army would have been tied to the Hudson Highlands. The great significance of West Point was that it enabled Washington to negate the strategic British position at New York City, while freeing his field army to perform the operational and strategic evolutions that would eventually secure American Independence at Yorktown in 1781.

1.2.2 19th Century Coastal Defense Fortifications

1.2.2.1 First and Second Series of Coastal Defense Fortifications

During the War of 1812, the vulnerability of the American coastline to foreign invasion was dramatically revealed by the blockade of the Chesapeake Bay and subsequent occupation of Hampton, Virginia in 1813; and the occupation and destruction of Washington, D.C. in 1814. This resulted in serious degradation to the American economy. For example, the value of exports from Maryland declined from $3,787,000 to $248,000 between 1813 and 1814, reflecting the effectiveness of the British blockade on both domestic and international commerce. In fact, foreign exports declined from $1,005,000 to $10,000 that year.[18] However, a small fortification at Norfolk, Virginia had repulsed a British attack on June 22, 1813; and the formal defenses at Fort McHenry at Baltimore had successfully defended the harbor against a determined British assault on September 13, 1814. One result of the War of 1812 was a realization that a formal system of coastal defense fortifications was necessary to secure America's coastlines, and thus America's commerce and economy.[19]

Previously, two "series" of coastal defense fortifications had been constructed by the United States. The first series was a relatively temporary set of fortifications constructed in response to a foreign affairs crisis that lasted from 1794 to 1800. These works were exclusively constructed of timber, earth and sod; and although constructed by the Federal government their location, design and construction were approved by individual state governments. The inevitable result was that this "First Series" of forts lacked uniformity and consistency, were frequently poorly sited and designed, and were constructed of temporary materials that rapidly disintegrated. The absence of trained military engineers to site and design these coastal defense forts was a great impediment, and would result in the formation of the U.S. Military Academy at West Point, New York in 1802. Among the first series of coastal defense fortifications were significant improvements to the Revolutionary War Fort Putnam at West Point. Upgrades to Fort Putnam included a significant expansion of the fort, a substantially revised fortifications trace to the south, and the

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[18] Stuart R. Bruchey and Eleanor S. Bruchey, "A Brief History of Commercial Banking in the Old Line State" in *Money and Banking in Maryland* (Baltimore, Maryland: Maryland Historical Society, 1996), 14.
[19] For the War of 1812 refer to "The War of 1812 Extracted from American Military History, Army Historical Series, Office of the Chief of Military History, United States Army" accessed on-line at http://www.army.mil/cmh-pg/books/amh/amh-06.htm on August 31, 2005.

construction of brick casemates to serve as "bomb proofs" to protect the garrison and stores from bombardment. Fort Putnam as it exists today is essentially one of the few surviving First Series Coastal Defense Fortifications, and quite possibly the only one on a DoD Installation.

The "Second Series" of forts were constructed in response to the Napoleonic Wars between France and England that resumed in 1803, and continued through the War of 1812. Hampered by many of the same constraints that had degraded the First Series of coastal defense forts, the inadequacies of the Second Series forts and lack of any comprehensive coastal defense scenario had been made apparent by the War of 1812. However, the success of Fort McHenry in particular demonstrated that properly sited and constructed fortifications could effectively repel a foreign attack and defend America's shorelines. One result of the War of 1812 was the formal establishment in November 1816 of the Board of Engineers for Fortifications. Commonly known as the "Fortifications Board" this organization would guide the construction of an extensive series of coastal defense fortifications commonly known as the "Third Series" of fortifications.[20]

1.2.2.2 Third Series Coastal Defense Fortifications

By 1816, the U.S. Military Academy was able to furnish a core contingent of trained military engineers, who featured prominently in the siting, design, and construction of this Third Series of fortifications. Succinctly, the Third Series of fortifications would eventually result in the construction of forty two forts around the coastline of the United States. Major efforts were focused upon defenses of the northeastern U.S. (harbors from New York City to Maine); Chesapeake Bay; southeastern United States; Gulf of Mexico; and San Francisco Harbor. The Third Series of fortifications would eventually be terminated by the American Civil War, and accompanying accelerated developments in firepower and naval technology that effectively rendered the Third Series fortifications obsolete. The Third Series forts varied greatly in configuration, design and construction but contained certain common characteristics. All Third Series forts were constructed of combinations of masonry and earth. Where available, locally quarried granite stones were used (predominantly in the northeastern United States). Elsewhere, locally manufactured bricks were the material of choice. Typically, the seacoast or water defenses consisted of simple masonry walls with casemated artillery pieces placed behind them. At the time of their design, naval technology and firepower was relatively limited, and was incapable of placing sustained artillery fire on a target to achieve a breach of the defensive wall. On the land-facing side, a series of interlocking outer works reinforced with the extensive use of earth and masonry provided these forts' strongest defenses, as designers expected that sustained attacks would be made upon the fortifications from this direction. Roman cement was also used at different locations throughout the fortifications.

Although the Third Series of Forts was the most visible and permanent component of the American coastal defensive system, it was only one of four principal elements:

- A strong navy to defend the coasts from hostile fleets at sea and protect seaborne commerce;
- Coastal defense forts;

[20] The two most comprehensive sources on the Third Series of Coastal Forts are Russell Reed Price, *American Coastal Defense: The Third System of Fortification, 1861-1864* (Mississippi State, Mississippi: Mississippi State University, Unpublished PhD Thesis, May 1999); and John R. Weaver II, *A Legacy in Brick and Stone, American Coastal Defense Forts of the Third System 1816-1867* (McLean, Virginia: Redoubt Press, 2001).

- An interior communications system of roads, waterways, harbors and canals that permitted American military forces to be transferred rapidly and expeditiously to threatened coastal areas; and
- A strong regular army to man and maintain the coastal defensive forts; augmented by a well-trained militia force in time of war.

A series of continuously changing priorities, often influenced by political rather than military or engineering considerations, affected the actual construction sequence of the Third Series Forts. However, defense of the Chesapeake Bay consistently remained at the top of the priority list. Fort Monroe at Old Point Comfort, Hampton Roads, Virginia was among the first of the Third Series Forts to be constructed. Begun in 1819, construction of this massive fort continued through 1837. Fort Monroe would become the largest of the Third Series Forts, and its early design and construction established precedents that were consistently maintained by other Third Series Forts.

Many of these Third Series Forts were occupied by the Confederate States of America during the American Civil War. Subsequent attacks by the Confederate and Federal armies were the only actual assaults upon these forts. The war began with an attack upon Fort Sumter in Charleston, South Carolina in April 1861; and one of the last combat actions of the Civil War was the capture of Fort Fischer, North Carolina in April 1865. Generally, the Third Series of Forts proved capable of requiring deliberate sieges before they could be captured, and withstood determined attacks for as long a period as could reasonably be expected. However, the American Civil War had demonstrated that the Third Series of forts were vulnerable to improvements in the size and destructiveness of artillery. Modern artillery had easily penetrated the walls of Fort Pulaski, Georgia and Fort Macon, North Carolina. Modern artillery had also effectively silenced barbette guns at other forts, and caused extensive damage to the masonry fortifications during the sieges at Fort Sumter, South Carolina and Fort Morgan. With the increased size of modern artillery, the casemates of the Third Series of forts were no longer capable of accommodating the larger guns. Advances in Naval technology had also reduced the effectiveness of the forts. Underwater mines, or “torpedoes” as they were known during the Civil War era, had proven more capable than gunfire at preventing the passage of naval vessels into harbors. Ironclads had proven resilient to gunfire from the Third Series fortifications, and steam-powered vessels were capable of higher speeds such that artillery emplaced in the fort casemates had limited engagement times. Modern artillery pieces also had substantially increased ranges, and many of the Third Series forts were found to be positioned too close to the harbors and cities to effectively defend them against modern cannon. The American Civil War dramatically demonstrated that the Third Series of Forts would not provide adequate coastal defense for the United States in the future.

1.2.3 Endicott Series Coastal Defense Fortifications

The Fortifications Board and Military Engineers, who had worked for decades to design and construct the massive Third Series Forts, were reluctant to abandon them. A number of experiments were performed to improve their capabilities, but for several decades after the Civil War the Third Series forts declined in importance, and American coastal defenses were not updated. By 1885 it was apparent to both political and military leaders that the nation’s coasts invited foreign naval attack, and the richest American ports with their fine harbors, the center of American commerce and trade, were the most defenseless.[21]

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[21] Adapted from Edward Ranson, “The Endicott Board of 1885-1886 and the Coast Defenses” *Military Affairs* XXXI, No. 2 (Summer 1967), 76.

To address the deficiencies of a coastal defense fortification system that was by now a fortification only in name, the Fortifications Appropriations Act approved March 3, 1885 directed that a special board be established to examine the efficacy of a new series of coastal defense fortifications to supersede the obsolete Third Series forts. This board was and is commonly referred to as the "Endicott Board" for its Chairman, Secretary of War William C. Endicott.

The Endicott Board recommended a massive military works project, consisting of the establishment of integrated defensive fortifications at twenty-seven major points, mounting no less than 2,362 pieces of modern artillery, and manned by an Army of 80,000 Coast Artillerymen.[22] The Endicott Board recommended the establishment of integrated defenses consisting of heavy six to twelve inch artillery pieces mounted behind substantial works of concrete and earth, in such a manner that they could be loaded under the protection of the fortifications, then elevated above the parapet to fire on the enemy, thus being known as "disappearing guns." The liberal use of electric mines to obstruct river channels was also proposed, and smaller batteries of rapid firing guns also defended by concrete and earthen ramparts were sited to protect the minefields. Mortar batteries were also proposed, carefully concealed behind heavy concrete and earthen ramparts, to provide effective plunging fire upon enemy naval vessels. Modern observation points, fire control mechanisms, and communications and signaling equipment were important components of the integrated Endicott series. However, the massive scope and attendant expense of the ambitious Endicott series fortifications surprised the U.S. Congress, and appropriations for design and construction were limited. It would take the crisis with Spain that eventually resulted in the Spanish-American War of 1898 to finally lend impetus to the development of the Endicott fortifications.

At the commencement of the Spanish-American War on April 1, 1898 it was discovered that only 151 pieces of artillery were in place and ready for immediate use in the Endicott series coastal defense fortifications. The American public was alarmed when the American Navy lost track of the Spanish Atlantic Fleet early in the War. Rumors that the Spanish Fleet was heading up the Atlantic Ocean to attack American ports and coastal cities resulted in "great apprehension" verging on panic.[23] Sitings of the Spanish squadron were replete up and down the entire North American coastline. A portion of the American fleet was retained in Hampton Roads for homeland defense. Secretary of War Alger recorded: "The calls made upon the War Department for immediate rescue from the advancing Spanish fleet were pathetic in their urgency…They wanted guns everywhere, mines in all rivers and harbors on the map."[24] Accordingly, the financial coffers were opened, and between 1898 and World War I the Endicott Series of fortifications was finally constructed.

Recognizing that technological advancements were remarkable since the Endicott Board's establishment and findings in 1885, a follow-on Fortifications Board was established in 1905 to review and update the findings of the Endicott Board. This Fortifications Board, generally known as the Taft Board for its Chairman Secretary of War William Howard Taft, made major recommendations for the construction of new fortifications, predominantly in America's new overseas possessions such as Hawaii, Puerto Rico, Cuba, the Philippine Islands, and the Canal

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[22] United States. Board on Fortifications or Other Defenses (Endicott Board), *Report of the Board on Fortifications or Other Defenses appointed by the President of the United States under the provisions of the act of Congress approved March 3, 1885* **(**Washington, Govt. Print. Office: 1886).
[23] Ranson, "Endicott Board", 84.
[24] Ivan Musicant, *Empire by Default, The Spanish-American War and the Dawn of the American Century* (New York: Henry Holt and Company, 1998), 297-298.

Zone in Panama. However, the Taft Board also made various technological recommendations to upgrade the Endicott Series fortifications in the Continental United States.[25]

As constructed, the Endicott series fortifications were poured concrete blocks. Earth was mounded to the front (seaward side) and permitted to vegetate naturally. From the sea, the fortifications appeared as natural sand dunes, and were all but invisible. The Endicott series fortifications were typically constructed on three levels. The first level contained ammunition (separate powder and shell) magazines, hoisting and trolley equipment for the ammunition, equipment storage areas, latrines, mechanical and electrical equipment rooms, and plotting (fire direction) rooms. Mechanical hoists and personnel stairs connected the first and second levels. The second levels contained firing pits for the artillery pieces, an ammunition processing area, and command posts for each gun and battery. Personnel ladders connected the second and third levels. The third level provided observation posts for each gun and the battery as a whole. Individual fortifications varied, depending upon the size and type of the guns. A design drawing for a typical battery consisting of two 12-inch disappearing guns is provided (Figure 1).

The early batteries were initially made of Roman Cement, but the majority of the latter batteries were Portland Cement. Some batteries contained reinforcing steel. Endicott batteries were frequently emplaced in proximity to the Third Series fortifications, apparently because the War Department already owned the land. In some cases, Endicott series batteries were constructed within the old Third Series Forts (for examples of this, see Fort Gaines and Fort Morgan, Alabama). At Fort Monroe, a series of Endicott batteries were constructed along the Old Point Comfort beach, extending from the seaward front of Fort Monroe to the east. One rapid-firing battery was installed within the old Fort itself. The Fort Monroe batteries were:

- Two 10-inch disappearing rifle battery, Battery Church, completed in 1899;
- Two 10-inch disappearing rifle battery, Battery Eustis, completed in 1899;
- Four 4.72” rapid fire guns, Front Four of Old Fort Monroe, completed in 1899;
- Three 12-inch disappearing rifle battery, Battery DeRussy, completed in 1901;
- Four 15-pounder rapid fire guns, Battery Irwin, completed in 1903;
- Two 12-inch disappearing rifle battery, Battery Parrot, completed in 1906; and
- Two 6-inch barbette mounted rifle battery, Battery Montgomery, completed in 1904; and
- Sixteen mortar battery, Battery Anderson; completed in 1898.

Fort Monroe’s defenses also included several modern rifles and rapid fire guns mounted directly on the terreplein of the historic Fort Monroe, and a control casemate for electric mines to be installed in the channel. [26]

The Endicott series batteries were generally rendered obsolete by the advent of naval and military aviation, but the Coast Artillery continued to man them through World War II. None of the Continental United States Endicott series batteries ever saw combat, but a number of the similar Taft series fortifications saw extensive combat during World War II in the Philippines Islands. As was typical for most installations, the Fort Monroe Endicott series fortifications were abandoned at the end of World War II. Once the Endicott series fortifications were no longer utilized by the Coast Artillery, they were generally neglected, and few of them have received any regular maintenance. Their massive size and heavy concrete construction have resulted in many of them surviving to this day, in various states of preservation and/or deterioration.

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[25] U.S. National Park Service, “Seacoast Fortifications Preservation Manual, Golden Gate National Recreational Area, San Francisco, California” (San Francisco, California: July 1999), 2:31. Accessed on-line at http://www.nps.gov/goga/history/seaforts/ on June 13, 2005.

[26] David A. Clary, *Fortress America, The Corps of Engineers, Hampton Roads, and United States Coastal Defense* (Charlottesville, Virginia: University Press of Virginia, 1990), 144-147.

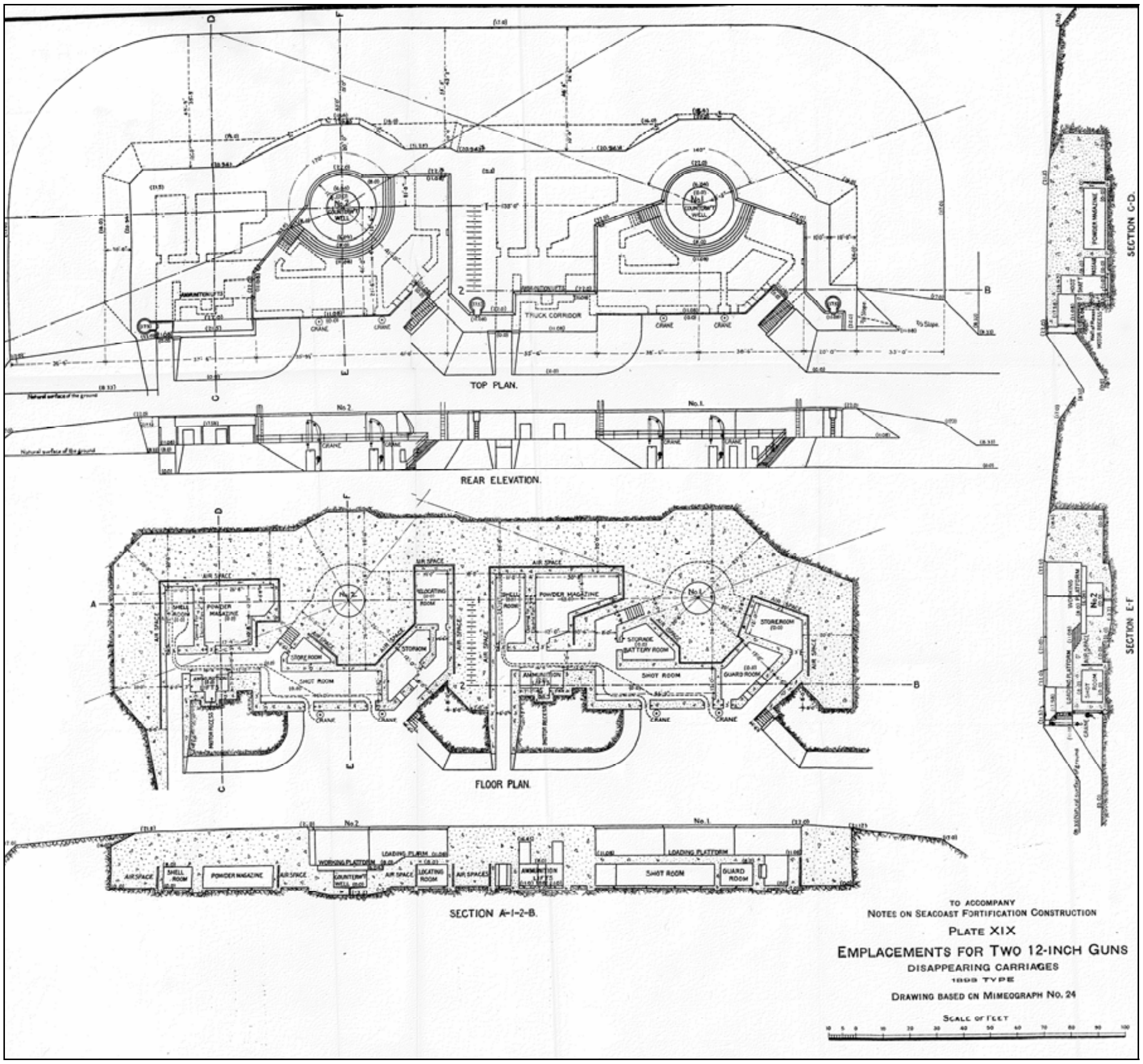

Figure 1: Typical Endicott Series Battery for two 12-inch disappearing guns
(Winslow, *Notes on Seacoast Fortification Construction*, Plate XIX)

1.3 Preservation Status

By the time of the War for American Independence, massive stone fortifications had been constructed throughout the nations of Europe and their colonial possessions. In North America, where military fortifications were frequently constructed in relatively remote and inaccessible locations, works built from readily available materials (typically brick, lumber and earth) tended to be more common than the ornate masonry edifices of Europe. Because of the nature of these building materials, most of these works were transitory, and have not survived to the present. Those works that have survived are typically in poor preservation condition, and are particularly vulnerable to erosion. Although the National Park Service, U.S. Department of the Interior has performed extensive study of pure earthworks, integrated field fortifications consisting of different materials (frequently stone or brick) combined with earth/sod have not received the same level of study. This type of fortifications are not only located on DoD installations such as the U.S. Military Academy, West Point, New York but at a range of public lands including state parks (Fort Crown Point, New York; Fort Griswold, Connecticut and Mount Independence, Vermont are representative examples) and private museums such as Fort Ticonderoga Museum, New York.

Of all the forty two Third Series Coastal Defense Forts, only Fort Monroe remains in DoD possession and use in 2005. However, the integrated use of masonry (Roman cement, brick and mortar) with earth/sod is consistent of other types of military fortifications and other types of historic properties at DoD installations. Additionally, many of the Third Series Forts are now owned and operated as public lands (Fort Macon, North Carolina; Fort Trumbull, Connecticut; Fort Adams, Rhode Island; and Fort Morgan and Fort Gaines, Alabama are representative examples). The age of these fortifications (150-200 years old), the different types of materials used, their location on coastlines where they are exposed to challenging weather and environmental conditions, and frequently inadequate maintenance have created a challenging preservation scenario.

Endicott series batteries are located on DoD installations (Fort Monroe; Naval War College at Newport, Rhode Island as examples); and state parks and public lands throughout the United States (examples given include Fort Morgan and Fort Gaines State Parks, Alabama; Fort Wetherill State Park, Jamestown, Rhode Island). Although the placement of earth against the concrete fortifications has been tentatively identified as a conduit for water infiltration, inspections of a number of these batteries revealed that the primary source for water infiltration is rather the horizontal surfaces of the batteries, and this study concentrated on means to manage water drainage and stabilize the horizontal concrete features of these historic properties.

1.4 Treatment Standards

In accordance with *The Secretary of the Interior's Standards for Historic Preservation Projects* (Washington, D.C.: U.S. National Park Service, Department of the Interior, 1979), and *The Secretary of the Interior's Standards for the Treatment of Historic Properties, with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* (Washington, D.C.: U.S. National Park Service, Department of the Interior, 1995) , four treatment alternatives for historic properties area available for DoD military fortifications:

- Preservation;
- Rehabilitation;
- Restoration; and
- Reconstruction.

Restoration is defined as “A property will be used as it was historically. Rather than maintaining and preserving a landscape, building, structure or object as it has evolved over time; the expressed goal is to make the historic property appear as it did at a particular time in its history.” Restoration would imply that all functional elements of a military fortification would be repaired or replaced, including firing steps, powder magazines, parapets, ditches, abbatis and other defensive measures, guardhouses, guard booths, and cannon. Restoration would normally be used for interpretive or educational purposes, which would be outside of normal DoD activities. Restoration is not considered to be an appropriate treatment for DoD military fortifications, and was accordingly excluded from further assessment by this study.

Reconstruction is defined as “a limited framework for re-creating a vanished or non-surviving landscape, building, structure or object with new materials, primarily for interpretive purposes.” Reconstruction would imply that all functional elements of a military fortification would be restored or reconstructed, including firing steps, powder magazines, parapets, ditches, abbatis and other defensive measures, guardhouses, guard booths, and cannon. Reconstruction would normally be used for strictly interpretive or educational purposes, which would not be in conformance with DoD activities. Although in some rare cases reconstruction might be necessary to integrate two segmented pieces of a single military fortification, such instances would be relatively rare. Reconstruction was determined not to be an appropriate treatment for DoD military fortifications, and was excluded from further assessment by this study.

Rehabilitation is defined as “A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces and special relationships. The historic character of a property will be retained and preserved.” In most cases, military fortifications do not lend themselves to rehabilitation; although one exception might be the rehabilitation of coastal defense fortifications to other uses. Such rehabilitation projects would require specialized design adapted to the individual fortification. Accordingly, this study will not discuss rehabilitation.

Preservation is defined as “retention of a historic property’s existing form, features, and detailing…. Protection, maintenance, and repair are emphasized while replacement is minimized.” Accordingly, preservation is the treatment standard that will be utilized for this study. Major elements of Preservation that apply to the preservation and stabilization of military fortifications are:

1. The historic character of a property will be retained and preserved. The replacement of intact or repairable historic materials or alterations of features, spaces, and special relationships that characterize a property will be avoided.
2. Each property will be recognized as a physical record of its time, place and use. Work needed to stabilize, consolidate and conserve existing historic materials and features will be physically and visually compatible, identifiable upon close inspection, and properly documented for further research.
3. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.
4. The existing condition of historic features will be evaluated to determine the appropriate level of intervention needed. Where the severity of deterioration requires repair or limited replacement of a distinctive feature, the new material will match the old in composition, design, color and texture.
5. Archaeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

An essential question that must be resolved is whether or not a military fortification is stable enough such it can be preserved in situ, or whether some level of reconstruction is necessary. If a fortification is not being actively eroded, if water is being adequately controlled or managed so that it is not undermining or entering or otherwise damaging the structure, and if the structural elements (masonry or earth) of the fortification are stable, then preservation can be performed in situ. However, if active erosion is occurring, if water is actively degrading or entering a structure in any manner, of if structural elements (masonry or earth) are no longer stable; these concerns will continue to be exacerbated until the survival of the fortification is threatened. Accordingly, they must be addressed. Some level of reconstruction may be determined to be necessary to stabilize the fortification. If previous documentation or studies of the fortification are available, to include original engineering drawings, then reconstruction in accordance with this information could be performed. As will be subsequently documented in this study, clear dating must be placed between original or historic features and any reconstruction. If adequate information is not available, then reconstruction should be performed to the minimum extent necessary to stabilize the fortification.

1.5 Study Organization

The second chapter of this report will review established maintenance and preservation procedures for core materials such as earthworks (earth and sod field fortifications), concrete, brick (masonry), and stone (masonry). The second chapter of this study will also introduce the use of dry-stacked or dry-laid stone, a construction technique extremely popular in New England at the time of the American Revolution and widely used in 18th century military fortifications in the northeast. The third chapter of this report will establish inspection and documentation procedures for military fortifications, regardless of their composition or preservation status. The fourth chapter will begin by presenting maintenance and preservation procedures for dry-stacked stone, then present a demonstration project at Redoubt No. 2, West Point which is constructed of dry-stacked stone and earth parapets. The fourth chapter will proceed by discussing preservation strategies for field fortifications constructed of different materials. These will include the Romans' Powder Magazine at West Point, which is a complex structure consisting of granite masonry on the exterior, earth parapets, and a brick interior; Casemates at Fort Monroe which are also complex structures consisting of granite masonry scarp walls, earth ramparts and brick interiors that are particularly prone to water infiltration; and an Endicott Series Battery at Fort Monroe which is typical of the later 19th and early 20th century coastal defense batteries constructed of massive poured concrete fortifications with earthen front parapets and horizontal poured concrete roofs. It is believed that these four fortifications will provide a starting point for the development and demonstration of preservation strategies for complex military fortifications of different timeframes that are constructed of a wide range of different materials. The final chapter will provide a DoD fact sheet on military fortifications, and conclusions.

It should be noted that during the period between World War I and World War II that U.S. Military Academy cadets traveled to Fort Monroe, Virginia to perform training on coast defense artillery batteries (Figure 2). Therefore, it is appropriate that this Legacy Resources Management Project involved both the U.S. Military Academy at West Point and Fort Monroe.

Figure 2: West Point Cadets training at Coast Defense Battery,
Fort Monroe, Virginia, c. 1920s
(Records of the Office of the Chief Engineer, U.S. Army, Record Group (RG) 77, National Archives and Records Administration II, College Park, Maryland.)

2.0 Maintenance and Preservation Strategies for Core Materials

This chapter will summarize established maintenance and preservation strategies for core materials that are used to construct military fortifications- earth, masonry (brick), masonry (mortared stone), and concrete. Knowledge of how preservation and stabilization is performed for these core materials is essential to successful maintenance of military fortifications.

2.1 Earthworks

Armies have constructed earthworks to protect and defend themselves for literally thousands of years, the most famous of antiquity being the forts that the Roman Army constructed on a daily basis. Soldiers today continue to construct fortifications using excavated soils and sand bags. Earthworks are constructed by the excavation and re-arrangement of soil. Wood is frequently used in the construction of earthworks, but because of its relatively fragile nature rarely survives more than a few years. Frequently sod will be planted or placed to protect the surface of earthworks, but in other cases grass and other vegetation will naturally grow atop the fortification. Earthworks are constructed to be relatively transitory or temporary in nature, such that they are never intended to be utilized for more than a relatively short period of time. Obviously, the survival of such temporary earthworks is tenuous at best. Surprisingly, in the United States, thousands of miles of earthworks constructed during the American Civil War remain relatively intact. Because of their dominating presence in numerous military parks, the National Park Service, U.S. Department of the Interior has assumed a leadership role in the development of strategies to preserve earthworks, and has performed extensive studies on this topic.

The National Park Service has made significant contributions in developing guidance documents for the preservation of earthworks. Among the most significant and current guidelines are:

- American Battlefield Protection Program, National Park Service. “Sustainable Military Earthworks Management.” Accessed on-line at http://www.cr.nps.gov/hps/hli/currents/earthworks/index.htm.

- Azola, Anthony. *The Effect of Management on Erosion of Civil War Battlefield Earthworks*. Virginia Polytechnic Institute; M.S. Thesis, February 2001.

- Johnson, Dr. James. E. *Managing Earthworks Under Forest Cover*. Washington, D.C.: National Park Service, U.S. Department of the Interior, 1998.

- National Park Service, U.S. Department of the Interior. *Earthworks Landscape Management Manual*. DRAFT. Washington, D.C.: 1989.

- Petersburg National Battlefield Park. *Environmental Assessment for the Preservation of Civil War Earthen Fortifications at Petersburg National Battlefield*. Petersburg, Virginia: National Park Service, U.S. Department of the Interior, 2001.

Field fortifications were almost always constructed out of earth, sometimes supplemented by wood. Although permanent military fortifications are built out of more durable materials such as bricks, granite, and concrete; earth is usually an important component of them also. In some cases such as the third series of Coastal Defense Forts, and the Endicott and Taft Series of Coastal Defense Fortifications, earth parapets were an integral component of the defensive strength of the batteries. **The National Park Service efforts at developing earthwork guidance are therefore the core approach for the preservation of all types of military fortifications.**

The National Park Service core documents should be consulted for a comprehensive description of earthworks preservation. However, the following procedures succinctly describe their approach to earthworks preservation.

1. Existing conditions should be comprehensively assessed, to include topography, vegetation, ground cover, overhead cover, water courses in the vicinity, existing erosion, animal use, visitor use, and any other fact that might influence the preservation of the earthworks. The National Park Service recommends the use of a multi-disciplinary team and GIS/GPS mapping techniques to perform this Existing Conditions assessment.

2. Historic Research. As much information regarding the history of the fortification as possible should be obtained. In the case of permanent fortifications, original design/engineering drawings may be available. In the case of field fortifications, maps or drawings might be available. Records of historic use of the fortifications should be made available. If the fortification was used at any time for purposes other than its original intent this may influence the preservation and maintenance of the property. When applicable, records of any designed or engineered modifications, changes, or alterations to the fortification should be documented. When available, maintenance records for any previous repairs and/or maintenance and/or preservation efforts should be documented. Again, a multi-disciplinary team consisting of historians, architects, and historic archaeologists should contribute to this study.

3. A detailed assessment of the Vegetation Cover conditions should be made. As noted by the National Park Service:

> To develop a holistic preservation strategy, the condition of an individual earthwork or an entire system should be evaluated. Three fundamentals lie at the heart of earthworks preservation treatment and management:
>
> - Establish and/or perpetuate continuous vegetative cover to stabilize and protect the soil from weather and human contact that may cause erosion.
> - Eliminate recreational or maintenance-related interventions that may disrupt the vegetative cover or forest floor.
> - Minimize destructive natural disturbances, such as wind thrown or felled trees, burrowing animals, or invasive exotic species.

An assessment of Vegetation Cover conditions includes assessing whether an earthwork is covered with grass or similar cover; or is protected by forest or similar cover.

4. A Management Approach is then formulated. According to the National Park Service:

> An integrated treatment and management philosophy, should address four general principles for the ongoing protection, sustainability, interpretation, and monitoring of earthworks:
>
> - Protect and preserve earthworks;
> - Use sustainable practices that consider minimal impact to the resource and the health of the associated ecological system;
> - Present earthworks clearly and legibly to the public;

- Monitor earthworks to achieve preservation goals.

5. Establish sustainable practices that require a minimum of recurring maintenance activities (to include irrigation of grass cover).
6. Determine how much visitor access will be required. Typically, fortifications on DoD installations will experience less visitor and pedestrian pressure than on a National Park Service site specifically operated to serve the general public. However, the amount of visitor access and use should be taken into consideration when planning for the long term preservation of earthworks or fortifications. If large groups such as staff rides or training classes regularly use military fortifications, then adequate facilities need to be planned to accommodate this level of visitation. If earthworks are located near family residential communities they may be vulnerable to increased pressures, to include inappropriate use such as children playing or riding bicycles upon them. Plan for vehicular access to the fortifications, and plan for pedestrian visitation at the fortification. Install an appropriate level of interpretation to support the planned level of visitation.
7. For grass covered earthworks, take measures to provide for complete vegetation coverage, and plan for annual maintenance activities that will sustain such vegetation coverage once established.
8. For earthworks are in forested areas, take measures to identify and remove hazardous trees, sustain a viable forest cover, manage the under-story to support interpretation, manage exotic or invasive species, and cover bare or exposed spots on the earthworks.
9. In all cases, for all activities, the National Park Service recommends that the minimum amount of work be performed, and that management activities should not be initiated unless they can be completed. For example, under no circumstances should earthworks be cleared of protective forest cover before a plan is implemented to protect them with grass cover. Management activities should not be initiated unless fully funded.

2.2 Dry Laid Stone Construction

Dry-laid or dry-stacked stone masonry is the "assembly of stone structures without mortar, relying on the forces of gravity and frictional resistance to construct [structures] that can last hundreds, sometimes thousands, of years." Such dry-laid stone masonry construction was used in antiquity, and examples have been found that are at least ten thousand years old in China; and eight thousand years old in Britain.[27] The use of dry-laid stone for construction was particularly well established in France, Great Britain, Scotland and Ireland. When European settlement of North America began, immigrants brought their traditional dry-laid stone masonry techniques with them, and rapidly took advantage of the quantity of raw materials to construct thousands of miles of dry-laid stone walls in New England, New York, and the Middle Colonies. One surviving example of military fortification of dry-laid stone is the Germain Redoubt at the French Fort Carillon (more commonly known as Fort Ticonderoga), Ticonderoga, Essex County, New York. This third redoubt at Fort Carillon was constructed in 1758, following the repulse of the British assault of that summer. This redoubt was intended to cover a potential avenue of approach to the northwest of the main fort that outflanked the defensive breastworks hastily constructed west of Fort Carillon by French General Montcalm in 1758. The Redoubt was a detached work, used to defend a potential avenue of enemy approach. Known as the Germain Redoubt, this redoubt was clearly constructed using "dry-stacked" fieldstone, and is still extant today [Photograph 1]. [28]

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[27] Carolyn Murray-Wooley and Richard Tufnell, "The DRY Stone Age- The Dry Stone Conservancy Promotes An Ancient Craft" *Cultural Resources Management Magazine* No. 12 (1997), 17.
[28] Cubbison, "Historic Structures Report, The Redoubts at West Point."

Photograph 1: Dry-Laid Field Stone Parapet Wall, 1758 Germain Redoubt,
Fort Carillon (Fort Ticonderoga), Essex County, New York
(Photograph by D.R. Cubbison).

It was only natural that when the Continental Army was formed in 1775, that American soldiers turned to the use of dry-laid stone masonry to construct military fortifications, similar to the redoubt at Fort Carillon that some of these soldiers had seen while serving as Provincials with the British Army during the Seven Years War. Today, numerous examples of this craft survive at the U.S. Military Academy, West Point, New York.

When Marine Battery (Chain Battery) on Constitution Island was initiated in January 1776, it was constructed using traditional dry-laid stone techniques, as documented in a letter to the New York Committee of Safety:

> The foundation of the intended Battery was completed on Sunday last, the length of which is one hundred and forty feet, the breadth at bottom twelve feet, and at the top is ten feet, and its height four feet on average. The materials are chiefly large rocks, from five hundred to one thousand weight, and some much larger, filled in with the largest stones it would take, and the small vacancies filled with coarse gravel instead of mortar, as that could not be used at this season of the year. With respect to the extension of the base to fifteen feet, it may be done, if thought necessary, at a very small expense.[29]

[29] Dr. Edward B. Jelks, *Archaeological Investigations at Constitution Island, United States Military Academy, West Point, New York, 1971* (West Point, New York: The West Point Fund, 1972), 20.

It is important to note that this description could just as easily apply to the Chain Battery on West Point, for the interior construction of this battery revealed by a September 2004 structural collapse was identical to the January 1776 description of Marine Battery's construction.[30]

Dry-laid stone masonry consists of vertically stacking field stone, such that gravity and friction permit it to stand without the use of mortar. Principles of dry-laid stone masonry construction are:

- Long stones are set into the wall to tie it together;
- Heavier, slab-like cap stones provide a level, uniform top to a wall;
- Rocks are placed so that each major stone bears on at least two other stones beneath it;
- Largest stones are set at the base, smaller stones are used in the interior;
- Chink or shim stones are wedged into the wall to help secure larger stones in place, and to fill voids;
- Construction must be perfectly vertical;
- Walls must be level across asymmetrical or convoluted ground; and
- A drainage ditch should be constructed on uphill sides and filled with gravel or rough stone to aid with drainage.[31]

When properly constructed, dry-laid stone structures can survive hundreds of years with minimal maintenance.

Dry-laid stone masonry has numerous advantages:

- Rock is a nontoxic building medium;
- With gravity and friction its only binding agents, its construction does not require any chemicals, mortar, additives, or lubricants;
- Most projects can be constructed without heavy machinery or power tools;
- Dry-stone is fully sustainable and recyclable, because no mortar is used dry-laid stone structures can be easily dismantled and the stone re-used;
- Foundations to frost depth are not required, so heavy or deep excavation is not required during construction;
- Dry-laid stone adjusts to freeze-thaw cycles and natural movements of the ground;
- Dry-laid stone permits water to move naturally through it, and drains freely, structures that are routinely inundated such as culverts, head walls, stream bank protection, channel lining and bridge abutments are particularly appropriate for dry-laid stone construction techniques;
- Appropriate stone can usually be found on-site, avoiding transportation of materials over great distances;[32]
- Dry-stone walls are earthquake resistant, since they naturally move with the earth. In March 2001 a recently constructed dry-laid stone wall near Seattle, Washington

[30] Cubbison, "Historic Structures Report, The Hudson River Defenses at Fortress West Point, 1778-1783."
[31] Editors of Readers Digest, *Back to Basics, How to Learn and Enjoy Traditional American Skills* (Pleasantville, New York: The Readers Digest Association, 1981), 68.
[32] Jane M. Wooley, "The Logic of Stone, An Advocate Looks at the Benefits of Dry Stone Masonry" *Stonexus* (Summer 2001), 35-36.

survived a 7.0 magnitude earthquake without damage (in fact, it merely settled more firmly into place).[33]

Many modern masons are trained exclusively in the use of mortar to construct stone structures, and are unfamiliar with dry-laid stone's maintenance and treatment. In the recent past, these walls were frequently repaired with the use of mortar, which causes substantial harm to any dry-laid stone structure. Within the past few decades there has been renewed interest in the use of dry-laid stone as a construction technique, and masons are again being trained in the United States to build using dry-laid stone masonry. The Dry Stone Conservancy has been recently formed to assume a leadership role in the revival of this traditional building technique (http://www.drystoneusa.org/).

Maintenance procedures of a stand-alone dry-laid stone structure are relatively straight forward:

- Insuring that the wall remains vertical, and has not shifted;
- Insuring that chink and shim stones remain in place;
- Insuring that the wall has a stable base (not undermined by erosion or changes in water patterns);
- Insuring that inappropriate materials have not been placed against the wall in such a manner as to place pressure on it (i.e. a slope slumping against the wall, or silt/debris/earth building up against the side of a wall);
- Insuring that vegetation is not growing out of the wall (the roots will disturb the stones), or that vegetation is not growing against the walls (such as a tree growing adjacent to or underneath the wall);
- Insuring that rocks have not been pulled out or similarly disturbed by animals or humans.

These basic maintenance procedures are appropriate for dry-laid structures that are strictly stone in composition, but must be expanded when earth has been placed inside dry-laid stone crib walls, or against an external retaining wall, to serve as ramparts for protection against musketry or artillery fire. Chapter IV of this report discusses the maintenance considerations in the case of integration of earth and dry-laid stone, as is typically used for military field fortifications such as those at West Point.

2.3 Brick and Mortared Masonry

Brick is one of the oldest and most durable of all building materials. In early Colonial America, the abundance of wood made building with brick unnecessary. Nevertheless, colonials often used brick to construct chimneys and building foundations. The Dutch in New Amsterdam brought with them a strong tradition of brick building, consequently a number of early brick buildings exist in the Hudson River Valley.[34] During the late 18th century and throughout the 19th century, brick making technology evolved such that higher quality bricks could be made in greater quantities at a lower cost. As the technology evolved, and prices fell, brick construction became more common throughout the United States. As brick construction became more prevalent, it became a common material in military architecture. Its durability and resistance to fire made it a natural choice for military engineers, particularly when constructing structures designed to hold gunpowder and other explosive material.

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[33] Carolyn Murray-Wooley, "The Stone Age, Still With Us, Dry Stone Masonry in the United States." *Stonexus* (Summer 2001), 32.
[34] Harley J. McKee, *Introduction to Early American Masonry* (Washington D.C.: National Trust/Columbia University Series on the Technology of Early American Building, 1973), 41.

2.3.1 Common Problems with Brick Structures

The biggest problem facing the preservation of historic brick is moisture infiltration. Brick used during the 18th and early 19th century, while durable, differ considerably from bricks constructed during the late 19th century and 20th century. Irregularities in the firing process and the pressing process often created bricks that absorbed twenty to twenty-five percent of their weight in moisture. By the late 19th century, improvements in brick making reduced the amount of moisture absorbed to less than ten percent.[35] The more moisture a brick absorbs the more susceptible to deterioration it becomes, particularly during periods of freeze and thaw. Once moisture infiltrates brick, it quickly degrades the structural stability of the individual units. Salts that are within the brick can crystallize on the surface as water seeps out. This creates a condition known as efflorescence, which can erode the face of the brick. The presence of moisture within bricks can also cause damage during intense periods of freezing and thawing.

The best way to prevent the deterioration of bricks through moisture infiltration is to remove the source of the moisture. Faulty gutters, leaking roofs and parapet walls can introduce moisture into the brick units and create a situation in which significant deterioration will occur. Moisture can also infiltrate brick through rising damp (ground water which creeps into the masonry via capillary action) and through condensation during periods of high humidity. Often, moisture infiltration can be prevented by repairing the source of entry. Repairs to gutters, flashing, roofs and parapets may be necessary to correct water infiltration keeping in mind that it may take years for historic masonry to dry out once the source of water infiltration has been addressed.

Rising damp should be addressed by ensuring that the earth surrounding the base of the brick wall slopes away from the structure. If possible, gutters should also extend away from the base of the wall so that water is deposited as far from the foundation as possible. Vegetation growing along the exterior walls should be managed so it is not allowed to touch the building exterior. Vegetation can trap moisture against the building and cause damage over time. Ivy or other climbing vines should not be allowed to develop on the building.

Mortar serves to keep masonry walls intact, keep moisture from entering the wall, allow for thermal expansion and permit moisture to escape. Although mortar lasts for decades, and in some cases centuries, it is sacrificial and will need to be re-pointed periodically. The presence of moisture in masonry walls can also cause mortar joints within the brick to fail. Structural settling over time, faulty gutters, capillary action, and extreme weather conditions can all introduce moisture into the joints. Over time, moisture weakens mortar joints, and will ultimately cause them to fail. Failed joints allow the masonry units to move and will ultimately cause structural failure. Often, historic brick walls were re-pointed using mortar that is not compatible with the masonry unit. The most common mistake is the use of mortar that is harder than the masonry unit, which can lead to serious problems particularly when the masonry unit in question is soft, 19th century bricks. Mortar that is too hard will damage brick masonry units since they expand and contract at different rates as environmental conditions change. Improper mortar will damage the brick and keep moisture from escaping the wall. Chipping, cracking, and spalling of brick indicate that an inappropriate mortar has been used in re-pointing. When this condition is present, the only long-term solution is the removal of the mortar and re-pointing.

[35] McKee, *Early American Masonry*, 55.

2.3.2 Inspecting and Assessing Historic Brick[36]

General Procedures

1. Inspect overall condition annually.
2. Records should be kept, in the form of a logbook and a systematic filing of invoices, detailing the masonry wall inspection and repair history.

Routine Inspection Procedures

1. Cracks
    - Cracks can be horizontal, vertical, diagonal, hairline, or major. Document the nature of the crack, explaining as best as possible the causes of the cracks (see below):

        a. Foundation erosion
        b. Decay and/or improper use of materials
        c. Structural failure
        d. Change in materials or geometry
        e. Changes in moisture content
        f. Thermal changes:
            i. Horizontal or diagonal cracks near the ground at piers in long walls: due to horizontal shearing stresses between the upper wall and the wall where it enters the ground.
            ii. Vertical cracks near the ends of walls.
            iii. Vertical cracks near the top and ends of the façade.
            iv. Cracks around stone sills or lintels: due the expansion of the masonry against both ends of the tight fitting stone piece that cannot be compressed.
    - What directions are the cracks going and where are they the widest?
    - Note sloped floors, bulging walls, and doors that do not fit.

2. Mortar
    - Inspect mortar joints to determine if they are loose or missing and evaluate their condition as good (no deterioration, disintegration, cracking, or spalling, evident; no moisture penetration; masonry units undamaged and stable), fair (some deterioration evident, localized minor disintegration, cracks, or spalling; minimal moisture penetration of the masonry wall; masonry units still undamaged and stable), or poor (major deterioration evident, large portions missing, completely disintegrated, or very loose, often in combination with loose or cracked masonry units and serious moisture penetration of the masonry wall).

3. Brick
    - Check for stains, wet spots, bulges, spalling, efflorescence, and missing brick.

4. Stone
    - Inspect stonework for wet spots, stains, spalling, bulges, and efflorescence.

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[36] This section is derived from the US Military Academy Cultural Resources Standard Operating Procedure #3, Inspection, Routine Maintenance, and Repair Procedures for Brick Structures.

Monitoring and Evaluating Cracks in Masonry

Some causes of cracking include: settlement or foundation erosion, decay of materials, incorrect restoration practices, structural failure, change in materials or geometry, and moisture and temperature changes:

1. In foundation piers and piles, general cracking is often due to settlement or rotation of the pier footing.
2. Vertical cracking or bulging of masonry foundation wall is often due to physical deterioration of the pier from exposure, poor construction, or overstressing.
3. Horizontal cracking or bowing of a masonry foundation wall may be caused by improper backfilling, or by swelling or freezing and heaving of water saturated soils adjacent to the wall.
4. Differential settlement of a masonry foundation wall may be caused by many different things including soil consolidation, soil shrinkage, soil swelling, soil heaving, soil erosion, or soil compaction.
5. Differential settlement of a chimney is often caused by inadequate foundations that may cause the chimney to lean and crack.

Crack Monitoring Techniques and Applications:

Monitoring Cracks Using Tape and Pencil:

1. Place a piece of tape on each side of the crack.
2. Draw one short line on each piece of tape at a convenient distance apart (two inches) and parallel to the crack.
3. If there is movement in the crack, the distance between the lines on the tape will vary; if the crack is long, several monitors will be needed.
4. Make a record chart of the distance between the marks on the tape at weekly intervals.
5. Keep accurate records of these measurements and place them along with photographs in file.
6. If significant widening occurs, report this with back-up data and copies of photographs to the Cultural Resources Manager.

Cracks may also be monitored using glass and epoxy (a microscope slide fastened with epoxy, bridging the crack; if the glass breaks, it is an indication that the masonry is moving) or by using a commercial crack monitor (Avongard Crack Monitor®). More complex and sophisticated non-destructive evaluation techniques (NDE) for masonry construction are increasingly available and applicable for use on historic structures, given the non-invasive nature of NDE. NDE available for use on historic masonry structures include radar (also referred to as impulse radar), impact echo, ultrasonic pulse velocity, spectral analysis of surface waves, electromagnetic detection, infrared thermography, and fiber optics.

Cracks may be serious and should be evaluated to determine if they are active/inactive and what the structural implications are. Thermal expansion cracks in masonry units should only be repaired to retard moisture penetration if active and/or of sufficient width. Hairline thermal expansion fractures usually need no repair. Inactive cracks may be repaired, but a structural engineer should examine structural cracks. Consult with an experienced structural engineer and the Cultural Resources Manager where questions exist over appropriate treatments. All work requiring re-pointing, patching masonry cracks, removing and replacing deteriorated masonry units, and reattaching or patching loose or spalled masonry units must be accomplished by a qualified mason with a minimum of five years experience repairing historic masonry buildings or features

2.4 Concrete

Roman builders used concrete extensively and developed methods for allowing concrete to cure underwater. Unfortunately, concrete technology was lost in Europe during the middle ages and not revived again until the 16th century. The English developed many uses for the concrete and by the early 19th century developed what became known as Portland cement. Although cement was used in a few isolated instances in the United States, its use did not become common until the late 19th century. The major breakthrough came in 1871 when an American company began producing a type of Portland cement in Coplay, Pennsylvania. The strength and versatility of concrete quickly became apparent to builders and in 1888, the Ponce de Leon Hotel in St. Augustine Florida, a structure made of poured concrete, was completed. Over the next few decades, the use of concrete as a building material grew rapidly.[37]

Military engineers quickly realized the value of concrete in the construction of gun emplacements and fortifications. Its high compressive strength made it an excellent choice for fixed fortifications. One of concrete's biggest drawbacks was its relatively low tensile strength, which made the construction of complex, concrete fortifications all but impossible. In 1877 however, American engineer Thaddeus Hyatt published *An Account of Some Experiments with Portland Cement Concrete, Combined with Iron, as a Building Material.* In this innovative work, Hyatt established the principle that iron reinforcement within concrete added a considerable amount of strength. It also allowed concrete to be used for more complex architectural applications. Although the method did not immediately catch on, by the early 1900s American engineers began utilizing this technique, with some of the earliest uses being in military fortifications.[38] Concrete artillery batteries at Hampton Roads, Virginia were among these fortifications.[39]

2.4.1 Concrete Deterioration in Military Fortifications

While concrete is a durable building material, it is subject to deterioration over time due to a number of causes. The principal threat to concrete preservation is moisture infiltration, which occurs primarily because of two reasons. The first major source is moisture introduced through precipitation including rain, sleet, and snow. Concrete is highly absorbent of moisture and will deteriorate if adequate drainage is not maintained. This problem is particularly evident in the Endicott series batteries that were constructed with massive horizontal surfaces, where constant maintenance of the drainage system is necessary to ensure that moisture does not pool on these flat surfaces and subsequently infiltrate into the structure. Some of the earliest drawings of these military fortifications indicate that the drainage system required weekly maintenance to ensure that moisture did not penetrate the building envelope. The maintenance program stipulated that all downspouts be kept clear, drains emptied of debris, and that drainage slopes away from the

[37] Carl W. Condit, *American Building: Materials and Techniques from the Beginning of the Colonial Settlements to the Present* (Chicago: The University of Chicago Press, 1968), 155-159.
[38] Thomas C. Jester, ed. *Twentieth Century Building Materials: History and Conservation* (Washington D.C.: National Park Service, 1995), 94.
[39] Col. Eben Eveleth Winslow, *Notes on Seacoast Fortification Construction*, Number 61 Occasional Papers Engineer School United States Army (Washington D.C.: Government Printing Office, 1920), 15-16.

building be monitored [Photograph 2 and Figure 3].[40] The detailed information that engineers provided for the maintenance of the drainage system indicates that they were fully aware that the failure of the system would cause problems almost immediately.

The second source of moisture infiltration originates through ground surfaces via capillary action. This condition generally results from poor drainage away from the foundation of a building, which allows water to pool near the base of the exterior walls. The concrete absorbs the water, which ultimately degrades concrete walls as the moisture is drawn up and into the wall. Moisture readings taken at the base of the wall and at other points will more accurately determine if moisture is entering the walls through capillary action.

Photograph 2: View looking at the drainage gutter on the inland side of Battery DeRussy at Fort Monroe Virginia. Soil and debris completely filled in this gutter significantly affecting the ability of the structure to shed water during periods of precipitation.
(Photograph by T. Beckwith, June 2005)

[40] U.S. Engineers Office, *Emplacement for 3 Twelve Inch Guns, Notes & Instructions for Garrison in Caring for the Drainage System etc. at These Emplacements* (Norfolk, Virginia: U.S. Engineers Office, 1901), 1.

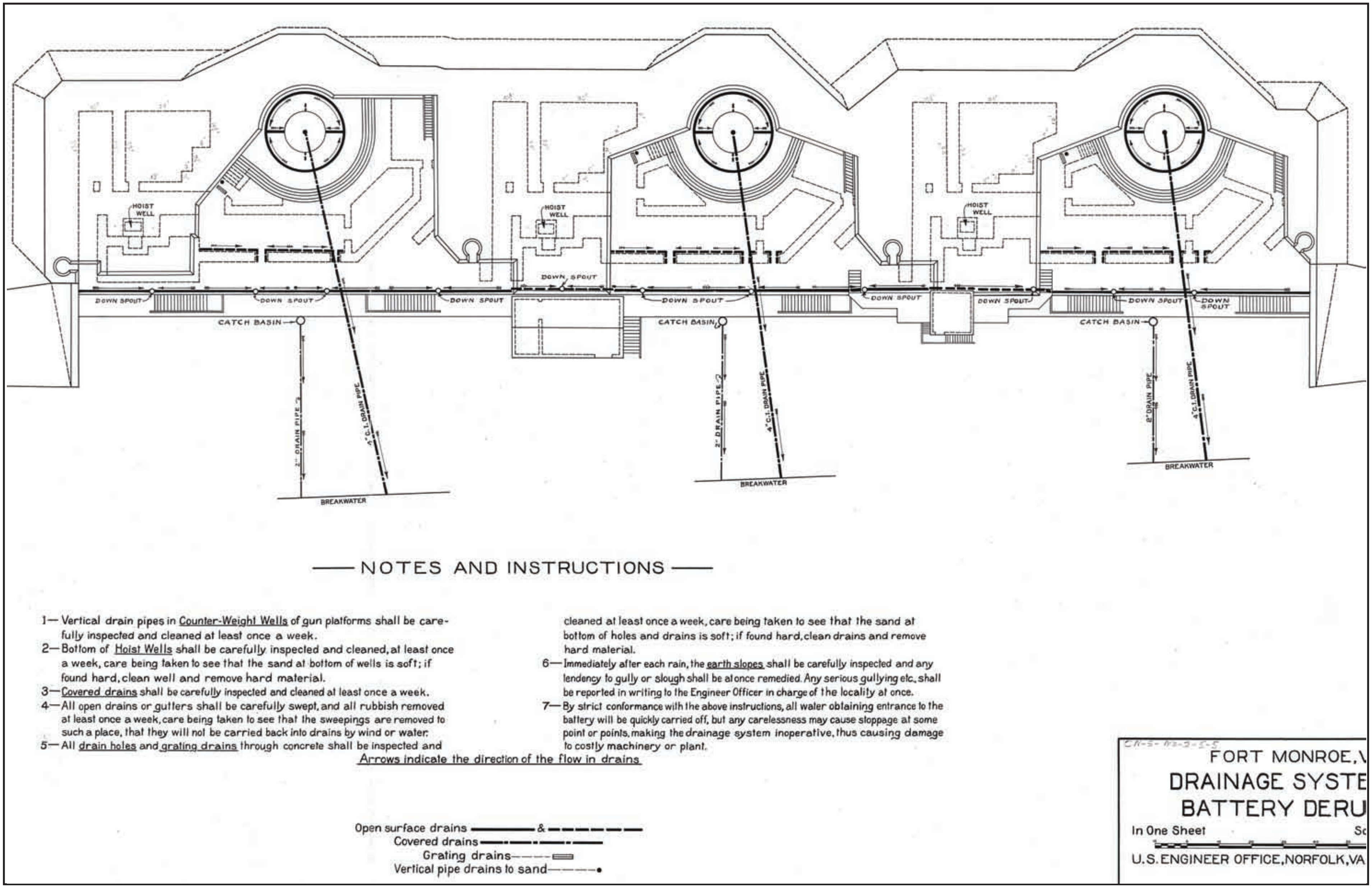


Figure 3: Notes and instructions for Drainage System at Battery DeRussy, 1920
(Directorate of Public Works Files, Fort Monroe, Virginia)

Another major cause of concrete deterioration can be found in the quality of the workmanship of the structure. Building large scale, fixed fortifications in the early 20th century constituted a new use of concrete as a building material. Sometimes, builders chose poor aggregate material or compromised the mixture by adding seawater. Other problems include the failure to tamp adequately the newly poured concrete out as it was placed in the form. This caused voids to form within the concrete wall and decreased the stability and strength of the structure. Another problem common in many concrete structures of the period is the existence of "cold joints." A cold joint forms when a poured layer of concrete hardens before the next adjacent layer is poured. This does not allow the separately poured layers to adhere adequately to each other, causing visible cracks in the surface of the walls [Photograph 3]. In some vertical joints, this condition may be deliberate. Early on in the construction of fortifications, engineers realized that constructing a monolithic, concrete gun emplacement did not produce the most structurally sound fortification. Irregular settling caused by the placement of heavy steel guns, stresses caused by blast effects, and the inevitable expansion that concrete undergoes as it cures over time caused engineers to construct planes of weaknesses in their fortifications. A plane of weakness in concrete involves building adjacent sections of a structure so that they will not bond to each other [Photograph 4]. This allows the engineer to have greater control over the location of settling cracks in the entire structure.[41] The existence of a plane of weakness may not necessarily indicate a significant structural problem. However, they should be monitored to ensure that separation is not increasing or that moisture is entering the structure via the large crack caused by a plane of weakness.

[41] Winslow, *Notes on Seacoast Fortification Construction*, 54-55.

Photograph 3: View looking at the seaward side of Battery DeRussy at Fort Monroe, VA. Note the horizontal crack on this exterior wall. This is an example of a cold joint, a condition that occurs when a layer of concrete is poured adjacent to a layer that has been allowed to harden. Cracks such as these allow moisture to infiltrate the structure and cause a great deal of damage. Note the presence of biological growth in some of cracks; this is a clear sign that moisture is present within the exterior walls. This portion of Battery DeRussy was once covered with earth but it was removed in the 1950s to accommodate base housing.
(Photograph by T. Beckwith, June 2005).

Photograph 4: View looking at Battery Church, Fort Monroe, Virginia. These particular sections have completely separated from each other. This may be a result of the use of a plane of weakness in the original design of the battery. A plane of weakness creates a joint between two adjacent sections of concrete that is designed to fail. This allows engineers to prevent unwanted cracks in concrete structures by allowing sections to settle independently of each other.
(Photograph by T. Beckwith, June 2005).

2.4.2 Inspecting Concrete Structures

Concrete structures should periodically undergo a thorough conditions assessment. This conditions assessment should review all available construction documents as well as any historic photographs of the structure. Any records related to the repair or maintenance of the facility should also be reviewed. The examination of historic records can aid in determining if conditions are persistent, or if the problem is of relatively recent origin. This information may aid in determining the exact cause of problems or in the evaluation of prior treatments.

The inspection of concrete structures should begin with a basic visual assessment of the exterior and interior of the building. Inspections should look for deterioration, damage or stresses throughout the building. This inspection should produce a record that identifies the extent of damage to the building. The record should include notes on the general condition as well as photographs of the structure. Photographs will provide an invaluable record that can guide future inspections and rehabilitation work. Any inspection should look for the following conditions within concrete structures:

- **Corrosion**: The rusting of reinforcement bars that are embedded within the concrete degrades the structural stability of concrete structures. Embedded bars are normally protected from corrosion, as they are not exposed to high levels of moisture or oxygen. High alkaline levels commonly found in concrete also protect the steel from rust. Over time however, carbon dioxide in the air reacts chemically with the concrete, reducing the alkalinity of the substance.

Another possible source of corrosion in concrete is the presence of sodium chloride within the structure. Sodium chloride is often found in concrete if seawater was used in the original mixture or if it is in constant contact with sea spray or road salts. The sodium chloride reacts with moisture, which produces electrolytes that corrode the steel reinforcing bars. As the steel corrodes, it expands which often causes the concrete covering the steel to crack and spall [Photograph 5]. This condition should be addressed and corrected as soon as possible as the steel bars are an integral component of the structural stability of concrete fortifications.

Photograph 5: View looking at Battery DeRussy, Fort Monroe, Virginia. This particular portion of the concrete spalled off and exposed the steel reinforcement beam embedded in the concrete. This condition may have occurred as a result of salts in the concrete rusting the steel. When steel corrodes it expands, which in turn caused the concrete face to spall off the building
(Photograph by T. Beckwith, June 2005).

- **Cracking**: Cracking can be found in nearly all concrete structures. Often cracking poses no major threat to the continued preservation of a concrete structure but should be monitored closely [Photograph 6]. The causes of cracking are usually caused by minor moisture infiltration, shrinking of the concrete as it cures, or settling of the structure over time.

Photograph 6: View looking at Battery DeRussy, Fort Monroe, Virginia. This portion of the battery exhibits a number of cracks with varying degrees of severity. Most of these are superficial but should be monitored over time to ensure that they are not adversely affecting the structural stability or allowing moisture to infiltrate the walls. Note that the two leaders and downspouts in the center of the photograph have been entirely removed.
(Photograph by T. Beckwith, June 2005).

- **Deflection**: Deflection consists of the sagging of concrete structural members. Factors that cause deflection includes poor construction techniques, lack of adequate reinforcement, overloading and excessive shrinkage.

- **Erosions**: Erosion occurs as a result of weathering (including precipitation, wind, salt air and sea spray) of the concrete surface [Photograph 7]. This condition is generally unavoidable but can be mitigated by ensuring that gutters and downspouts are working properly.

Photograph 7: View looking at the top of the observation tower, Battery DeRussy, Fort Monroe, Virginia. This tower exhibits some erosion caused by exposure to weather. Overtime, erosion will wear away the surface layer of concrete and ultimately allow moisture to infiltrate the structure. The black on the roof appears to be tar, which was routinely applied to waterproof the building.
(Photograph by T. Beckwith, June 2005).

- **Spalling:** Spalling is a condition in which the surface layer of concrete separates from the substrate [Photograph 8]. It can occur for multiple reasons and can threaten the continued preservation if it allows moisture to infiltrate the exterior walls of the structure. One of the major reasons for spalling is that the surface layer of the concrete is often exposed to greater variances of temperature than the substrate. Over time, the constant expansion of the surface degrades the structural bond between it and the substrate. This ultimately leads to the failure of that bond. Spalling can also occur if moisture is within the concrete wall. The presence of moisture over time also destroys the bond between surface and substrate and will eventually cause the surface to separate.

Photograph 8: Detailed view looking at the underside of Battery DeRussy, Fort Monroe, Virginia. This portion of the wall exhibits significant spalling. Spalling can occur for many reasons, in this instance it appears that moisture infiltrated the concrete walls causing the surface layer to fall off. This portion of the building also features a substantial amount of biological growth, clear evidence of a serious moisture problem.
(Photograph by T. Beckwith, June 2005).

- **Stains**: Staining of concrete can be caused by a myriad of factors. Efflorescence, rust, and biological growth can all cause stains on concrete [Photograph 9]. Generally, such discoloration is cosmetic only and by itself is not a threat to the structural stability or continued preservation of a concrete structure. However, it may indicate a more serious structural problem that often requires a high degree of attention. Rust stains may suggest corrosion of reinforcement bars, while biological staining may indicate significant moisture infiltration problems. The cause of stains should be investigated to determine if a more serious problem is present or if it is simply visually unattractive or discordant.

Photograph 9: View looking at Battery DeRussy, Fort Monroe, Virginia. These rust stains are likely a result of the metal stairs that once provided access to the tower. Discoloration such as these is generally cosmetic and does not pose a threat to the continued preservation of the structure. Stains however should be scrutinized to ensure that they are not caused by a more serious issue.
(Photograph by T. Beckwith, June 2005).

2.4.3 Maintenance of Concrete

The first step in the maintenance and preservation of historic concrete is controlling the amount of moisture infiltration that enters the building [Photograph 10]. Controlling moisture in military fortifications presents some unique challenges. The first major challenge is that the roof and exposed horizontal surfaces of military fortifications feature a very low pitch. The low pitch allowed earth to be placed on the roof and kept the profile of the battery, as viewed from the ocean, very low. While the low-pitched roof does lower the profile of the battery, it hinders the drainage capability of the roof during periods of intense precipitation. Engineers attempted to correct this problem by covering the roof with tar and other coatings but no suitable solution was ever found.[42] The second major challenge to controlling moisture is the maintenance requirements of the gutter system within this series of fortifications. Designers recognized how important it was to keep the drainage system operating to keep water from infiltrating the concrete walls of the battery. The following instructions are taken from the 1901 plans that recommend a very aggressive approach to maintaining the system:

> ”Notes & Instructions for garrison in caring for the drainage system etc. at these emplacements”

[42] Winslow, *Notes on Seacoast Fortification Construction*, 237.

1. Vertical drain pipes in counter weight wells of gun platforms shall be carefully inspected & cleaned, at least once a week.
2. Bottoms of Lift Wells shall be carefully inspected & cleaned at least once a week.
3. Covered drains shall be carefully inspected & cleaned, at least once a week.
4. All open drains or gutters shall be carefully swept, and all rubbish removed at least once a week. Care being taken that the sweepings are removed to such a place, that they will not be carried back into drains by wind or water
5. All drain holes through concrete floors shall be inspected & cleaned at least once a week, care being taken to see that the sand at bottom of holes is soft, if found hard, clean drain & remove the hard material.
6. Grating drains shall be inspected & cleaned at least once a week, care being taken to see that sand at bottom of drain is soft, if found hard, clean drain & remove hard material.
7. Immediately after each rain the earth slopes shall be carefully inspected and any slight tendency to gully or slough shall be at once remedied, any serious gullying etc. shall be reported in writing to the engineer officer in charge of the locality at once.
8. By strict conformance with the above instructions all water obtaining entrance to the battery will be quickly carried off, but any carelessness may cause stoppage at some point or points, making the drainage system inoperative.[43]

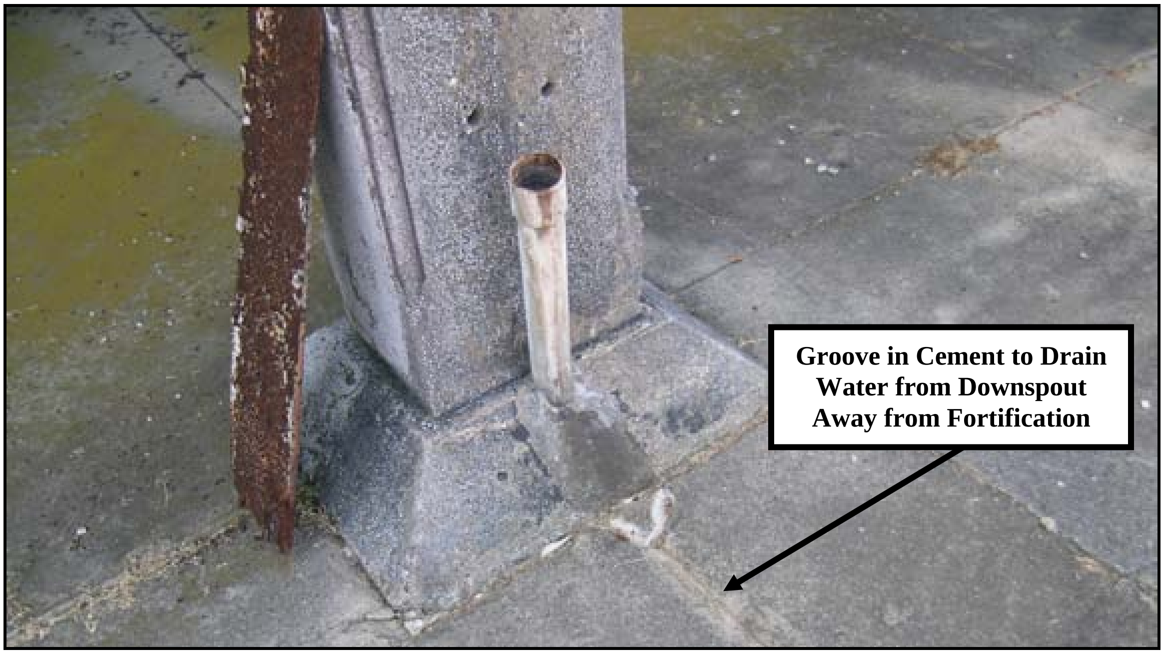
The focus on the recurring, in this case weekly, maintenance program indicates that the engineers realized that if the system were neglected, even for a short period of time, moisture infiltration problems would certainly develop. Before any work can begin on rehabilitating the structure, steps need to be taken to correct the moisture infiltration issues. These steps include restoring the drainage capability of the battery, ventilating the interior of the battery, and sealing the roof of the battery. The implementation of these measures will help to begin the process of drying out the concrete walls so that stabilization and repairs can take place. Any repair would ultimately fail if repairs to the battery were to occur without first addressing the moisture infiltration problem. As these measures are being undertaken, the moisture content of the interior should be frequently monitored to ensure that the measures taken are decreasing the amount of moisture within the structure. Once the moisture levels within the building have receded, the job of rehabilitating the concrete can begin.

[43] U.S. Engineers Office, *Emplacement for 3 Twelve Inch Guns.*

Photograph 10: View looking at one of the chain hoist system at Battery DeRussy, Fort Monroe, Virginia. The presence of substantial biological growth, extensive corrosion, and the great amount of spalling that has occurred indicates a significant amount of moisture infiltration. Before any rehabilitation work can begin, the building needs to be allowed to dry out. (Photograph by T. Beckwith, June 2005)

The initial step to correcting the moisture infiltration problem is to restore the drainage capability of the existing system. Frequently, the entire gutter system is entirely inoperable, or has not been maintained for years if not decades. Some of these solutions may be very simple while others will require more effort and expense. The first priority is to clear the existing system of vegetation, dirt, and debris. Over the years and in the absence of regular maintenance, a significant amount of debris typically collects within the drainage and gutters that has effectively rendered the drainage system useless. Removing all of this debris will allow water to sheer off the upper levels of the fortification and ultimately flow away from the building. This will prevent water from pooling on horizontal surfaces, which can be a major source of deterioration in concrete structures. Some of the interior drains, particularly those that convey water from the center of the gun pits, run through the concrete structure to the exterior walls. Each of these drains should be examined thoroughly to ensure that nothing has clogged the drains within the walls, or that the lining is still intact. Debris should be removed and the lining repaired if necessary. Another major component of the drainage system that needs to be repaired is the downspouts and leaders that convey water from the first floor to the ground level [Photograph 11]. Many of these downspouts and leaders are completely missing and some are severely damaged. At some point, it also appears that some of these drains were repaired incorrectly. The base of the downspouts was filled in with Portland cement so that even if the drainage system was still functional, it would not be able to move moisture away from the foundation of the building [Photograph 12]. The cement should be removed so that the water can flow into the grooves that are designed to carry water away from the foundation. Once these repairs are completed, the earth surrounding the base of the foundation should also be examined to ensure that it is properly graded. If any portions are keeping water from flowing away from the building, they should be re-graded to ensure that water flows away from the building.

Photograph 11: Detailed view of one of the leaders at Battery Parrott, Fort Monroe, Virginia. Many of the downspouts and leaders are missing or severely damaged, which is the case with this particular example. This condition inhibits the drainage system's ability to guide water away from the foundation of the building.
(Photograph by T. Beckwith, June 2005)



Photograph 12: Detailed view of one of the downspouts at Battery DeRussy, Fort Monroe, Virginia. Many of the downspout bases have been filled in with Portland cement. Even if the leaders and downspouts still existed, water would not flow away from the foundation. The concrete needs to be removed to restore the ability of the drainage system to shed moisture. Note the groove in the cement, which is designed to carry water away from the foundation.
(Photograph by T. Beckwith, June 2005).

The next step to stabilizing the battery is to provide adequate ventilation to the interior of the building. Buildings that lack adequate ventilation often allow humidity levels within to rise to unsafe levels. High humidity within the building envelope can lead to unwanted biological growth, deterioration of concrete surfaces, and pest infestation. The specific problem with military fortifications is that they have very few door openings and almost no window openings. The openings that do exist, with few exceptions, have been completely closed. The closure of these openings traps the moisture that infiltrated the building envelope, which ultimately prevents the masonry from ever drying out. For masonry buildings in the Mid-Atlantic States and coastal areas, it is recommended that they receive at least two air exchanges per hour during the winter months and three to four air exchanges during the summer months. [44]

Because there are so few openings in military fortifications, it is recommended that all doors and windows are opened to facilitate greater air movement throughout the structure [Photograph 13]. In order to monitor the effect of the ventilation, monitoring devices should be placed within the battery so that temperature, humidity, and the amount of moisture within the concrete walls can be recorded. This data can be used to determine if a passive ventilation system is providing enough air exchanges or if a more aggressive approach is required. Prior to the installation of the passive ventilations system, moisture levels of the interior and exterior concrete walls should be taken at various points. The data should be recorded and checked periodically at the same points (at least once per month) to ensure that the building is drying out.

[44] Sharon C. Park, *Preservation Briefs No. 31: Mothballing Historic Buildings* (Washington, D.C.: National Park Service, Technical Preservation Services, 1993), 9-10.

Even if all of the doors and windows are opened it may not provide enough ventilation for the structure. The systematic collection of temperature, humidity, and moisture levels should provide enough information to determine if a passive ventilation system is effective. If the data indicates that air is not moving through the building, then the installation of an active system should be considered. An active system may simply consist of vent and exhaust fans strategically placed to facilitate air movement throughout the battery. Prior to the installation of an active system, the building should be examined closely to determine how best to dry out the wettest areas. The placement of the intake and exhaust fans may be made more effective depending upon many factors including which areas are the wettest. An active system may also be made more effective by regulating the times at which it is turned on and off. The use and placement of the active system should be carefully considered and implemented in response to the nature of the data gathered.[45]

Photograph 13: View looking at the exterior of Battery DeRussy, Fort Monroe, Virginia. The doors in the left portion of this photograph prevent adequate air exchange within the battery. These doors should be opened and replaced with grates that will allow air to flow through the battery, while still preventing people from accessing the interior.
(Photograph by T. Beckwith, June 2005)

The roofs of military fortifications should be examined closely to determine if extensive repairs are necessary. While some areas of the roofs may be in good condition, other areas may have deteriorated significantly. Ideally, the roof should be one of the first elements of the building envelope to be addressed. However, the roof will likely need some extensive repairs before a waterproof membrane can be applied. It appears that at some point, a layer of tar or a type of

[45] Ibid, 10.

asphalt was typically applied to the roofs of military fortifications [Photograph 14]. Engineers realized that since concrete conducted heat poorly, the surface layer often experienced different rates of expansion over the course of a day. Over time the variance in the rates of expansion between the surface layer and the substrate caused the surface layer to fail [Photograph 15]. Builders used tars, asphalt, and felt to waterproof the surface layer of concrete fortifications with varying degrees of success. Tar provides excellent protection from the elements, however, over time the elasticity of the material gradually declines and it begins failing. When tar fails it often cracks and causes pieces of the surface layer to scale off. More research is necessary to determine what the best method would be for waterproofing the roof; however it is likely that whatever method is chosen, it will require periodic reapplication to ensure that the waterproof membrane is working properly. Finally, vegetation should not be permitted to grow on roofs, on any horizontal or vertical elements of the fortifications, or elsewhere immediately on the fortifications. The vegetation's roots cause damage directly to the fortification, and the roots can actually separate and disintegrate the structural concrete, particularly at concrete joints [Photograph 16]. Additionally, the vegetation serves to retain moisture against the concrete, and prevents sun and wind action from naturally drying out the fortification.

Photograph 14: View looking at the roof of Battery DeRussy, Fort Monroe, Virginia. The low pitch of the roof makes it difficult for the structure to shed moisture during periods of high precipitation. Engineers recognized the need for a working drainage system, and stipulated that the gutters, downspouts, and drains be cleaned on a weekly basis. The black substance appears to be tar or asphalt, which was applied to keep moisture from infiltrating the battery. This coating failed and the roof is now exhibiting some cracking. The presence of biological growth in the cracks clearly indicates a significant amount of moisture infiltration into the concrete.
(Photograph by T. Beckwith, June 2005).

Photograph 15: View looking at the roof of Battery DeRussy, Fort Monroe, Virginia. Note how this portion of the roof has deteriorated significantly. Differences in the rate of expansion between the surface layer and the substrate cause the surface layer to disintegrate and become unattached from the substrate. Over time, this allows moisture to pool atop the fortification, exacerbating the problem.
(Photograph by T. Beckwith, June 2005)

Photograph 16: View looking at Battery DeRussy, Fort Monroe, Virginia. The horizontal surfaces surrounding the gun emplacements appear to be in remarkable shape. Although there is some biological growth in the seams, there is very little cracking or erosion of the surfaces. What little vegetation there is in the seams should be removed to facilitate drainage and natural drying.
(Photograph by T. Beckwith, June 2005).

3.0 Inspection and Documentation Procedures

Recurring inspections of general site conditions at military fortifications on DoD sites is important to establish a baseline of existing conditions at each site, so that trends that would eventually cause degradation to the features can be identified and reversed in a timely manner. Integral elements of recurring site inspections are:

- Weather Conditions;
- “Relic Hunting” or artifact collecting;
- Inappropriate uses of fortifications;
- Erosion;
- Vegetation changes;
- Animals or pests; and
- Inappropriate military training or activities.

Each individual element will be discussed in detail below. Finally, a sample site inventory form developed at West Point is provided that is applicable for use any DoD installation or historic site.

<u>Weather conditions</u>, both during the site visit, and recent weather, should be recorded. Weather conditions such as freeze/thaw cycles, heavy rainfall, snow melting, heavy snow all have the potential to damage a military fortification, and should be particularly noted.

<u>“Relic hunting</u>,” also known as “pot hunting” or artifact collecting, consists of the use of metal detectors or other excavation techniques by amateurs, who search military sites for artifacts for personal collections, commercial sales, or some combination thereof. Military collecting is an extremely popular hobby in the United States and other nations. Use of metal detectors except under the provisions of a DoD sponsored archaeological investigation or a permit issued in accordance with the Archaeological Resources Protection Act (ARPA), is a criminal violation of ARPA. Military sites on DoD property, because of the presence of artifacts such as insignia, buttons, bullets, weapons, projectiles, and buckles, are particularly valuable to “relic hunters.” The presence of relic hunters can be noted through small excavations, usually using a trowel or small shovel such as a military entrenching tool. Such excavations will result in a small hole with well-define sides. Some relic hunters will attempt to hide their excavations with leaves or similar debris. Any freshly excavated dirt or soil should be investigated. More aggressive relic hunters will employ shovels and sifters, and the resulting excavations and soil piles are distinctive. When indications of such activities are located, they should be documented using photographs, and DoD law enforcement activities should be notified so that a formal criminal report can be filed. Identifying locations where relic hunters are frequently looting can assist law enforcement personnel in ARPA investigations and prosecutions.

<u>Inappropriate use</u> of military fortifications such as campfires, “parties,” and similar public gatherings can be noted through the presence of trash, graffiti, fires, and similar disturbances. Although the use of military fortifications by members of the DoD community and general public for educational purposes should be encouraged, unsupervised recreational use frequently causes severe damage or destruction to military fortifications. Evidence of inappropriate uses should be documented using photographs, and DoD law enforcement activities should be notified so that a formal criminal report can be filed. Identifying locations where informal parties and gatherings are occurring can assist law enforcement in establishing effective patrol routes and patterns.

<u>Erosion</u>- Military fortifications, particularly those comprised of earth or sod, are extremely vulnerable to removal of soil by rain, water, foot traffic, and vehicle tires. Fortifications should

be monitored for the presence of foot paths, bicycle ramps, etc. Stone or brick fortifications, or the height and slope of earthworks, can also be enticing to skateboarders and similar recreational users. Where footpaths are informally created, they can lead to severe erosion that will eventually damage or destroy earthen fortifications. Informal paths should be blocked with informal barricades such as deadfalls, formal barricades such as fences or planted vegetation (hedges), or signage. Vehicles, particularly dirt bikes, four wheel ATVs used recreationally, or military vehicles performing training activities, can also cause severe damage to earthworks. Other inappropriate uses can be reduced with the use of appropriate signage, and law enforcement patrols. Once a fortification has had protective vegetation removed from it, measures must be taken to re-plant appropriate vegetation before erosion occurs. Any damage to stone or brick fortifications should be appropriately documented with photographs and a narrative report. The location of damage or new erosion should be recorded on a simple sketch map or design drawings of the fortification.

<u>Vegetation changes</u> are particularly important to the long-term survival of a fortification. Large trees that have died, or appear to no longer be stable, should be identified and professionally removed. The presence of suddenly lush vegetation may indicate a new source of water infiltration or water runoff that could potentially damage the fortification. Protective vegetation that is dying or deteriorating must be noted so that appropriate corrective action (fertilization, watering, re-planting, etc.) can be promptly taken.

<u>Animals</u> observed in the vicinity should be noted. Some animals are obviously deleterious to a military fortification, such as groundhogs or similar burrowing creatures. Their presence should be noted, and Pest Control should be notified to remove the animals. Other animals such as deer sometimes create established paths that have the potential to cause erosion, knock down dry-laid stone walls, or similarly damage a military fortification. Animals such as deer also have the potential to denude an area of protective vegetation, and measures to restrict animals from military fortifications through the use of fencing, controlled hunting, etc. may be necessary. The presence of domestic animals such as horses or cows could suggest that protective fencing in the vicinity is no longer viable, and that these animals are able to roam at will over the fortifications. Animal hooves are capable of causing considerable damage to earthworks, and measures should be taken to remove any domestic animals from fortification sites immediately. Pests such as bees, hornets, wasps, poisonous snakes, ticks, etc. should be noted in locations where public visitation, or military training, occurs. Such pests have the potential to harm visitors, and Pest Control should be notified to take appropriate corrective action.

<u>Other inappropriate uses</u> should be noted. Military fortifications frequently occupy key or topographically prominent terrain. Such terrain encourages military or recreational activities such as orienteering, hunting, land navigation training, etc. Where such activities result in uncontrolled pedestrian pressure upon a fortification, notification through military or similar command channels might be necessary to develop alternative locations for such training that does not endanger the military fortification, or to devise procedures to effectively protect the fortification. Where appropriate, military training might be prohibited or limited within an established buffer zone around a vulnerable fortification. Where necessary, signage or fencing might be necessary to establish a clearly delineated buffer zone.

Once a conditions baseline for a military fortification is established, it must be regularly monitored to identify trends or changes that might be causing harm or damage. Monitoring visits can be performed to different schedules, depending upon geography and weather. A particularly remote site may not need to be visited during winter months when access is difficult. Alternatively, a military fortification in a location where hunting or military training is occurring might need to be visited more frequently during such activities to ensure that it is not being harmed or damaged. Military fortifications that are vulnerable to relic hunting should be visited more frequently during spring and fall, when vegetation is reduced, and soil conditions encourage the use of metal detectors. Military installations with seasonally heavy rainfall would require more frequent monitoring of earthen or sod fortifications during such periods. Any time that a particularly severe weather event has occurred such as heavy rainfall, tropical storms, tornadoes, high winds, an ice storm, etc. any military fortifications in the affected areas should be visited. This permits fortifications that have been damaged to be immediately identified, so that appropriate corrective action can be taken before conditions worsen.

Each site visit should be consistently documented on a standard form, and the site visit forms (with photographs and site drawings where appropriate) maintained in a record file. A record of corrective action, where necessary, should be attached. This permits effective long-term monitoring of changing conditions at a military fortification that may not be apparent over a short-term timeframe.

U.S. Military Academy
Cultural Resources Site Monitoring Form

Site	
Date of Visit	
Visit Performed By	
Weather (current and recent)	

Observation	Indicators	Findings and Actions Taken
Relic Hunting	Small blade-dug holes, metallic trash excavated and discarded, vehicle tire tracks	
Vandalism	Trash, graffiti, fire rings	
Ground Disturbance	Pedestrian trails, fire pits, bicycle tracks	
Tree Falls		
New Vegetation		
Vegetation Changes	Tree died, tree hit by lighting, tree lost branch, vegetation dying or dead	
New Erosion	INDICATE ON MAP AND PHOTO-DOCUMENT IF POSSIBLE	
Animals Observed In Vicinity	Deer in particular, domestic animals	
Pests	Groundhogs, rodents, bee hives, snakes	
Other Inappropriate Uses	Military training, scout camping, hunting	
Other Concerns		
Remarks		

Form Prepared by D. R. Cubbison, DHPW, USMA, 08 July 02

4.0 Preservation and Stabilization Approach

4.1 Dry-Laid Stone and Earth

4.1.1 Inspections

These fortifications, most typically of the Revolutionary War period but also occasionally of the Civil War era, consist of dry-laid stone parallel retaining walls filled with dirt, loose stone and miscellaneous construction debris that would then have been firmly tamped or compressed into place to comprise an effective barrier to artillery or musketry fire. The correct military term for these walls is the scarp wall (when referring to the front wall of the works), and the space between these walls comprises the rampart. Historically, these retaining walls would have been covered with earth, log or wooden parapets, and/or covered with sods, to provide additional protection to both soldiers and the works. Over the passage of time once abandoned, the wooden parapets rapidly disintegrated and vanished, and only the scarp walls and ramparts survive. The compression of the earth and fill inside the dry-laid stone walls resulted in a tightly compacted earthen mass that is as resistant to erosion as it was to gunfire. Where used, sod has also proven an effective defensive measure against erosion. These fortifications are extremely similar to the more traditional earthworks, which are so common to Civil War battlefields in particular, and whose preservation treatments have been well characterized by the National Park Service as previously discussed.

The dry-laid stone walls have also proven resistant to erosion, as their construction permits them to naturally expand and contract with freeze-thaw and thermal expansion cycles, while the openings in the dry-laid stone permits water to naturally percolate out of the ramparts.

The first inspection step should be to prepare detailed measured drawings of the fortification. The emerging use of Global Positioning System (GPS) survey technologies makes the creation of such drawings relatively simple. For military installations where surveying instruction is given, military students or cadets could develop such surveyed drawings as a portion of their training. These measured drawings should be provided in a large enough scale to permit areas of erosion, deteriorated stone, vegetation problems, trees and tree canopies, etc. to be adequately recorded.

Dry-laid stone should be carefully inspected, to insure that the construction technique is actually dry-laid stone and not mortared stone [Photograph 17 and Photograph 18]. Weather conditions (such as heavy rain) and the passage of time will sometimes remove softer historic mortar, and mortared stone might be perceived as dry-laid stone. A careful inspection inside stone joints will usually reveal the presence of mortar, where it has been utilized. The joints must be carefully inspected, as heavily weathered or eroded soft historic mortar may often appear as simply clay or mud [Photograph 19, Photograph 20 and Photograph 21]. If mortar is detected, then the fortification should be treated as mortared masonry, and well-documented preservation and maintenance techniques for masonry structures should be utilized (see previous Chapter II).


Photograph 17: Redoubt Wyllis, Fortress West Point (1778-1783), Dry-Laid Stone Interior Walls, Powder Magazine, U.S. Military Academy, Orange County, New York.
(Photograph by D.R. Cubbison)

Photograph 18: Redoubt Four (1779-1783), Fortress West Point,
Dry-Laid Stone Walls at West Reentrant Angle.
(Photograph by D.R. Cubbison)

Photograph 19: Mortared Parapet Wall, 1756 Grenadier Redoubt, Fort Carillon (Fort Ticonderoga).
(Photograph by D.R. Cubbison)

Photograph 20: Mortared Stone, 1759 Light Infantry Redoubt,
Fort Crown Point, Essex County, New York.
(Photograph by D.R. Cubbison)

Photograph 21: Mortared Stone, 1759 Light Infantry Redoubt, Fort Crown Point.
(Photograph by D.R. Cubbison)

The following inspection items are of particular importance.

- Vegetation cover. These fortifications must be protected by a thick, contiguous layer of vegetation such as a mixture of grasses that provides complete ground cover, and protects the interior earth, stone and rubble from erosion. The extant ground cover should be complete. Any gaps or holes in the vegetation cover should be identified. A close examination of the vegetation cover should be made to identify even small holes or gaps in coverage, as sparsely growing vegetation will also expose the fortification to erosion. Vegetation that grows in clumps should also be noted, as although it will appear to provide full protection, such incomplete vegetation will not provide adequate erosion protection to the ramparts.
- Dry-laid stone. Bulges, gaps, or holes in the dry-laid stone indicate locations where the stone has failed. Once erosion begins, it will continue until the walls eventually structurally fail and collapse, unless measures are taken to control the water and stabilize the eroded portions of the earthwork. Bulges, gaps, or holes should be identified and monitored. The conditions behind the erosion causing this damage to the wall should be investigated and identified if possible.
- Chink or Shim stones. Dry-laid stone should be evaluated for the presence of the small chink-stones that actually hold the masonry wall together. These small stones are usually the first to fall out, and once they are removed from the dry-laid stone it becomes vulnerable to more massive failures. Their loss or absence indicates that the wall has lost a considerable portion of its natural strength, and that repair is warranted.
- Dry-laid stone. In previous years repair work to dry-laid stone walls was frequently performed with the use of mortar. The introduction of mortar to dry-laid stone walls is

extremely damaging, as the ability of the dry-laid stone to naturally expand and contract is degraded, and the mortar often serves to trap or contain water within and behind the stone. The use of relatively hard mortar with a large quantity of Portland Cement is particularly destructive. The presence of mortar within the joints of any dry-laid stone structure should be noted and documented.

- Large vegetation growing on the earthworks. The presence of any large trees growing on the fortification should be identified, and the condition of the tree noted. Generally, trees growing directly on the works should be removed at ground level, and the stump permitted to naturally rot. The stump must be carefully monitored to ensure that it does not become a new erosion location. The roots of a tree growing on a dry-laid stone work are particularly destructive, as they grow behind the stone work and serve to dislodge the stones. The small chink-stones are particularly vulnerable to being displaced by roots. Additionally, the relatively narrow parapets usually do not provide adequate anchorage for a large tree, and trees growing on earthworks are particularly vulnerable to being blown down by high winds, taken down by ice storms or heavy snowfalls, or similar meteorological events. When such trees are blown over, the displacement of soil caused by their root balls results in catastrophic damage to the earthwork.

4.1.2 Repair

Repair to dry-laid stone walls should be performed by a professional mason with experience working on historic dry-laid stone walls. In areas such as New England and Middle Tennessee where dry-laid stone is a traditional construction technique, local masons are usually available who are experienced in working with this type of masonry. Such masons might be government staff or contractors.

First, complete documentation should be performed of the structure, generally to HABS Level III standards. No actions should be taken to repair the fortification until its present condition is comprehensively recorded. Such documentation should be incorporated into a professional report, and it should be permanently archived at an appropriate institution such as the State Historic Preservation Office, installation Library, installation Museum, or a local Historical Society. Multiple copies of this documentation are preferred, so that a catastrophic event such as fire or flood at a single institution does not destroy all copies of such documentation. Following this, a complete site inspection by a Cultural Resources Professional with the mason should be performed, using the standards identified in the section above. Upon completion of this inspection a detailed Scope of Work (SOW) for repair should be developed by the Cultural Resources Professional, with the technical assistance of the mason. If the repair work is to be contracted out, the assistance of a Contracting Officer or Contracting Officers Representative can facilitate the preparation of a viable SOW that can be easily released for bids.

A sample SOW for the repair and stabilization of Redoubt No. 2 and its detached battery at West Point is provided below. Redoubt No. 2 was constructed of dry-laid stone and earth in 1778 by the Continental Army. It is representative of military fortification types constructed of a combination of dry-laid stone and earth. A demonstration project utilizing this SOW will be performed in the fall of 2005.

Site specific conditions will require that this sample SOW be adjusted as appropriate. One significant difference is the type of grass used for different regions. A local agronomist should be consulted to recommend a mixture of cold-season and hot-season grasses that is appropriate to local weather and soil conditions, and that will provide complete coverage of the fortification.

It is important that no mortar be introduced into traditional dry-laid walls. Introduction of mortar will inhibit the ability of dry-laid stone to naturally expand and contract in response to temperature fluctuations, and will prevent water from naturally percolating through the walls. If a military fortification contained dry-laid masonry, it must be repaired and maintained as dry-laid masonry. In any case where mortar has been inappropriately introduced into a dry-laid stone wall, and particularly where "hard" mortar with a large proportion of Portland Cement has been utilized, it must be removed as a component of the repair project.

Another important consideration as regards dry-laid stone walls occurs in situations where the walls are located on a slope. In the case of Redoubt No. 2 at West Point, and as will frequently be the situation for other military fortifications, this was not the situation, because the Redoubt was located on dominant terrain. However, in cases where a fortification is located on a slope, a small ditch should be excavated on the upslope (ascending or upslope) side of the dry-laid stone wall. This ditch should be filled with rocks, gravel and similar construction debris to serve as a French drain to remove water from the dry-laid stone wall. This ditch should be tied into a drainage system, either existing or newly constructed. The ditch can be covered with top soil and suitably landscaped or disguised at the completion of the construction project.

4.1.3 Maintenance

Once repairs have been completed, a routine inspection and monitoring program should be established. Site inspection procedures have been previously provided, and should be adhered to. Once these fortifications are stabilized, maintenance specific actions are relatively limited.

Specific maintenance points for dry-laid stone and earth fortifications are as follows:

- Each spring, vegetation should be inspected, and selective re-seeding as appropriate should be performed for areas where vegetation has died, diminished, or been removed over the winter. Vegetation monitoring is particularly important, as military fortifications usually consist of soil excavated or removed from protective ditches around the work. Accordingly, the soil on top of the fortifications are usually not top soils, rather they are usually poorer quality soils that often make it difficult for vegetation to become well established. Re-seeding may require several seasons or applications to provide complete vegetation coverage.
- A mason should visit the fortification every six months, and insure that chink or shim stones are tight and present. The mason should manually tighten loosened chink or shim stones, and replace any missing chink or shim stones as appropriate. Chink stones and shims should be no smaller than one inch to 1 ½" by three inches in size; and should be recovered from the site when possible. Slate stones cannot be used, as they are not strong enough to be effective. Chink stones and shims should generally match the color and type of stone used in the adjacent dry-laid masonry. Do not bring chinking stones beyond the face of the major masonry stones.

4.1.4 Dry Laid Stone Demonstration Project - USMA Redoubt No. 2

Materials: Dry Stacked Masonry with Earth Ramparts

Location: Redoubt No. 2 and Detached Battery, West Point Fortress, West Point, Orange County, New York

Owner: U.S. Military Academy, West Point, New York (USMA)

Site History: Redoubt No. 2 and its detached Battery were constructed by the Continental Army in 1778 to serve as advanced outposts as a component of Fortress West Point. Redoubt No. 2 and its detached Battery were manned by the Continental Army until 1783, when they were subsequently abandoned. Redoubt No. 2 is located on a prominent piece of high ground approximately 1,500 feet west of Redoubt No. 1. This redoubt is located on higher ground that commands Redoubt No. 1. This redoubt is a pentagonal redoubt adapted with the incorporation of a sixth short face cutting across the principal salient angle. This appears to have been necessitated by the terrain, an adaptation that would have been completely in agreement with military engineering treatises of the middle 18th century.[46] Redoubt No. 2 is constructed of dry-laid fieldstone parapet walls at the base, and the remainder of the redoubt is well-packed earth only (which may have originally been faced with sod or timber). As with Redoubt No. 1, there is no ditch. The interior circumference of this redoubt was probably originally 160 feet (five faces of thirty feet each, plus a short face of approximately seven to eight feet). Thus, 160 men would have been required for its defense. Because of severe erosion problems caused by previous improper clearance of protective vegetation from this redoubt, the original thickness of the parapet walls, the possible presence of any banquette or embrasures, and the location of the entrance can no longer be discerned. Arnold succinctly noted of Redoubt No. 2: “The same as No. 1, No bomb proofs.” The redoubt is located on high ground, and its elevation provides the redoubt with a commanding presence. The choice of a modified pentagonal shape appears appropriate to the terrain. Redoubt No. 2 has been under extreme erosion pressure for a number of years, but its continued survival under these adverse conditions suggests that it was an extremely well constructed fortification.[47]

Although possible, no subsequent use by the U.S. Army Garrison at West Point or the U.S. Corps of Cadets at the U.S. Military Academy has been documented. Repair work is known to have been done at this Redoubt in the early 20th Century, although no details regarding the extent or amount of these repairs have been documented. Redoubt No. 2 and its detached Battery were located in a heavily wooded area through at least 1965. Sometime between 1965 and 1975 the redoubts were cleared, presumably as a component of the USMA’s American Revolution Bicentennial activities. Since this clearing, the redoubt and battery have displayed marked deterioration. Further exacerbating the maintenance condition of this earthwork is the construction in 2000 of the nearby Stony Lonesome II Housing, which has resulted in considerable pedestrian pressure upon the fortification. This deterioration has reached a point by 2005 that the redoubt and battery will not survive another decade without preservation and stabilization efforts.

Conditions: Photographic documentation of Redoubt No. 2 and its Detached Battery were performed in 1965, 1975 and 1995. The conditions of the battery since 1965 are well documented. Portions of the battery have completely vanished since 1965. The north parapet wall of the battery catastrophically failed and collapsed in winter 2004-2005. All interior walls of the redoubt have also catastrophically failed and collapsed in winter 2004-2005. The winter of 2004-2005 was marked was by exceptional freeze-thaw conditions caused by wildly variable temperatures, with record snowfalls, and torrential rains in the fall of 2004 followed by additional torrential rains in the spring and fall of 2005. This winter season caused devastating damage to the redoubt.

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[46] As with Redoubt Wyllis, Redoubt No. 2’s shape is nearly identical to a pentagonal redoubt presented as Plate II, Figure 4 by Lochlee, *Elements of Field Fortification.* In this case, however, the redoubt was adapted by adding a short side cutting across the most prominent salient angle, as described.
[47] Cubbison, “Historic Structures Report, West Point Redoubts.”

Scope of Work:

1. Remove all disintegrated sand bags and loose sand from the interior of the south parapet wall. Protect earthworks from further erosion during this process through laying plywood or similar protective material (i.e. straw, etc.) across the ramparts.

Any obviously inappropriate repairs, or ineffective previous repairs, that hide or disguise any components of a fortification should be removed. In the case of USMA Redoubt No. 2, sand bags were placed against one of the historic dry-laid stones to stabilize it during nearby construction. The sand bags were never removed at the end of the project and disintegrated, hiding the original dry-laid stone wall beneath the sand, and serving to hold water and moisture against the dry-laid stone wall. Removal of these sand bags and sand was necessary to adequately assess the condition of the surviving dry-laid counterscarp wall.

As with all activities at a historic site, measures must be taken to preclude the introduction of any additional erosion as a result of pedestrian or vehicular movement.

2. Perform complete photographic documentation and record drawings of site conditions following removal of sand bags, to Historic American Building Survey (HABS) Level III.
3. With Stone Mason experienced in dry-laid stone construction, evaluate entire redoubt.
4. Identify areas where stones have actively failed or collapsed, and areas of active erosion.
5. Identify areas where walls are to be re-constructed to 1965 (earliest photographic documentation) levels.
6. Identify areas where earth must be removed to permit dry-laid stone reconstruction.
7. Remove stones that are actively failing or collapsing. All stones should be clearly marked and labeled with chalk or similar removable markings.
8. Remove dirt to stable soil level.
9. All reconstruction work must be done is small segments, that can be accomplished in a one or two working days. Measures must be taken to protect existing parapet walls adjacent to work areas from further erosion (i.e. laying down plastic, tarps, etc.)

Work areas must be minimized. If concerns are identified with procedures, or the quality of the contractor’s work, then the entire fortification will not be compromised.

10. Replace lost or missing chinking stones and shims in remaining dry-laid stones.
11. Missing chink stones and shims should be used to fill the voids between dry-laid stones, decreasing joint sizes to about 1/8” to ½.” Chink stones and shims should be no smaller than one inch to 1 ½” in size by three inches in size; and should be recovered from the site (large numbers of these stones that have fallen out of the joints surround the parapet walls). Slate stones cannot be used. Chink stones and shims should generally match color and type of stone with adjacent dry-laid masonry.
12. Do not bring chinking stones beyond the face of the major masonry stones.
13. Place water permeable fabric cloth above historic stone and earth surface. Place pennies dated to the year of implementation above the cloth to provide firm dating for any future work.

The use of dated pennies provides a clear line of demarcation between original features of a fortification, and any restoration work. The pennies will survive and provide a definitive record of dating in the future. Pennies are relatively inexpensive, and will not introduce any discordant elements into the fortification.

14. Replace previously removed stones, or critical missing stones, as appropriate. No mortar is authorized for use.
15. Replacement stones, where necessary for reconstruction, will be recovered from stones that have fallen from around the base of the parapet walls. Clean stones with a stiff brush and water before they are re-installed.
16. Newly reset stonework should be indistinguishable from the original and surrounding stonework.
17. In areas where erosion is likely to occur, or has previously occurred, use stone to construct a natural “French drain” inside or underneath the earthwork to remove water from the fortification. Use natural stones to discretely construct such a drain.
18. Where necessary, bring in clean fill dirt. Areas where substantial quantities of soil have eroded should be re-filled and re-graded. Dirt should be sifted to ensure that it is clean, or can be certified to be clean fill dirt. Care must be taken that archaeological or historic artifacts are not inadvertently introduced to the redoubt from an outside source.
19. The entirety of the redoubt’s earthen parapet should be planted with “Seed Mix No.2” per the *Redoubt 1 and 2 Preservation Plan*. This consists of a combination of warm and cold season grasses, locally adapted, that will provide consistent ground cover.
    a. Seed used will be a mixture of *Bouteloua curtipendula* (Sideoats grams) and *Schizachyrium scoparium* (Little Bluestem).
    b. Prepare the seed by mixing it with an extender, such as vermiculite, sand, sawdust or cat litter. Combine four pounds of extender with every pound of seed. Dampen the mix slightly and mix thoroughly;
    c. Distribute seed by hand-passes; walking and sowing in parallel rows, then repeating the process perpendicular to the first passes. Ensure thorough seed distribution;
    d. After seed is scattered, the area should be lightly raked so that about ¼” of soil covers the seeds.
    e. Use hand roller to lightly press the seeds into the soil.
    f. Scatter a light covering of clean wheat or oat straw across the top of the seeded areas and shake out any clumps;
    g. Water seeded areas with one inch of water. Use of drip irrigation is preferred, but may not be feasible given remote location of powder magazine. Use of a transportable water tank will be necessary.

This seed mix was identified by the USMA agronomist for the specific soil and climatic conditions of the Hudson Highlands. A local expert should be consulted for each specific locale.

20. Once the redoubt has been re-seeded, mowing should be reduced in frequency and intensity. The grass should be permitted to grow to a six inch height, and mowed only when necessary to maintain that height. All mowing should be done by hand only.

Cutting the grass too low will damage it, and harm the protective benefits of the vegetation on the ramparts.

21. A careful record of all work performed, including brick or stone replaced, must be maintained. A weekly progress report with photographic documentation will be required. Digital photographs are acceptable.
22. Construct a simple representative historic type fence around the perimeter of the redoubt. Discrete, attractive “Preserve Our Heritage, Please Do Not Climb on the Fortifications” signs can be placed on the fencing.

23. Construct viewing platforms per previous cadet project to provide alternative pedestrian viewing locations, with interpretive signage.

Once a fortification is stable, measures must be taken to reduce or remove future pedestrian pressure. When feasible, the construction of a viewing platform to enable visitors to look into the fortifications, and provide a view that is better than that provided by the top of the fortification, will substantially reduce pedestrian traffic upon the works.

3.0 Additional Instructions - The USMA will designate a staging/lay-down area within close proximity to the work site.

In addition to the work at the fortification itself, it must be recognized that any government construction team or contractor will require a staging/lay-down area to store and service equipment, stockpile supplies, etc. Such a location must be designated in advance, should be reasonably close to the fortification, and should be sited in such a manner that no historic or archaeological resources would be endangered. Identification of such a work area is an important component of any construction project at or in the vicinity of a historic property.

4.0 Statement of Qualifications

4.1 The Contractor must demonstrate previous experience with performing restorations of late 18th and/or early 19th century dry-laid stone structures.
4.2 The Contractor must demonstrate familiarity, and that contractor is trained and skilled in historic dry-laid masonry construction techniques.

This demonstration project was performed in the spring of 2006, following the preparation of this draft report. A discussion of the demonstration project is provided as Appendix C.

4.1.5 Demonstration Project- Redoubt No. 2 Visitor Viewing Platform, West Point

As noted by National Park Service guidance for earthworks preservation, an important consideration in managing earthworks is to remove pedestrian traffic from them. The severe damage caused by frequent pedestrian traffic is well documented at Redoubt No. 2 at West Point, where a foot path has been worn between twelve and eighteen inches into the historic redoubt surface, and numerous dry-laid stones have been displaced (Photograph 22). To assist with resolution to this problem, the U.S. Military Academy's Civil and Mechanical Engineering Department assigned a First Class Cadet Project in Academic Year 2004 to design an effective visitor viewing platform. The intent of the project is to provide a location with superior views to those obtained by actually walking upon the fortifications. The cadet project guidelines were established as follows:

Project Title:
Observation Platforms at Redoubts One, Redoubt Two (two platforms, two sites)

Project Location: Historic (Revolutionary War) Redoubts One and Two, Vicinity heath Loop, Stony Lonesome II Housing
Project Type: Engineering Study, Fabrication
USMA POC: Douglas R. Cubbison, Acting Cultural Resources Manager, x3522, Fax x2529, DHPW (EP&SD).
Engineering Expertise(s): Civil Engineering, Structural Strength, Structural Design, Foundations and Footers, Timber Fabrication.

Project Description:

1. Redoubts One and Two were constructed in 1778 to serve as advanced defensive positions at the West Point Fortress. They were originally constructed of dry-laid stone, earth, and timber. These redoubts are being damaged by extensive pedestrian usage. Viewing platforms are required to relieve some of the pedestrian usage of these historic resources.
2. Project calls for engineering design, and fabrication of a viewing platform at each redoubt (two projects, two sites – one at Redoubt One, one at Redoubt Two). The viewing platforms should be sited so that both redoubts are visible from each platform.
3. Viewing platform should provide for pedestrian safety, be constructed of timber, be durable (twenty years design standard), and be tall enough to permit visitors to see interior of adjacent redoubts and batteries.
4. Design should provide, if possible, for at-grade foundations to minimize ground disturbance.

Military Applications: Civil Engineering, Construction Design, Timber Fabrication, Construction Supervision, Project Planning and Management, Soldier/Worker Safety, Visual and Aesthetic Improvements to Installations.

During Cadet Academic Year 2004 Cadets Brian Mitchell and Jared Oren, working with Colonel Ronald Welch as their academic advisor, prepared a design for these viewing platforms. At the inception of this Legacy Resources Management Program their design was reviewed for construction feasibility by The U.S. Military Academy Directorate of Public Works. The design was refined by construction specialists, and subsequently constructed as a Demonstration Project (Photographs 23, 24 and 25). Some limited removal of trees within the Redoubt No. 1 and No. 2 vicinity was necessary to create clear visual lines of sight from and between the viewing platforms.

Design features of this viewing platform, which are available as a standardized design (provided as Appendix D) for the use of DoD installations and other historic sites, are:

- Platform size of nine by fifteen feet to accommodate nineteen visitors (size based upon a West Point maximum class size of eighteen cadets with one instructor, with seven square feet allocated to each spectator);

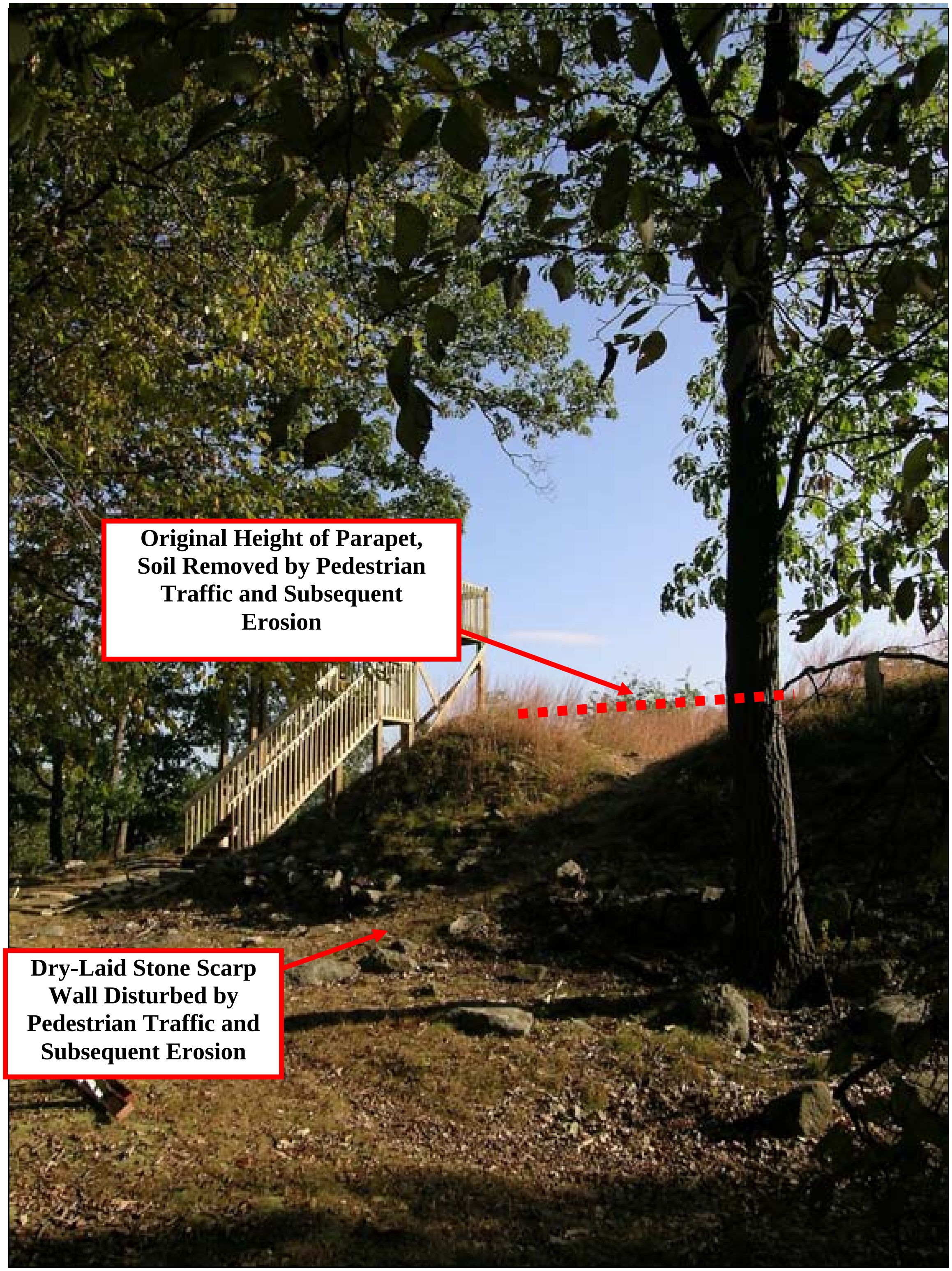
It should be noted that the size of the viewing platform should be adjusted at individual sites to accommodate anticipated visitation.

- Design to survive West Point weather conditions of one hundred mph winds with full winter snow load;

The strength of the viewing platform should be adjusted for each individual location's local conditions.

- At-grade foundations to minimize ground disturbance and excavation;
- Unpainted lumber construction to blend with natural landscape;
- Railings and steps designed to provide for pedestrian safety;
- Adequate space provided for installation of interpretive markers and/or similar signage;
- Adequate height to see clearly into the interior of redoubt (Photograph 26);
- Relatively simple design that can be constructed by any general contractor (specialized construction skills are not required);
- Use of standard lumber (specialized materials are not required);
- Twenty-year design standard (service life can be extended through routine maintenance).

Once the viewing platforms are installed, additional measures must be taken to preclude future damage from occurring to the fortifications, to include placing of appropriate signage, restoration of damaged paths so that they are no longer visible, and placement of measures that limit public access while still permitting visibility of the historic resource (e.g. historic fencing, historic chevaux-de-frieze, etc.).



Photograph 22: Damage caused to Redoubt No. 2 by pedestrian traffic and subsequent erosion.
(photograph by D. Cubbison, September 2005)

Photograph 23: Cadet Academic Project and DoD Demonstration Project, Redoubt No. 1 Viewing Platform, U.S. Military Academy, Orange County, New York. Note how the natural wood colors blend with the surrounding landscape and vegetation.
(Photograph by D.R. Cubbison, September 2005)

Photograph 24: Cadet Academic Project and DoD Demonstration Project, Redoubt No. 2 Viewing Platform, U.S. Military Academy, Orange County, New York. Note how the natural wood colors blend with the surrounding landscape and vegetation.
(Photograph by D.R. Cubbison, September 2005)

Photograph 25: Cadet Academic Project and DoD Demonstration Project, Redoubt No. 2 Viewing Platform, U.S. Military Academy, Orange County, New York. Note how the natural wood colors blend with the surrounding landscape and vegetation.
(Photograph by D.R. Cubbison, September 2005)

Photograph 26: Cadet Academic Project and DoD Demonstration Project, Redoubt No. 1 viewed from new Viewing Platform, U.S. Military Academy, Orange County, New York. The ability of this structure to provide excellent views of the layout of the fortification that cannot be obtained from any other perspective is dramatically demonstrated by this photograph.
(Photograph by D.R. Cubbison, September 2005)

4.2 Mortared Masonry (Brick) and Earth

In addition to fortifications that utilize a combination of masonry with earth, some fortifications are comprised of complex mixtures of materials. Even when a fortification was constructed solely of stone, structures with a specific function were constructed of different materials. An example of this is Romans' Powder Magazine at Constitution Island, USMA. Because granite and similar igneous stones sometimes contain ferrous materials, locations used for the storage of gunpowder and explosives were usually constructed of brick, which was felt to be a safer material. Romans' Magazine is constructed of mortared masonry (native granite quarried on the island) scarp walls, filled with earth. Inside the ramparts is an arched brick powder magazine. During the late 19th century a number of Endicott series artillery batteries were constructed inside earlier fortifications, with their concrete structures tied directly to the historic brick.

The mixture of different types of construction materials will sometimes introduce specific points of failure or deterioration. In particular, different types of materials will expand and contract at different rates, resulting in cracks or similar structural failures at attachment points which will then serve as a conduit to introduce water into a fortification. Similarly, structures such as the Endicott Batteries were constructed with different foundations than the original fortifications that they were anchored to. Accordingly, the newer fortifications will settle and move at different rates and in different conditions than the original fortifications, potentially resulting in cracks or similar structural failures at different locations that could then serve as a conduit to introduce water.

4.2.1 Inspections

The first inspection step should be to prepare detailed measured drawings of the fortification. The emerging use of GPS survey technologies makes the creation of such drawings relatively simple. For military installations where surveying instruction is given, military students or cadets could develop such surveyed drawings as a portion of their training. These measured drawings should be provided in a large enough scale to permit areas of erosion, deteriorated stone, vegetation problems, trees, etc. to be adequately recorded. Particular attention should be paid to recording different types of structural materials, and to recording connection or transitional locations.

The following inspection items are of particular importance:

- Connection or transition points between different materials must receive particularly detailed inspections. Signs of stress, strain, or failure, should be looked for. Spalling of materials, stress cracks through stones or bricks, failure of mortar joints, exposed reinforcing steel, exposed corners or foundations, doors, walls or windows out of alignment, vegetation growing between different structural elements, etc. are all indications that a structural failure has either occurred, or is imminent. Such locations should be carefully recorded, documented, and monitored. Simple instruments such as crack monitors should be utilized to determine if cracking is continuing, or if a structural feature has stabilized. A number of such crack monitors are commercially available, and are easily used without the need for any training. If engineering or design drawings of the fortification are available, the historic approach to joints and connection points must be documented and understood.
- In addition to a comprehensive examination of connection points, particular emphasis must be paid to the top (roof, attic, or parapet) connections between discordant materials. Obviously, rain or other runoff water is most likely to enter a structure from the top. Connection points must be carefully examined to ascertain how water is being managed and drained, if gutter and drainage systems are intact and functioning, if joints are intact and viable, if capstones are present or have been damaged, etc. A firm understanding of how the fortification was originally designed to capture and remove water must be obtained. Locations where such systems are missing, have been removed, or have been damaged must be identified. Downspouts and drainage systems may have to be internally examined using a video camera, to look for blockages or ruptures.

4.2.2 Repair

The most important aspect of fortifications comprised of different materials, sometimes constructed at different times, is that natural elements such as water and contraction/expansion and settling must be planned for and addressed.

Starting at the highest elevations of a fortification, the management of water (both rain and runoff/drainage) must be planned for. Active systems must be in place to capture water, and move it away from joints, connection points, assemblies, and foundations. Most commonly, the fortifications historically had some type of system designed and installed. The location and designs of such systems must be researched and understood, and current conditions must be assessed. Where such systems are present, they should be repaired to the maximum extent possible. If elements have been removed, have deteriorated, or been damaged so severely that they cannot be repaired, then they should be replaced in-kind using identical materials, methods, designs, textures, features and colors. If historic systems have been removed in their entirety, and if sufficient documentation is available to permit them to be replaced, then the historic water management systems should be re-installed. If such documentation is not available, then a modern water management system would have to be designed that is compatible with the historic fortification, but is sufficiently distinctive in design that it will not be mistaken by visitors as comprising an original portion of the fortification.

At any point where different materials are adjacent to each other, measures must be in place to accommodate the natural movements of the structures. Most commonly, the fortifications historically had some type of system designed and installed. The location and designs of such systems must be researched and understood, and current conditions must be assessed. Where such systems are present, they should be repaired to the maximum extent possible. If elements have been removed, have deteriorated, or been damaged so severely that they cannot be repaired, then they should be replace in-kind using identical materials, methods, designs, textures, features and colors. If historic systems have been removed in their entirety, and if sufficient documentation is available to permit them to be replaced, then the historic joint systems should be re-installed. If such documentation is not available, then a modern joint system would have to be designed that is compatible with the historic fortification, but is sufficiently distinctive in design that it will not be mistaken by visitors as comprising an original portion of the fortification.

Such repairs have to be designed on a case-by-case basis for individual fortifications, as circumstances can vary greatly between different sites.

4.2.3 Maintenance

Once effective water management and structural systems are established, there are no historic preservation specific maintenance procedures. Rather, standard procedures for the repair and maintenance of any similar structure should be utilized. Gutters, leaders and downspouts have to be cleaned semi-annually, once in the spring, and once in the fall.

4.2.4 Demonstration Project- Romans' Powder Magazine, West Point

Materials: Mortared Masonry with Earth Parapets, Brick lined interior

Location: Romans' Battery and Magazine, Constitution Island, Putnam County, New York

Owner: U.S. Military Academy, West Point, New York (USMA)

Site History: With the onset of armed hostilities between Great Britain and American revolutionaries in 1775, American political and military leaders recognized the need to fortify the Hudson River to deny British naval and land forces unconstrained access to this crucial river corridor. Early evaluations of the Hudson River identified Martelaer's Rock and West Point, along with Anthony's Nose to the south, as preferred locations for fortifications to impede the river. The Martelaer's Rock and West Point location was particularly well suited, for here the river is at its narrowest, and makes two right angle turns. Sail-driven boats must slow and make numerous changes of tack to negotiate these turns, a job exacerbated by shifting winds in the narrow river gorge. In early September 1775 a self-styled military engineer named Bernard Romans' arrived at Martelaer's Rock to supervise construction of "Fort Constitution" on the island.[48] Work progressed slowly, obstructed by chronic shortages of money, men and materials; poor engineering work on Romans' part; and jurisdictional arguments between various revolutionary leaders.

In October 1777 British General Henry Clinton led an expedition north from New York City, ostensibly to link up with another British army under the command of General John Burgoyne moving south for Albany. On the evening of October 7, 1777 the small American garrison on Constitution Island was approached by a British party, the vanguard of Clinton's force. The Americans fired a single cannon shot at the British and then abandoned the island, burning their barracks but leaving numerous military stores intact, and failing to "spike" (disable) the cannon on the island. Clinton's command subsequently occupied the island on October 8th and demolished whatever remained of military value.[49]

Among the military fortifications constructed by Romans' at Constitution Island was a powder magazine, located at the northern end of his battery. This powder magazine was completely excavated by renowned archaeologist J.C. Harrington in 1973. Harrington's report provides a comprehensive discussion of this important historic resource.

Romans' Powder Magazine (and the other portions of Romans' military fortifications) comprises the earliest construction projects still in existence that was performed by the U.S. Army. The Powder Magazine is considered to be a contributing element to the USMA NHL, and is individually eligible for the National Register of Historic Places. The Powder Magazine is used by the History Department for instructional purposes.

Conditions: The USMA CRM first visited this site in the summer of 2001. At that time the powder magazine, although demonstrating a number of weakened locations and potential failures, was generally intact. Beginning in the spring of 2002 the USMA Constitution Island Caretaker, reported that collapses to the powder magazine were eminent. Since that time, the powder magazine has catastrophically failed.

A site visit in October 2003 revealed that approximately sixty square feet of the western interior face of the powder magazine has catastrophically failed, collapsing into the interior [Photographs 27 through 35]. In addition to the catastrophic collapse of the masonry on the western interior face, the brick work on the east and northern sides of the Powder Magazine has also failed or partially failed, collapsing into the interior. The remaining brick inside the Powder Magazine is bulging and appears to be close to catastrophic collapse. The western masonry exterior wall is also bulging in several locations, and a visual inspection suggested that catastrophic failure of the western parapet wall of the Powder Magazine into the Hudson River, resulting in a total loss of this resource, is imminent. Finally, one six square foot collapse of the parapet (scarp wall) of Romans' Battery was also noted immediately to the south of the Powder Magazine. This collapse,

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[48] Following the completion of Fort Constitution, the island was alternately known as "Constitution Island" or "Martelaer's Rock" until the 20th Century, when "Constitution Island" became the generally accepted name. For consistency, this report will use the more common "Constitution Island" for all discussions of the island after construction of Fort Constitution in 1775.

[49] For the history of Fort Constitution, refer to Lincoln Diamant, *Bernard Romans', Forgotten Patriot of the American Revolution (*Harrison, New York: Harbor Hill Books, 1985), pp. 69-121; Merle G. Sheffield, *The Fort That Never Was, A Discussion of the Revolutionary War Fortifications Built on Constitution Island, 1775-1783* (West Point, New York: Constitution Island Association, 1969); and Charles E. Miller, Jr., Donald V. Lockey and Joseph Visconti, Jr., *Highland Fortress, The Fortification of West Point During the American Revolution, 1775-1783* (West Point, New York: Department of History, U.S. Military Academy, 1979).

when combined with the catastrophic failure of the Powder Magazine itself as previously documented, strongly suggests that the entire resource is immediately endangered.

Scope of Work:

1. Perform complete photographic documentation and record drawings of site conditions to Historic American Building Survey (HABS) Level III.
2. Erect temporary fencing and signage around the project area.
3. Spray vegetation currently growing on exterior of magazine with glyphosate herbicide (e.g. “Roundup-TM”).

In the case of Romans’ Magazine, the exterior and interior had been overgrown with various weeds and vegetation that completely obscured the exterior of the work, and limited the ability to adequately assess its condition. In such circumstances, a commercial herbicide should be applied to remove the obscuring vegetation. In other cases, extant vegetation may not be providing sufficient protective covering to the earth ramparts, and could be contributing to erosion rather than preventing it. Often, weeds and other vegetation “crowd-out” or prohibit the growth of more beneficial grasses. In these circumstances, the offending vegetation must be removed.

4. A qualified mason should assess the interior and exterior of the fortification for locations where brickwork or stonework has failed, or where collapse or failure is eminent. Locations where re-pointing or stabilization is necessary will be identified.
5. The interior of the powder magazine will be cleared of all debris. All usable bricks and stones will be salvaged. Unstable or eroded soil will be removed by hand from the parapets.
6. Remove bricks that are actively failing or collapsing. All bricks should be clearly marked and labeled with chalk or similar removable markings.
7. Remove dirt to stable soil level.
8. All reconstruction work must be done is small segments, that can be accomplished in a one or two working days. Measures must be taken to protect existing parapet walls adjacent to work areas from further erosion (i.e. laying down plastic, tarps, etc.).

Work areas must be minimized. If concerns are identified with procedures, or the quality of the contractor’s work, then the entire fortification will not be compromised.

9. Place water permeable fabric cloth above historic earth surface. Place pennies dated to the year of implementation above the cloth to provide firm dating for any future work.

The use of dated pennies provides a clear line of demarcation between original features of a fortification, and any restoration work. The pennies will survive and provide a definitive record of dating in the future. Pennies are relatively inexpensive, and will not introduce any discordant elements into the fortification.

10. Soil that has eroded away will be replaced using “clean soil” which has been screened to eliminate any artifacts or other items; or soil salvaged from the interior.
11. Stone masonry on exterior of powder magazine shall be stabilized, re-set, re-pointed as appropriate.
12. Stable brickwork inside the powder magazine shall be re-pointed as appropriate.
13. A gap should be left between the earth/masonry of the rampart and the brick interior, to provide for differential rates of expansion between the different materials.

14. Because these are hand-made bricks, and a future protective shelter will limit their exposure, a mortar composition with no Portland cement, 1 part hydrated lime, and 2-3 parts sand should be utilized. The mortar color should be matched to the historic mortar color.

The proper selection of mortar is critical, particularly for historic bricks. Refer to previous Section 2.3 of this report for discussions of preservation procedures and repairs for historic brickwork.

15. Disintegrated brickwork inside the powder magazine shall be re-pointed, re-set, re-constructed as appropriate utilizing salvaged bricks.
16. Stable stonework inside the powder magazine shall be stabilized, re-set, re-pointed as appropriate.
17. Disintegrated stonework inside the powder magazine shall be re-set, re-pointed, re-constructed as appropriate utilizing salvaged stone.
18. No new bricks or stone will be used for this project. Only salvaged materials will be utilized.
19. Once walls are reconstructed as appropriate, the floor of the powder magazine and the top of parapets will be leveled.
20. Top of parapets and floor of powder magazine will seeded.

    a. Seed used will be a mixture of *Bouteloua curtipendula* (Sideoats grams) and *Schizachyrium scoparium* (Little Bluestem).
    b. Prepare the seed by mixing it with an extender, such as vermiculite, sand, sawdust or cat litter. Combine four pounds of extender with every pound of seed. Dampen the mix slightly and mix thoroughly;
    c. Distribute seed by hand-passes; walking and sowing in parallel rows, then repeating the process perpendicular to the first passes. Ensure thorough seed distribution;
    d. After seed is scattered, the area should be lightly raked so that about ¼" of soil covers the seeds.
    e. Use hand roller to lightly press the seeds into the soil.
    f. Scatter a light covering of clean wheat or oat straw across the top of the seeded areas and shake out any clumps;
    g. Water seeded areas with one inch of water. Use of drip irrigation is preferred, but may not be feasible given remote location of powder magazine. Use of a transportable water tank will be necessary.

This seed mix was identified by the USMA agronomist for the specific soil and climatic conditions of the Hudson Highlands. A local expert should be consulted for each specific locale.

21. Remove temporary fencing and signage once grass is well established.
22. A careful record of all work performed, including brick or stone replaced, must be maintained. A weekly progress report with photographic documentation will be required. Digital photographs are acceptable.
23. Once powder magazine and parapet has been re-seeded, mowing should be reduced in frequency and intensity. The grass should be permitted to grow to a six inch height, and mowed only when necessary to maintain that height. All mowing should be done by hand only.

Cutting the grass too low will damage it, and harm the protective benefits of the vegetation on the ramparts.

24. A protective structure will then be constructed above the magazine.

In the case of Romans' Magazine, the brick arch originally served as the ceiling of the structure. Earth and stone rubble was placed on top of the magazine to serve as protection against shellfire. The top of the magazine was then covered with an artillery firing platform and protective parapet. These additional structural features are no longer present, and the interior of the powder magazine is exposed to the elements. The exposure of the brickwork in particular to continuous rainfall and water runoff is particularly deleterious. Accordingly, a custom protective shed type roof was designed to manage the water at the magazine.

3.0 Additional Instructions

- 3.1 The work site is not directly accessible by vehicle. Vehicle access is within approximately 75 feet of the work site.
- 3.2 The USMA will designate a staging/lay-down area within close proximity to the work site.

In addition to the work at the fortification itself, it must be recognized that any government construction team or contractor will require a staging/lay-down area to store and service equipment, stockpile supplies, etc. Such a location must be designated in advance, should be reasonably close to the fortification, and should be sited in such a manner that no historic or archaeological resources would be endangered. Identification of such a work area is an important component of any construction project at or in the vicinity of a historic property.

4.0 Statement of Qualifications

- 4.1 The Contractor must demonstrate previous experience with performing restorations of late 18th and/or early 19th century brick structures.
- 4.2 The Contractor must demonstrate familiarity, and that contractor is trained and skilled in historic brick and masonry construction techniques.

5.0 Comments

- 5.1 Because a protective structure will be constructed over this resource to protect it from rain and snow-melt, water runoff inside the structure was not taken into consideration. It is believed that the protective structure will provide sufficient protection against water infiltration into the resource.

This demonstration project was in progress in the winter of 2006, when this Final Report was being prepared, and had not been completed prior to completion of this study.

Photograph 27: Catastrophic Failure, sixty square foot collapse, Interior of Romans' Powder Magazine, Looking Northwest.
(Photograph by D. R. Cubbison, 31 October 2003)

Photograph 28: Catastrophic Failure, sixty square foot collapse,
Interior of Romans' Powder Magazine.
(D. R. Cubbison, 31 October 2003)

Photograph 29: Catastrophic Failure, sixty square foot collapse, Interior of Romans' Powder Magazine.
(D. R. Cubbison, 31 October 2003)

Photograph 30: Catastrophic Failure, sixty square foot collapse,
Interior of Romans' Powder Magazine, Looking North.
(D. R. Cubbison, 31 October 2003)

Photograph 31: Brick Collapse, Interior of Romans' Powder Magazine, Looking East.
(D. R. Cubbison, 31 October 2003)

Photograph 32: Collapse of Brick Stairs, Interior of Romans' Powder Magazine, West Entrance.
(D. R. Cubbison, 31 October 2003)

Photograph 33: Imminent Failure of Interior Brick Wall,
Interior of Romans' Powder Magazine, Looking Northeast.
(D. R. Cubbison, 31 October 2003)


Photograph 34: Imminent Failure of Exterior Masonry Parapet Wall, Romans' Powder Magazine.
(D. R. Cubbison, 31 October 2003)

Photograph 35: Six Square Foot Collapse, Romans' Battery Parapet (Scarp) Wall, South of Romans' Powder Magazine.
(D. R. Cubbison, 31 October 2003)

4.2.5 Demonstration Project- Protective Shelter, Romans' Magazine, West Point

When Romans' Magazine and Battery was originally excavated and subsequently stabilized by Dr. J.C. Harrington before the Bicentennial of the American Revolution, one of the planned design features was a shelter type roof to protect the feature from rainfall and similar weather damage. Unfortunately, this protective shelter was never designed or constructed, and the magazine and battery subsequently failed approximately thirty years after their stabilization. As a component of this project, an architect from the West Point Directorate of Public Works designed a protective shelter, under the supervision of the West Point Cultural Resources Manager. The design was refined by construction specialists, and will be constructed as a demonstration project following stabilization and preservation of Romans' Magazine.

Particularly vulnerable fortification features might require the construction of a shelter or roof to protect them from rainfall and similar direct weather damage. Design features for such a shelter or roof, which is available as a standardized design (provided as Appendix E) for the use of DoD installations and other historic sites, are:

- Minimize height to avoid addition of intrusive visual feature to historic landscape;
- Open sides with adequate height to permit unobstructed pedestrian viewing of historic resources from ground level;
- Designed to survive West Point weather conditions of one hundred mph winds with full winter snow load;

The strength of the viewing platform should be adjusted for each individual location's local conditions.

- At-grade foundations to minimize ground disturbance and excavation;
- Unpainted lumber construction to blend with natural landscape;
- Railings and similar features designed to provide for pedestrian safety, while permitting unobstructed viewing of resources;
- Adequate space provided for installation of interpretive markers and/or similar signage;
- Relatively simple design that can be constructed by any general contractor (specialized construction skills are not required);
- Use of standard lumber (specialized materials are not required);
- Twenty-year design standard (service life can be extended through routine maintenance);
- Minimize footprint, while extending "drip line" of protective shelter outside of envelope of historic resource;
- Provide for water drainage and removal from historic resource vicinity; and
- Designed to preclude use of structure by birds or similar intrusive animals.

4.3 Brick, Masonry and Earth Casemates

4.3.1 Historic Context- Casemates

A casemate is, in its simplest form, an artillery firing position located within the interior of a fortification. Casemates have been used since the inception of artillery, and their use is documented as early as the Middle Ages in European castles. A casemate permits an artillery piece to be serviced and fired from behind the rampart of a fortress, thus protecting both the artillery crew and the cannon. A casemate can be constructed of either brick or masonry, or sometimes a combination of the two materials. A casemate was protected from direct fire by a heavy brick or masonry wall, known as the scarp wall of the fortress. This scarp wall would be pierced by an angled hole that would permit the cannon to be traversed, known as an embrasure. The top of the casemate would similarly be protected by a combination of earth, brick, masonry or cement. An essential element of a casemate was that it contained a ventilation system to evacuate the choking black powder smoke from the interior of the casemate. Casemates might be open, in which case their rear would be open to the fort's parade ground; or closed, in which case their rear might be enclosed with a wall or another structure. Casemates were often described as being single, such that the casemate consisted of a single firing chamber; or double, such that the casemate consisted of a front and rear (or double) firing chamber. A great advantage of casemates was that they enabled multiple tiers of cannon to be emplaced in the faces of a fortress, significantly increasing its firepower.

Casemates were most frequently used on the water side of a fortification, as it was believed that the cannon mounted on a ship would be unable to penetrate the scarp walls of a casemate. They were occasionally used on the land side of a fortification, positioned so that they could provide flanking fires without being exposed to direct artillery fire. The principal features of a casemate are (Figure 4):

- Scarp Wall (main defensive wall);
- Embrasure to fire through Scarp Wall;
- Arched Top with Drainage System;
- Arched Sides and Rear;
- Floor; and
- Firing Platform for artillery piece.

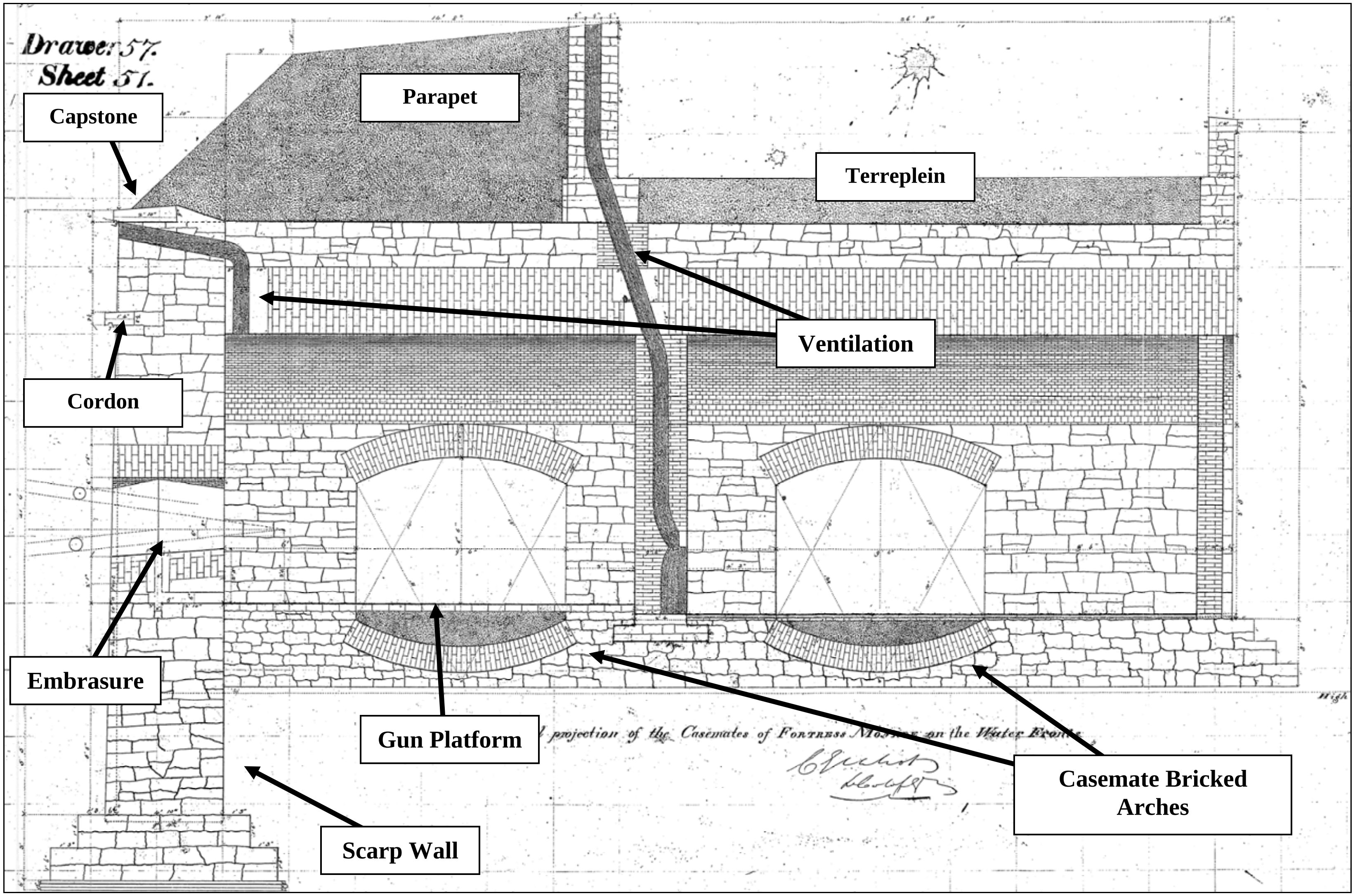

Figure 4: Components of a Third Series Coastal Defense Fortification, adapted from "Vertical Projection of the Casemates of Fortress Monroe on the Water Front" (undated) (RG 77, National Archives and Records Administration II).

As previously described, the scarp wall of a fortification was a tall, thick vertical wall typically constructed of locally quarried mortared stone in the northeastern United States; and brick (locally manufactured) in the southeastern United States. The scarp wall was the major defensive structure of a fortification, and defended the guns in the casemates from direct artillery fire. As such, it had to be thick enough to resist artillery fire, and tall enough to prevent an enemy from easily scaling it. The top of the masonry scarp wall was normally protected by a capstone, which prevented moisture from directly entering the masonry from its top. This capstone was normally a different stone than that used in the scarp wall; limestone or bluestone was typically used. An additional feature is that the scarp wall normally contained a horizontal row of projecting stones located below the capstones, called "cordon" stones. These cordon stones, according to West Point Engineering Professor Daniel Hunt Mahan, served the following purpose:

> The top stone of the wall, termed the *cordon*, or *coping*, projects beyond its face, and serving as a *larmier* or *drip,* protected it from the effects of the rain water, which runs from the parapet upon the coping.[50]

The cordon stones also served as an engineering point of reference for the elevation of the scarp wall, ditch, counterscarp walls and outer works. As with the more traditional capstone, the cordon stones were typically different masonry than the scarp wall itself, and were often limestone or bluestone. The scarp wall served as the front of the casemate.

Embrasures were openings between the interior of the casemates and through the scarp wall to permit the artillery pieces within the casemates to fire. Embrasures were usually tapered in an "hour-glass" shape to permit wider fields of fire for the cannon, while limiting the actual penetration through the scarp wall, as any penetrations through the wall would obviously weaken it. In some few cases, loopholes were also inserted through the scarp wall, to permit muskets or rifles to fire from the casemates. Loopholes were essentially considerably smaller versions of the embrasures. Quite frequently the edges of the embrasures were faced with different masonry, often limestone or sandstone. Some embrasures were closed with heavy steel shutters hung on iron pins installed into the scarp wall inside the casemate for additional protection to the casemate, while closed embrasures often had removable windows installed.

The most significant design aspect of casemates was the use of overhead arches to provide structural support for the mass of protective earth (rampart and parapet) located above the casemates [Photograph 36]. Interior arches were also incorporated on the sides, interior compartments, and ends of the casemates. These interior arches provided for communications between and within the casemates, provided additional space for the crew to service the cannon within the casemate, and ensured that the artillery pieces located within the casemates would have wider fields of fire. In fact, and although not immediately obvious, all structural arches are actually double arches, with arches at both the top and the bottom [Photograph 37]. Unless altered by construction or deterioration, the bottom of the double arch is in nearly all cases hidden by the casemate floor. The casemate interior is almost always constructed of brick, and these double brick arches are the structural elements that sustain the weight of the earth, brick, masonry and concrete above the casemates.

The top arch is under compressive forces, and the strength of the interlocked mortar and brick resists these forces. The bottom arch provides balance and alignment for the entire structure. So

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[50] Professor Dennis Hart Mahan, *An Elementary Course of Military Engineering* or *Summary of the Course of Permanent Fortification and of the Attack and Defence of Permanent Works: for the Use of the Cadets of the U.S. Military Academy* (New York: J. Wiley, 1862), 1: 8.

long as the mortar is maintained in good condition, and the bricks retain their structural stability and alignment, the arch provides an extremely strong structural element. However, maintenance of the strength of the mortar and brick is integral. In particular, permitting the mortar to become wet will eventually damage or deteriorate the mortar, thus degrading the structural strength and stability of the arch. Additionally, removing, damaging, or destroying any bricks from the arch would also be deleterious. Managing water infiltration within casemates is the single most important preservation and stabilization issue regarding these relatively complex engineering structures.

Photograph 36: Arch within the casemates at Fort Adams, Rhode Island.
(Photograph by T. Beckwith, August 2005).

Photograph 37: Bottom casemate arch, partially exposed. Fort Adams, Rhode Island.
(Photograph by T. Beckwith, August 2005).

It should also be noted that the scarp walls and casemates were not attached to each other. Each was free-standing, and had separate foundations. Thus, even if the scarp wall were destroyed by enemy action, the casemates would still remain intact. From a structural standpoint, this enabled the massive scarp wall and casemates to differentially settle, thus avoiding structural faults or cracking at traditionally vulnerable locations such as the construction joints.[51]

The floor of the casemate provided a stable firing platform for the artillery piece. When on the bottom floor of a fortification, the floor might be packed earth. More typically, and for casemates placed atop each other, the floors would be brick. Where casemates were enclosed, some of the floors might be wood. Depending upon the size and weight of the artillery piece emplaced within the casemate, the firing platform would be brick or concrete, and might contain steel rail(s) to support the weight of the cannon and permit it to traverse.

As briefly discussed above, installing and maintaining an effective drainage system to manage water entering from the top of the rampart and terreplein is a critical component of the design of the casemates. Although Professor Mahan of West Point would note:

> When the casemates also serve as quarters for the garrison, the rear, towards the parade, is closed by a brick or stone parade wall, which forms the front wall of the quarters. A brick partition wall separates the quarters from the gun gallery.

[51] Weaver, *A Legacy in Brick and Stone*, 23.

> Arched recesses and flues are made in the piers for chimneys, and the parade wall, the sides of the piers, and soffit of the arch, are suitably finished to give a dry and well ventilated dwelling.[52]

The truth is that drainage systems of the casemates were notoriously inefficient. Inspection reports of the casemate quarters at Fort Monroe consistently noted them to be wet, damp and unhealthy. One 1887 report went so far as to state "In some of the casemates used as quarters fronts 1, 2, and 3 there are considerable cracks, caused by the arches separating from the scarp and parade walls. Water penetrates through these cracks and the floor beneath near the sides of the casemates is wet. The casemates are not suitable for use as quarters on account of the dampness, and the gun rooms next to the scarp wall are not adapted to the accommodation of modern ordnance."[53] Another inspection in 1889 stated: "The cellar-like condition of any and all casemates renders them totally and absolutely unfit for human habitation."[54]

Because a major component of this project was to identify means to preserve and stabilize integrated masonry and earth structures, casemates have been identified as a typical brick and earth integrated structure, and have also been identified as being particularly problematic by nature of being buried underneath a mass of earth, concrete, brick and sod. Accordingly, understanding potential water infiltration routes through military fortifications into the casemates, and historic drainage solutions, is critical to comprehending and addressing how masonry and earth structures can be stabilized.

First, the top of the fortifications consist of two major elements. A mass of earth called the parapet provided the major defensive strength between the artillery and soldiers inside the fortification and an attacker outside. To stabilize the earthen parapet, it was almost always planted or covered with a relatively thick layer of sod. The parapet was pitched to the front to permit natural water drainage to the exterior (or scarp wall) of the fort.

The parapet terminated in a natural slope at the capstone of the scarp wall. Water was permitted to naturally drain across the top of the capstone and off the front (exterior) of the capstone. Potential damage to the scarp wall, and potential water dripping into the embrasures, was controlled by the previously mentioned cordon stones. Neither the cordon stones nor capstones were pitched to facilitate drainage, rather they were placed horizontally.

The rear of the parapet was normally stabilized by a masonry wall, either brick or stone, which might or might not be protected by a capstone.

Second, a level area placed behind the parapet provided a location for the defenders to load and fire muskets, and load and fire cannon, at attackers. This level area was known as the "terreplein." At Fort Monroe, the terreplein was grass and earth. At Fort Adams and Fort Trumbull, the terreplein was concrete. At other fortifications the terreplein might be brick. At Fort Monroe, no provisions for drainage of the terreplein are provided, meaning that any water falling onto the terreplein percolates through the soil to the casemates. At Fort Adams and Fort Trumbull, the terreplein is pitched to drain onto a gutter system, and eventually into cisterns to provide drinking water for the garrison. The terreplein was designed to be low enough so that soldiers standing on

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[52] Mahan, *Elements of Permanent Fortification*, 1:27.
[53] Records of the Office of the Chief Engineer, U.S. Army, Record Group 77, Sub-group B, Series Fortifications Map File, "DR-58A," National Archives and Records Administration II, College Park, Maryland.
[54] Clary, *Fortress America*, 115.

the terreplein could be protected by the parapet from artillery or musketry fire. The terreplein contained firing platforms for the artillery pieces; and a smaller wood, stone or earthen firing platform for infantrymen located directly behind the parapet and referred to as the banquet or firing step. Portions of the earthen firing step are still visible at Fort Monroe. At Fort Monroe, the rear of the terreplein is stabilized by a masonry wall, stone in this case, which is protected by a limestone capstone. At Fort Adams and Fort Trumbull, water drainage is performed through simple sheet runoff from the rough edge of the terreplein into the gutter system. This rear terreplein wall at Fort Monroe effectively prevents water from naturally draining off the rear of the terreplein into the parade ground, and instead serves to contain water on the terreplein.

The major drainage system at Fort Monroe was provided immediately above the arches of the casemates. An archaeological excavation conducted at Fort Monroe in 1981 revealed that each casemate arch was covered by an A-shaped roof constructed of S-shaped terra-cotta tiles set in mortar, and then covered with a thick waterproofing layer of tar. Half-round terra-cotta tiles with a diameter of 10" cover the peak of these roofs [Figures 5 through 8]. These A-shaped roofs provide the waterproofing directly over the tops of the casemate arches. At the bottom of the A-shaped roofs an actual water drainage system was designed and installed. The core of this drainage system was a half-round concrete gutter, probably manufactured of Roman cement, placed to provide water drainage directly above the joining of the casemate arches. This concrete gutter in turn penetrated the parade ground wall of the casemates, and became a standard gutter system. The area immediately above this concrete gutter was open. Above this cavity was a small arch of un-mortared bricks laid lengthwise. This brick arch was not water-proofed, except with a thick layer of tar where it joined the A-shaped roof. Above this rough brick arch was a layer of gravel covered with a deep layer of almost pure coarse light gray sand, clearly emplaced during the original fort construction, and probably intended to facilitate water percolation into the concrete gutters. The archaeologists believed that this sand was derived from the excavation of the ditches of the fort. The archaeologists noted that the tiles covering the casemate vaults appeared to be intact, and surmised that leaks in the casemates were due to breaks in the concrete gutters or dams of debris within the concrete gutters.[55] This is believed to be the original drainage system installed in 1824. Drawings of Fort Monroe from 1837 and 1841 display the same design features.[56]

A careful examination of the parade ground side of the casemates, where the gutters that drained these historic casemate water systems exited, revealed that these systems are no longer functioning as intended. Water could be observed running through the brickwork, biological growth was observed at the gutter exits, and the brick was moist if not actually wet [Photographs 38 through 41].

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[55] Phyllis Sprock, Ecologist, Fort Monroe, "Memorandum For Record: Casemate Drainage System" (Fort Monroe, Virginia: March 6, 1981).

[56] Records of the Office of the Chief Engineer, Drawer 57, Sheet 71, November 1, 1837, Fortifications Map File, Fort Monroe, Virginia, RG 77, National Archives II, College Park, Maryland; and Records of the Office of the Chief Engineer, Drawer 57, Sheet 83, April 3, 1841, Fortifications Map File, Fort Monroe, Virginia, RG 77, National Archives and Records Administration II, College Park, Maryland.

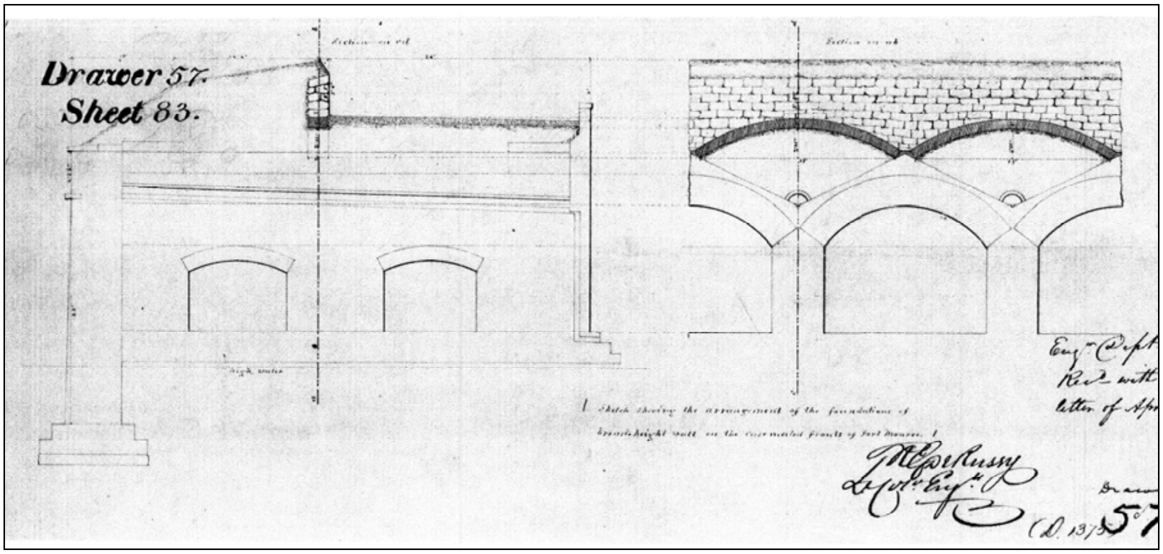

Figure 5: 1841 Engineering Drawing of Fort Monroe Casemates.
(RG 77, National Archives and Records Administration II)

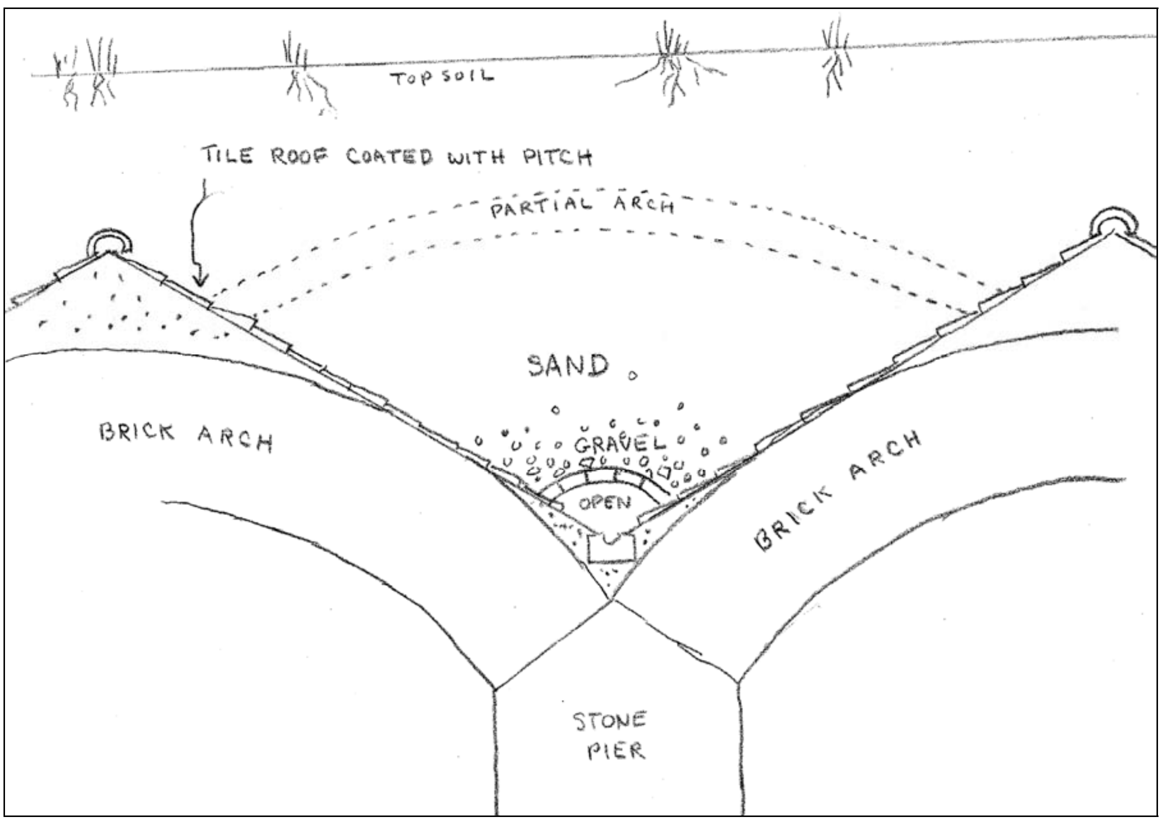

Figure 6: 1981 Drawing of Drainage System Above Arches of Fort Monroe Casemates.
(From Phyllis Sprock, "Memorandum for Record, Casemate Drainage System.")

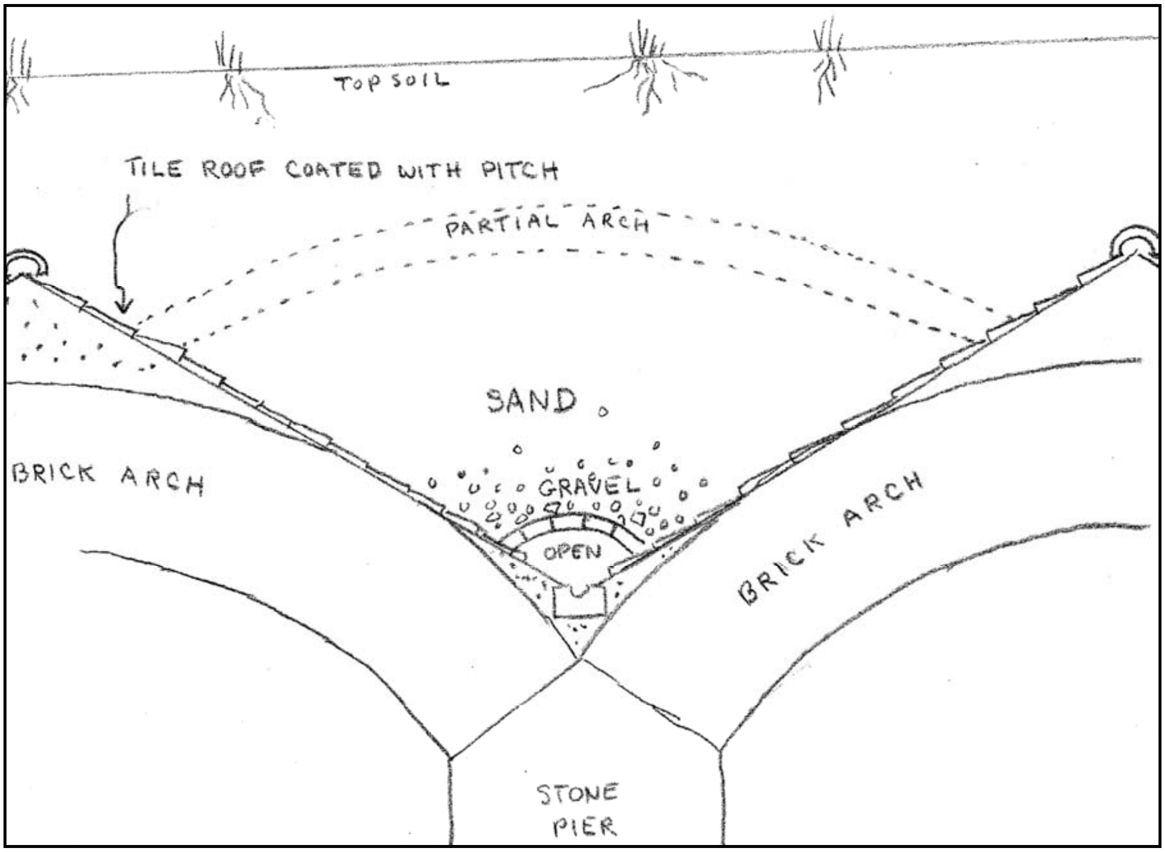

Figure 7: A figure produced during a 1981 investigation of the drainage system of Casemate 22. The system consists of a pitch covered, tile roof that drains to a gutter between the casemate vaults.
(From Phyllis Sprock, "Memorandum for Record, Casemate Drainage System.")

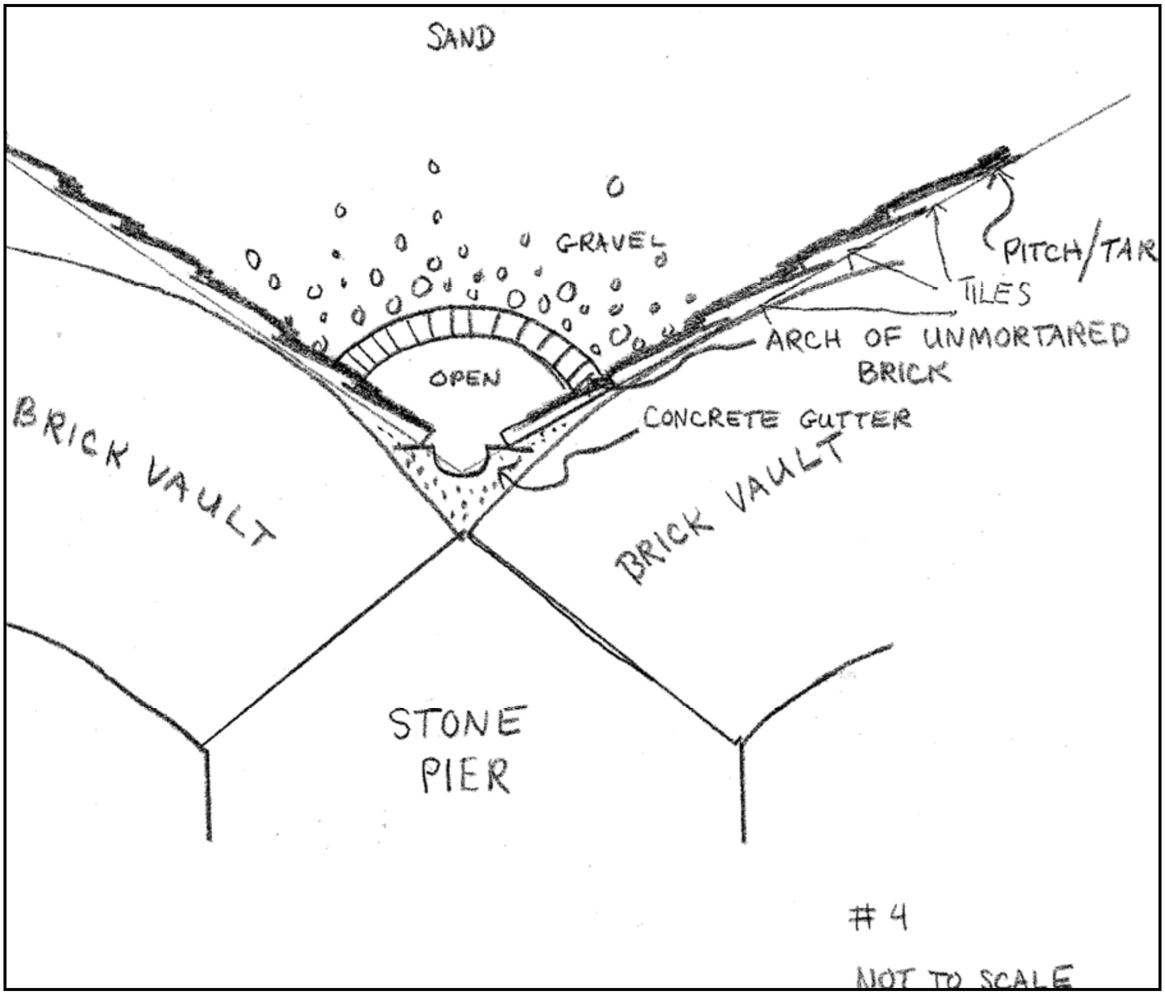

Figure 8: Another figure taken from the 1981 investigation into the drainage system of Casemate 22. This illustration details the gutter system that runs parallel to the brick vaults. It is likely that many of the gutters are clogged with debris. Failure of the gutter would prevent the water from draining adequately from the building and create moisture infiltration problems within the masonry walls.
(From Phyllis Sprock, "Memorandum for Record, Casemate Drainage System.")

Photograph 38: View looking at the exterior of Casemate 21, Fort Monroe, Virginia. These exterior walls exhibit efflorescence around the gutter down spouts. Biological grown can also be discerned along the upper brick courses, another indication of moisture infiltration into the masonry walls.
(Photograph by T. Beckwith, June 2005)

Photograph 39: View looking at the exterior of Casemate 21, Fort Monroe. This casemate suffers from extensive moisture infiltration. The failure of the gutter system or the membrane that covers each of the arches allowed moisture to penetrate the structure. Note that portions of this brick wall have been re-pointed. It is unclear if an appropriate mortar mixture was used in this re-pointing of the masonry walls.
(Photograph by T. Beckwith, June 2005)

Photograph 40: Detailed view of one of the exterior gutters at Casemate 21. These gutters provide an outlet for the moisture that is collected by the gutter system. A cursory inspection of these gutters indicates that at least some water is flowing out of the downspouts. This indicates that a portion of the drainage capability of the gutter system is intact. Note that some of the mortar exhibits signs of biological growth, and that several of the mortar joints have failed.
(Photograph by T. Beckwith, June 2005)

Photograph 41: View looking at another gutter on the exterior of Casemate 21. Although this appears to be functioning, the presence of efflorescence around the gutter and on the masonry indicates that moisture is seeping out through the masonry and depositing salts on the brick exterior. This suggests that the interior gutter system has at least partially failed.
(Photograph by T. Beckwith, June 2005)

Finally, the vertical vents designed to remove black powder smoke from the casemate interiors were usually protected with masonry chimneys or horizontal metal vent caps. Obviously, for these vents to function they had to remain open, and they were designed with mechanisms to preclude water from pouring down them.

An extensive series of repairs to the casemates of Fort Macon, North Carolina was performed between 1998 and 2002. During these repairs, it was determined that Fort Macon possessed nearly an identical drainage system. The one significant difference noted is that the Fort Macon casemates were waterproofed with lead sheeting that was then covered with tar, rather than the tile system used at Fort Monroe [Photograph 42]. Why the two forts have different systems is not known. Possibly the lead was found to be more economical than the more complex tile system, or possibly it was felt that the lead would be a more effective water-proofing than the Fort Monroe tile system.

This study was unable to identify any other casemate drainage systems that have been professionally or archaeologically investigated to the extent that Fort Macon and Fort Monroe have been. However, an 1866 design drawing created for West Point for a generic casemate depicts a similar drainage system, strongly suggesting that this may have been the standard casemate design.[57]

Photograph 42: View looking at the excavated casemates at Fort Macon, North Carolina. The design of the gutter system is similar to the system at Fort Monroe, Virginia. The major difference is that the Fort Macon Casemates are constructed of lead coated copper covered with tar while the Fort Monroe Casemates are ceramic tiles coated with tar.
(Photograph courtesy of Fort Macon State Park, Division of North Carolina Parks and Recreation.)

The following seven conduits for water infiltration into casemates have been identified. It should be noted that these water infiltration conduits are applicable to nearly any brick/masonry and earth structure:

- Water infiltration down smoke vents;
- Water infiltration through scarp walls, to include capstones and cordon stones;
- Water percolation through parapet;
- Water infiltration through rear parapet wall;
- Water percolation through terreplein;
- Water infiltration through rear terreplein wall; and
- Water infiltration through failed gutter and drainage system.

Even if water infiltration is prevented at six of these seven conduits, the failure to prevent water infiltration at even one of these locations could easily result in severe water problems within casemate interiors. As an example of what can occur to casemates if water infiltration is not

[57] Records of the Office of the Chief Engineer, Drawer 155, Sheet 10, February 7, 1866, Fortifications Map File, U.S. Military Academy, West Point, New York, RG 77, National Archives and Records Administration II, College Park, Maryland.

controlled, Figure 9 is a photograph taken of Fort Putnam at West Point c. 1870. The brick casemates at Fort Putnam were constructed c. 1793, during the construction of the first series of Coastal Defense Fortifications. At that time the original Revolutionary War Fort Putnam was expanded, and brick casemates were installed. Fort Putnam was manned through the War of 1812, and abandoned shortly following the cessation of hostilities. Thus, only fifty years of neglect resulted in their total failure and collapse.

Figure 9: Collapsed Brick Casemate, Fort Putnam, West Point, New York, c.1870.
(Pitman Collection, Special Collections and Archives, U.S. Military Academy Library, West Point, New York).

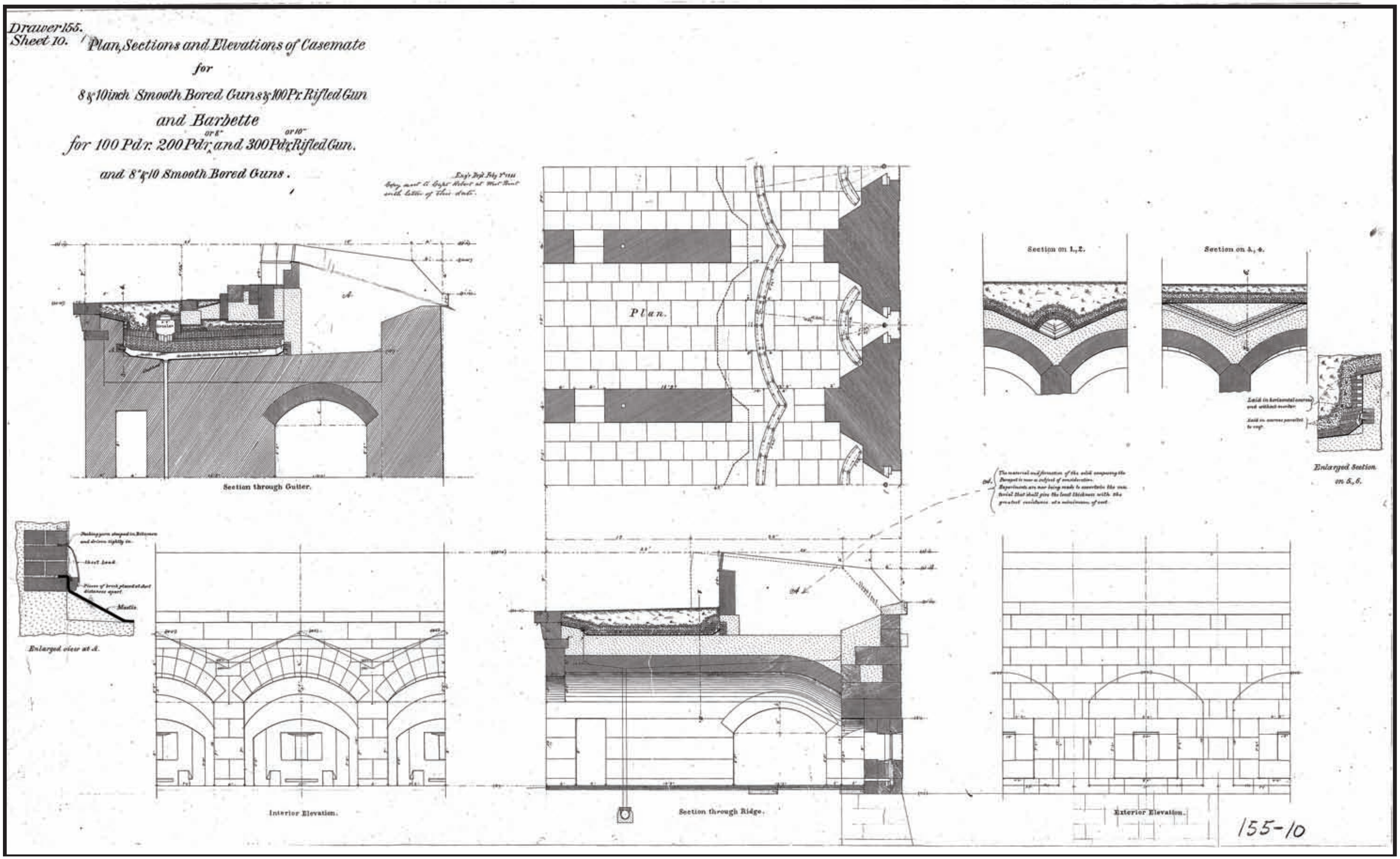

Figure 10: Typical Casemate, 1866 West Point Engineering Design
(RG 77, National Archives and Records Administration II)

4.3.2 Case Studies in Casemate Preservation

Currently, two of Fort Monroe's three casemate segments are actively used as critical installation activities-Casemates 21 as the Post Chaplain's Offices and Post Religious Facility; and Casemates 20 as the Casemate Museum. Because of severe water infiltration problems, Casemate 22 is currently used for storage only [Photograph 44]. The Chaplain's Casemate is currently experiencing an intensive amount of water infiltration although it is unclear as to the exact cause. To combat these high levels of moisture infiltrating the Chaplain's Casemates, Fort Monroe has adapted a considerably reduced maintenance approach. This simplified maintenance approach was in large part dictated by fiscal restraints.

First, relatively large air-conditioning systems were installed within the casemate vents, which have proven successful in removing substantial amounts of humidity from inside the casemate interiors [Photograph 44]. Second, in response to sandblasting to remove lead based paint that previously occurred within the casemate interiors that caused severe damage to the brick faces thus resulting in the deposition of large quantities of brick dust within the offices, a coating was added to the interior of the brickwork within the casemates. This coating appears to have been successful to some extent in maintaining drier conditions within the casemate interior, and in solidifying the damaged bricks and preventing them from further spalling or disintegrating that in turn negated the dust problem within the offices. However, site visits to Fort Monroe suggest that this coating may also be retaining moisture within the historic brickwork. Third, at several arches within the Chaplain's Casemates, water infiltration is particularly severe, and has resulted in considerable "pooling" of water on the casemate floors. In an attempt to resolve this concern, plastic drip pans have been installed underneath several of the casemate arches [Photograph 45 and Photograph 46]. These drip pans are designed to catch water infiltration, and direct it down plastic hoses to drains located underneath the casemate floors. Unfortunately, site visits revealed that the drip pans are not working as designed, and that they apparently overflow as water staining on the floors underneath them was obvious at two locations. It is interesting that this situation is analogous to that which previously existed at Battery Anderson, an Endicott series mortar battery at Fort Monroe constructed of Rosendale Concrete between 1896 and 1897. This battery also experienced significant seepage of water, and an additional interior ceiling of corrugated iron was inserted to remedy the problem, similar to the more recently installed plastic drip pans at the Chaplain's Casemates. In the case of Battery Anderson these shortly failed, as minerals contained in the water formed blockages that obstructed the corrugated iron ceiling and its drainages.[58] A close examination of the plastic drip pans in the Fort Monroe casemates has revealed that the identical situation has manifested itself, substantially reducing their effectiveness.

The site visits also noted that the drip pans had been installed directly into the bricks of the arches rather than the mortar joints, using hardware that was not corrosion resistant (such as stainless steel). Thus, the bricks, which are essential to the structural stability of the casemates, have been permanently compromised. Had the installation been into the mortar joints, they could easily have been removed, and relatively simple re-jointing performed to restore the mortar, at any time in the future. The non-corrosive hardware is already showing early evidence of corrosion, which will eventually cause additional damage to the bricks.

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[58] Major Eben E. Winslow, *Lectures on Seacoast Defense, Number 35 Occasional Papers, Engineer School, U.S. Army* (Washington Barracks, District of Columbia: Press of the Engineer School, 1909), 63.

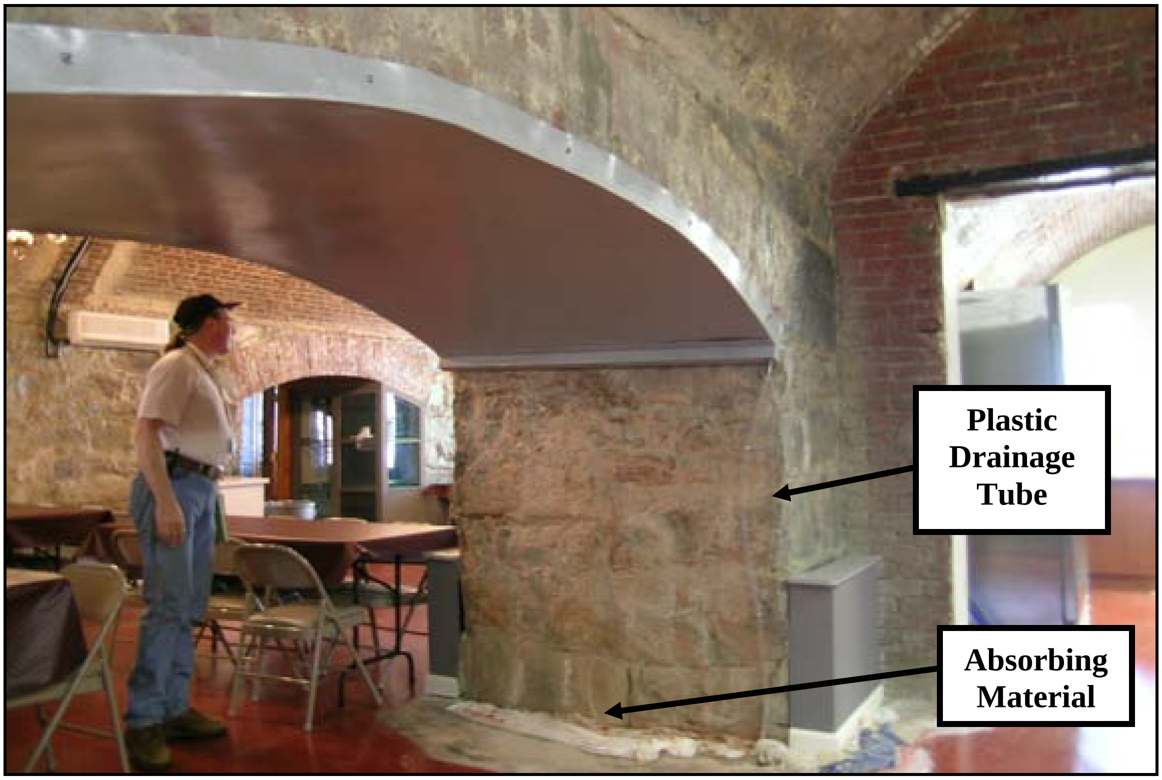
Photograph 43: View looking at one of the vaults in Casemate 22, Fort Monroe, Virginia. This arch exhibits signs of significant moisture infiltration; the most obvious is the amount of efflorescence on the surface of the masonry. Over time, the moisture in the walls will cause the mortar joints to fail. Left untreated, this condition will persist and the structural stability of the casemate will be compromised.
(Photograph by T. Beckwith, June 2005)

Photograph 44: View looking at the top of the Casemate 21, Fort Monroe. The parapet placed on top of the casemates makes it difficult to inspect the condition of the drainage system and to make repairs. The units located along the ridge are air conditioning units, installed within the original smoke vents through the parapet.
(Photograph by T. Beckwith, June 2005)

Measurements of humidity levels in the brick arches above the drip pans indicated extremely high levels of moisture. Personal observations confirmed that the mortar had been entirely compromised at several locations of the brick arches, and had become soft and pliable from the moisture. The bricks were also observed to be wet and softened from the moisture levels. Given the critical importance of the bricks and mortar to providing the structural strength of the casemates, the water retention problems apparently being introduced by the drip pans are of extremely serious concern. In fact, at least one of the arches where the drip pans have been installed displays a stress crack, which suggests that serious damage is being caused to these casemates by this installation [Photograph 47]. No attempt was made to monitor or evaluate whether or not the high levels of moisture within the walls were producing mold within the inhabited casemates. However, our site visits suggest that this is also a possibility.

In short, the Fort Monroe approach is a textbook example of how expedient or limited responses to water infiltration problems by attempting to provide solutions within the casemate interior are almost certain to be unsuccessful. Such responses are only addressing the visible problems, where water is actively entering the casemate interiors. They do not address the core water infiltration and drainage problems, and do not remove the source of the water entering the casemates. Attempting to manage or control the water once it has entered the casemates provides a "stop-gap" solution to an immediate problem, and temporarily maintains usability of a working space. However, as evidenced by the continuing water problems within the Chaplain's Casemate, they fail to provide any permanent resolution. Rather, they may in fact be exacerbating the problem, by disguising the severity of the actual water infiltration. In the particular case of the Chaplain's Casemates drip pans, the interim solution is in fact introducing considerably worse problems that may threaten the long-term structural stability of the casemate arches.

Photograph 45: Interior view of Casemate 21 of the arches that provide access between the vaults. Water is seeping through the masonry and collecting on the floor of the vaults, also a recurring problem in Casemates 20 and 22. In the 1990s, engineers installed a water collection system intended to drain the water. While this has been marginally effective at preventing water from pooling, it does not solve the cause of the problem, which is the failure of the gutter system.
(Photograph by T. Beckwith, June 2005)



Photograph 46: Another view of the water collection system that engineers installed in Casemate 21. This system consists of an impermeable barrier attached to the underside of the archways. The clear tube in the center of the photograph allows water to drain from the system. The deterioration of the bricks and the mortar will continue despite the installation of this system. Note the absorbing material placed on the floor to collect water that has spilled from the system, which is not functioning as intended. It is likely that the continued presence of this system will accelerate the deterioration of the bricks and mortar.
(Photograph by T. Beckwith, June 2005)

Photograph 47: Detailed view of one of the arches in Casemate 21. The mortar in this arch failed and a crack has developed in the arch, which has likely compromised its structural integrity. Note the glossy surface of the stone. At some point, a coating was applied to the masonry to control dust. This coating may be contributing to the deterioration of the mortar as it serves to trap moisture in the walls.
(Photograph by T. Beckwith, June 2005)

Recently, two separate restorations were undertaken at casemates using different solutions. Both Fort Macon in North Carolina and Fort Adams in Newport, Rhode Island had significant moisture infiltration problems in their respective casemates. While both had similar problems with an identical roofing system, they each used a different solution to correct the problem.

Fort Macon in Atlantic Beach, North Carolina dates from the 1830s and protected Beaufort Harbor from naval attack. The Fort contains thirty-six brick casemates, which by the late 20th century suffered from deferred maintenance. Water penetrated the brick walls and ceilings of the casemates, which caused the brick and mortar to decay. In order to preserve the casemates the water infiltration problem needed to be addressed before any restoration work could begin. Accordingly, Fort Macon performed a complete rehabilitation of the fortification from 1988 to 2002. Fort Macon's approach entailed the removal of all gun platforms, and all earth, from the ramparts and terreplein. This resulted in the complete exposure of the top of the casemate arches and attendant drainage system. Mr. Paul Branch, Site Manager of Fort Macon with the North Carolina Division of Parks and Recreation described the design approach [Photograph 48]:

> We made the decision to sacrifice the gun mounts on the terreplein so we could completely waterproof the casemate valleys. The mounts were removed, and then all the casemate valleys totally excavated to reveal the lead sheathing. The valleys were partly filled with concrete to relieve some of the weight stress. The old lead sheathing was repaired where necessary. Then, new lead sheathing was

> applied over the old lead. We decided to go with lead because it is a time-honored means of waterproofing and was in keeping with the original construction techniques. We did not trust the use of some of the modern membrane type materials because their longevity and permanence had simply not been proven by time. We wanted to waterproof the casemates in as permanent a way as possible. In the attached photos…you can see what the casemate tops looked like and the new lead being applied over the old. We used a Tennessee company named Nelco, one of only a few to be found in the U.S. We were told there are only about fifty men trained as "lead burners" in the U.S. total and Nelco had about ten of them. They did excellent work on what was a very tedious, meticulous job. Once everything had been completely covered in new lead, five coats of tar and tar paper were applied over it. Once this was done, new drain lines were laid to tie in to the old existing gutter system, and the casemate valleys backfilled. We then rebuilt the gun mounts that had been removed, and grassed and sodded the terreplein. For the most part, the work has been completely successful. Except in a very heavy, prolonged storm, we essentially have no leaks. The few leaks we do experience are not a concern, since water will always find its way in somewhere that you least expect it if you have enough rain over a long period of time.[59]

As this project progressed, additional maintenance challenges were noted and addressed:

- Deterioration of the lead sheath in places due to chemical actions and acids from the underlying brick and mortar (in Macon, we found a thin layer of clay between the masonry and lead that largely prevent this).
- Uneven subsidence and settling of the scarp and parade walls away from the casemate vaulting. This was a serious surprise that caused a major concern for the structural integrity. This subsidence of the different walls away from each other resulted in cracking and gaps that had to be filled with high-pressure grouting. At one point, we installed pins between the scarp wall and casemate vaulting to bond them together to keep the scarp from settling outward.
- Cracks extending through the casemate vaulting at weak points such as embrasures and communication passages. These were filled from above and below with high pressure grouting.
- Gaps and problems with capstones on top of the walls that allowed water to filter down into the masonry from above. Be sure your capstones are all in place and grouted to prevent water penetration directly into the walls.
- Gaps where the joints of the original lead sheathing meet the walls. If the lead is just turned up against the masonry with no flashing to keep water out, or if the flashing has somehow been displaced or failed, leaks will result.
- Problems from backed up water drainage system above the casemates. At Macon, water originally settled through the soil into the valleys of the casemates and was removed by filtering through dry brick arches into downspouts in the parade walls that carried the water to underground cisterns. This was fine so long as there was no blockage. In time there were places where the pipes and dry arches have become clogged with sand and debris that allows water to back up in the soil over the casemates and find other avenues to filter down below.[60]

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[59] Personal Communication from Mr. Paul Branch, Historic Site Manager, Fort Macon State Park, North Carolina Division of Parks and Recreation, June 26, 2005.
[60] Ibid.

Photograph 48: View looking at the waterproofing of the casemates in Fort Macon, North Carolina. Engineers placed new lead sheeting over the old lead sheeting, and then sealed it with five coats of tar and tarpaper. A PVC drainage system was then added above the tar.
(Photograph courtesy of Fort Macon State Park, Division of North Carolina Parks and Recreation.).

The Fort Macon preservation approach appears to have been entirely successful in resolving water infiltration problems into the casemates. This was a major component of a $12,300,000 and four-year restoration project for the fort. The Fort Macon approach ensured that the core water infiltration problems were identified and addressed. From a purely historic standpoint, no modern materials or intrusions were introduced to the fortification. Rather, the historic drainage system was repaired using traditional materials and methods. Clearly, this is the preferred approach when time and funds are available.

From a preservation standpoint, this constitutes an extremely aggressive approach. The amount of earth removal, moving and restoration necessary; and the amount of project time and particular construction skills required; resulted in considerable expense. Additionally, if there are construction, installation or material problems; identification of the maintenance problem and subsequent resolution would likely require similar expensive re-excavation of the casemates. Given the financial and schedule considerations necessary to implement this preservation strategy, it would be feasible only in rare circumstances.

An additional consideration is that the ramparts and terreplein might contain archaeological resources. For example, the Virginia State Historic Preservation Office considers the top of Fort Monroe to constitute an historic archaeological site. Thus, the removal of soil from Fort Monroe would require either an archaeological excavation, or monitoring by a professionally qualified archaeologist during removal. Either alternative would be expensive, in both budget and schedule terms.

Fort Adams in Newport Rhode Island offers a compelling solution to the problem of leaking casemates. Fort Adams experienced similar maintenance problems to Fort Monroe and Fort Macon, with substantial water infiltration occurring within their casemates, but chose to implement an alternative approach to the problem. Instead of repairing the existing system, Fort Adams installed a protective, waterproof membrane over the top of the casemates, immediately underneath the earthen rampart. It is intriguing that this approach is similar to that endorsed by Engineer E.E. Winslow, who had extensive experience with the construction and maintenance of military fortifications in the early 20th century:

> The best and most satisfactory way of keeping seep water out of magazines is, of course, to stop it at the exterior surface when this can be done; the next best way is to intercept it by an interior damp proofing surface, such surface always having a slope so as to carry off the water in some direction which will do no harm; the least satisfactory way of avoiding trouble from seep water is to stop it at the walls of the room either by the application of one of the patented substances on the market for this purpose or by building what is practically a room within a room.[61]

Discussions with Mr. Eric Hertfelder, Executive Director of the Fort Adams Trust and Mr. Arnold N. Robinson, Associate with the Newport Collaborative Architects, Inc. were performed during a site visit in July 2005. Mr. Robinson provided design services for the recent installation of a waterproof membrane on the historic casemates at Fort Adams. This casemate project received a Historic Preservation Award from the Newport Historical Society in 2004. The Newport Historical Society's discussion of this project noted:

> Publicly-Owned Properties: Restoration of the Casemates at Fort Adams
> Rhode Island Department of Environmental Management, *owner*
> Fort Adams Trust Executive Directors, Tony Palermo and Eric Hertfelder,
> *funding and project coordinator*
> Rhode Island Historical Preservation and Heritage Commission, *project review*
> Newport Collaborative Architects, *research, plans and supervision*
> Dimeo Construction and Grande Masonry, *lead contractor team*
>
> Fort Adams is the largest and most elaborate coastal fortification in the United States. Constructed 1824-1857, it was part of the "Third System" of national fortifications, the culmination of the art and science of defending against seaborne invasion and land based siege. Even as Fort Adams was being completed, the development of effective rifled cannon for warships spelled the end of this type of fortification. Fort Adams thus represents the last and best of its type, and is the only such site open and actively interpreted to the public in Rhode Island. Fort Adams has been designated a Threatened National Historic Landmark, and is an official project of Save America's Treasures.
>
> The North Casemate Project represents the first completed interior restoration effort at the fort since it went out of military hands in 1965, the first to tackle and solve water infiltration problems stemming from the fort's complex earthen and masonry roofing system, and the first to research and recreate missing wooden fenestration systems for the casemates. The project was part of a strategic plan developed by the Fort Adams Trust and top priority was given to restoring one area of the fort to the highest standards in order to create a tangible display of

[61] Winslow, *Lectures on Seacoast Defense*, 64.

> what the fort looked like when its systems were intact; to generate public interest and enthusiasm for continuing the restoration efforts; to secure historically accurate interior spaces for interpretation and installation of exhibits, and for public and private events.
>
> The project area included the interior and exterior walls of the northern front, the roof over the six north casemates and the north gate, and the interior of the six north casemates. The work involved the rehabilitation of the roof over the area; the repair or restoration of the exterior casemate walls; the repair of the walkway adjacent to the casemates; the enclosure of the opening to the casemates with historically accurate doors, window frames, trim, and glass; the restoration of the interior of the casemates.
>
> In all these areas the time spent on historical research and the resulting historical accuracy of the work, the sensitivity with which modern material and systems were introduced, the careful design work on the part of the project architects and the high quality of the workmanship in executing the work distinguish this project.
>
> This project benefits not only the goals of the Fort Adams Trust, but all of the communities around Narragansett Bay. With the completion of the restoration, the entire north front of the fort facing Newport Harbor is now in its original condition and illuminated every evening with sunken lights. The fort stands as a beacon at the mouth of the Bay. When it was first built, the fort made a statement about military might; it now makes an equally strong statement about Rhode Island's commitment to historic preservation.
>
> The restoration of the north casemate area comes at a critical time in the history of the fort and catches an important part of the structure just before its decline into total ruin. The restoration of the north casemate area at Fort Adams marks both an end and a beginning. This project is complete, but it is only a first step toward the eventual restoration and interpretation of other historic spaces at Fort Adams.
>
> The ultimate success of the long term goals for Fort Adams will require a continuing commitment not only on the part of the Fort Adams Trust and its able and competent staff, but all of us in Rhode Island. The Newport Historical Society, with this award, signals its readiness to stand by those who have the responsibility for this heroic task and to help in whatever way in can. All of those involved with this daunting and difficult project are to be congratulated on the outstanding quality of this project and for setting an exemplary standard for the nation in the care and preservation of publicly owned historic properties.[62]

Mr. Robinson provided descriptions of previous water infiltration problems at the Fort Adams Casemates and provided a description of the methods used to correct the problem. The restoration used the “Sarnafil” roofing system ® to waterproof the rampart portion of the casemates. The Sarnafil roof is essentially a “green” roofing system that is placed underneath vegetated earth to provide protection from moisture. The system is comprised of a heavy waterproof membrane,

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[62] Newport Historical Society, “Historical Preservation Award Recipients, 2004 Award Winners” accessed on-line at http://newporthistorical.org/historic3.htm on August 29, 2005.

protected by soil, with a top of sea grass that will provide both hot weather and cold weather protection. This system is a patented system developed by the Sarnafil Corporation.[63] Approximately two feet of soil had to be removed from the top of the rampart to implement this approach. The terreplain portion of the casemates was protected using a more traditional approach of tar paper and gravel, designed to drain into an existing gutter system. Lead flashing was incorporated at several different locations of this project to provide comprehensive waterproofing; and all exposed masonry to include the scarp walls and other walls was re-pointed at the same time. The system, installed within the past year, has worked very well [Photographs 49 through 52; and Figures 11 through 14]. Only a small amount of water infiltration has been noted, and is believed to be occurring from the horizontal faces of the Cordon Stones. Because the water infiltration problems in Fort Adams have been effectively solved by this preservation approach, museum exhibits are now installed within some of the casemates, and other casemates are available for public and private rentals, generating necessary revenue for the Fort Adams Trust and continued preservation efforts at Fort Adams. A major advantage of this system is that limited earth removal is necessary, thus reducing budget and schedule impacts. Essentially, this system installs a new roof directly at the top of the casemates.

Photograph 49: View looking at earthen ramparts at Fort Adams, Newport, Rhode Island. The waterproof membrane is located underneath the earth. Workers are installing a conventional tarred roof system at the terreplein. Note the historic masonry smoke vents in the foreground.
(Photograph by T. Beckwith, July 2005).

[63] "Sarnafil – World Class Roofing and Waterproofing" accessed on-line at http://www.sarnafilus.com/ on August 29, 2005.

Photograph 50: View looking at earthen rampart at Fort Adams, Newport, Rhode Island. The sea grass planted on the rampart is left uncut to provide greater erosion protection to the soil underneath. The sea grass was specifically chosen for the coastal conditions of Rhode Island.
(Photograph by T. Beckwith, July 2005).

Photograph 51: Another view looking at the earthen rampart at Fort Adams, Rhode Island. Note the flashing located between the earth and the cordon stone.
(Photograph by T. Beckwith, July 2005).

Photograph 52: View looking at the stone wall that separates the earthen rampart from the terreplein. Note the lead flashing along the rampart wall. This keeps moisture from infiltrating and degrading the rampart wall. Additionally, note that the rear parapet wall has also been re-pointed.
(Photograph by T. Beckwith, July 2005).

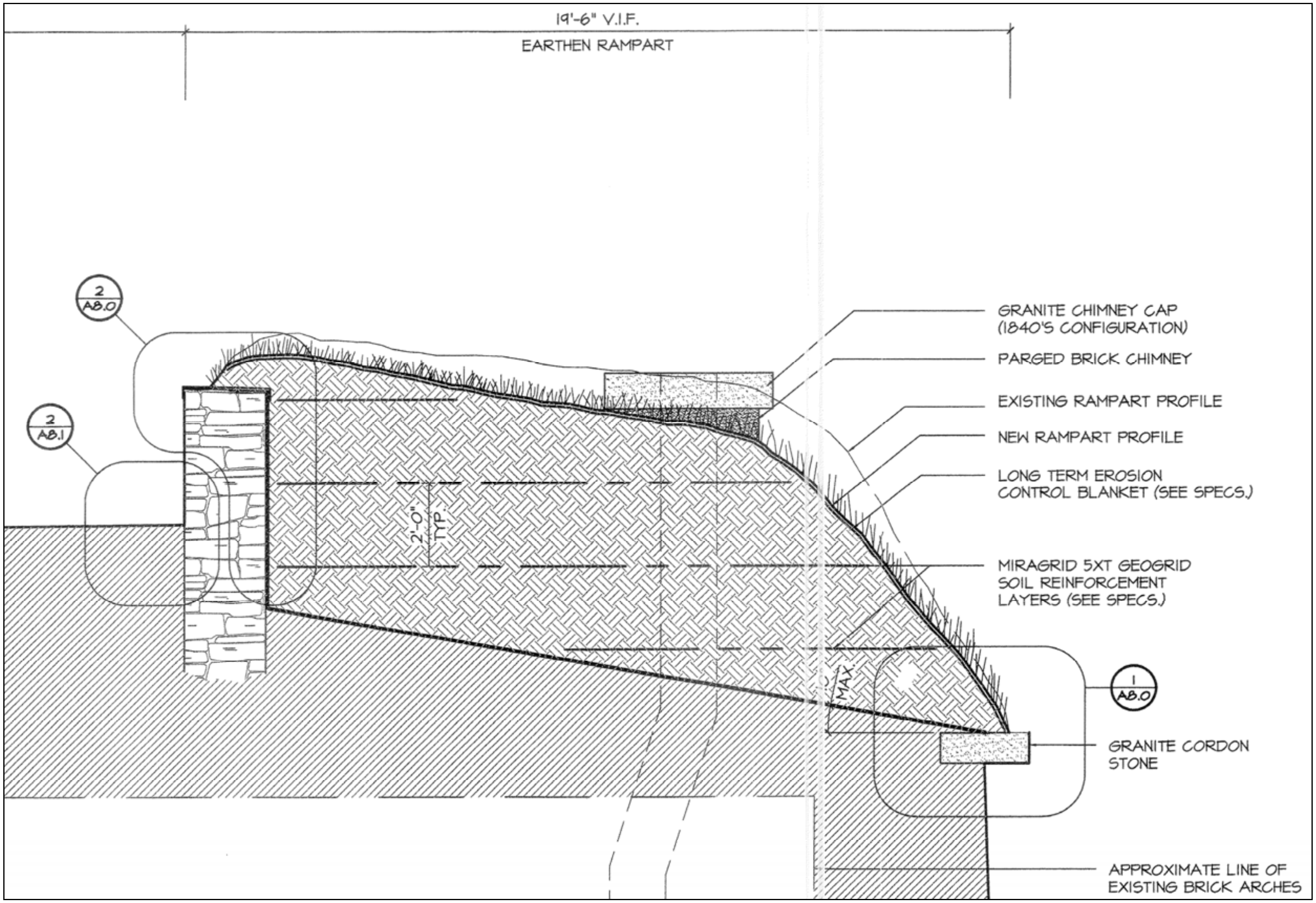

Figure 11: Detailed view looking at the profile of the earthen rampart at Fort Adams, Rhode Island.
(Detail from *Terreplein and Rampart Repairs at Fort Adams State Park Newport, Rhode Island*, Newport Collaborative Architects, Inc. Newport, Rhode Island, 15 July 2004, sheet 9 of 17)

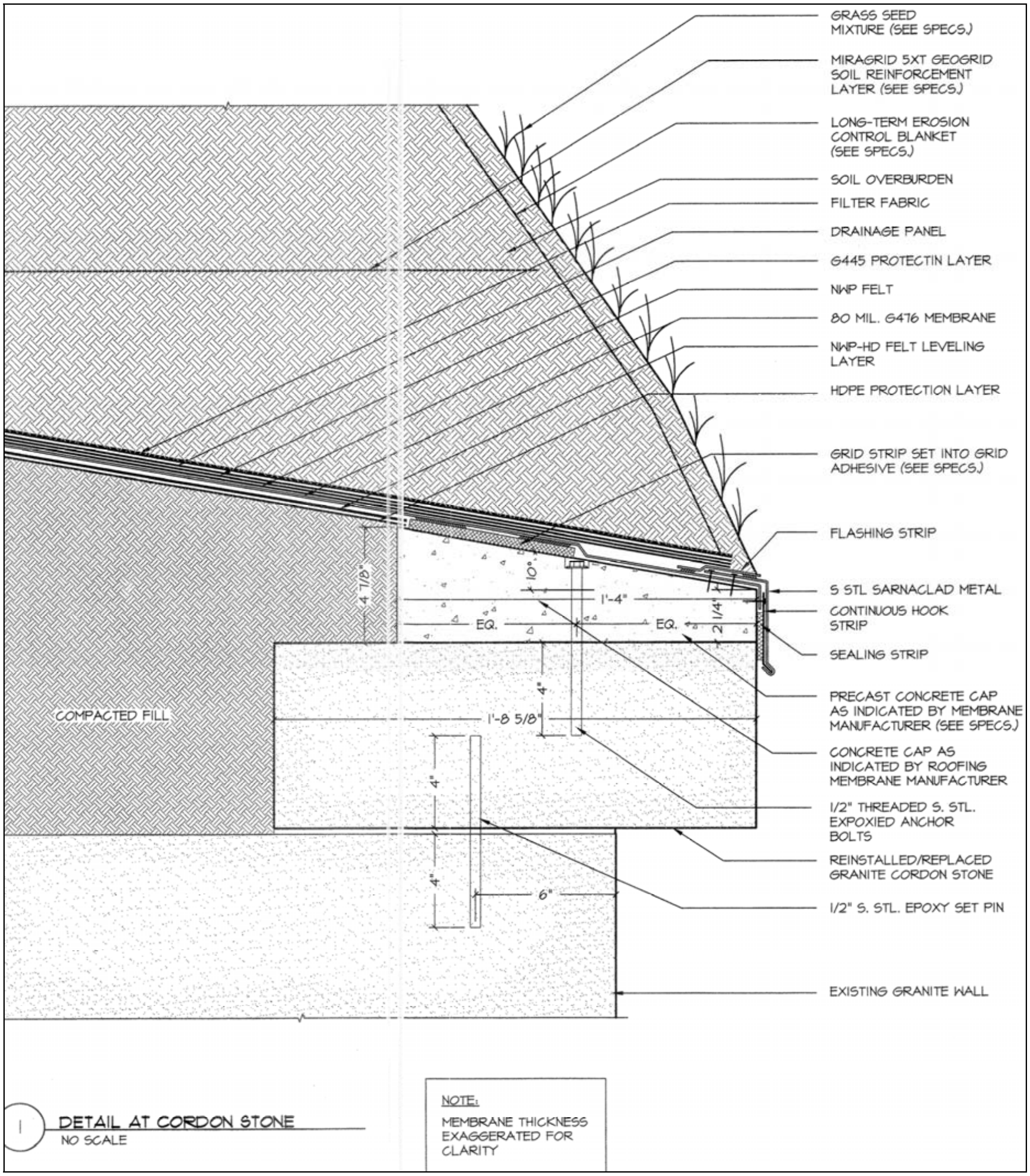

Figure 12: Detail illustrating the capstone of the earthen rampart at Fort Adams, Rhode Island.
(Detail from *Terreplein and Rampart Repairs at Fort Adams State Park Newport, Rhode Island*, Newport Collaborative Architects, Inc. Newport, Rhode Island, 15 July 2004, sheet 9 of 17)

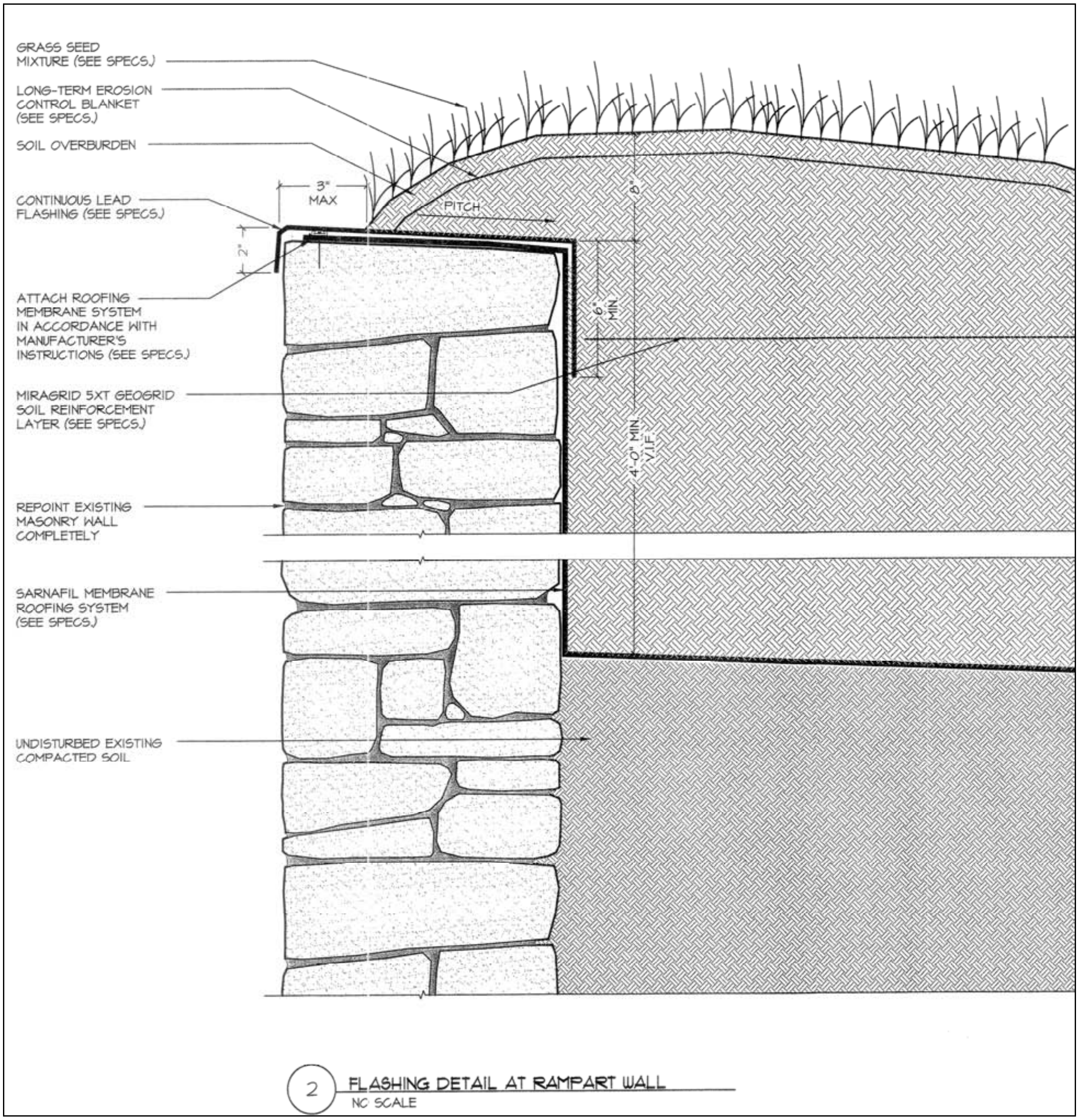

Figure 13: Detail of the flashing at the rampart wall. The lead flashing keeps moisture from infiltrating the rampart wall.

(Detail from *Terreplein and Rampart Repairs at Fort Adams State Park Newport, Rhode Island,* Newport Collaborative Architects, Inc. Newport, Rhode Island, 15 July 2004, sheet 9 of 17)

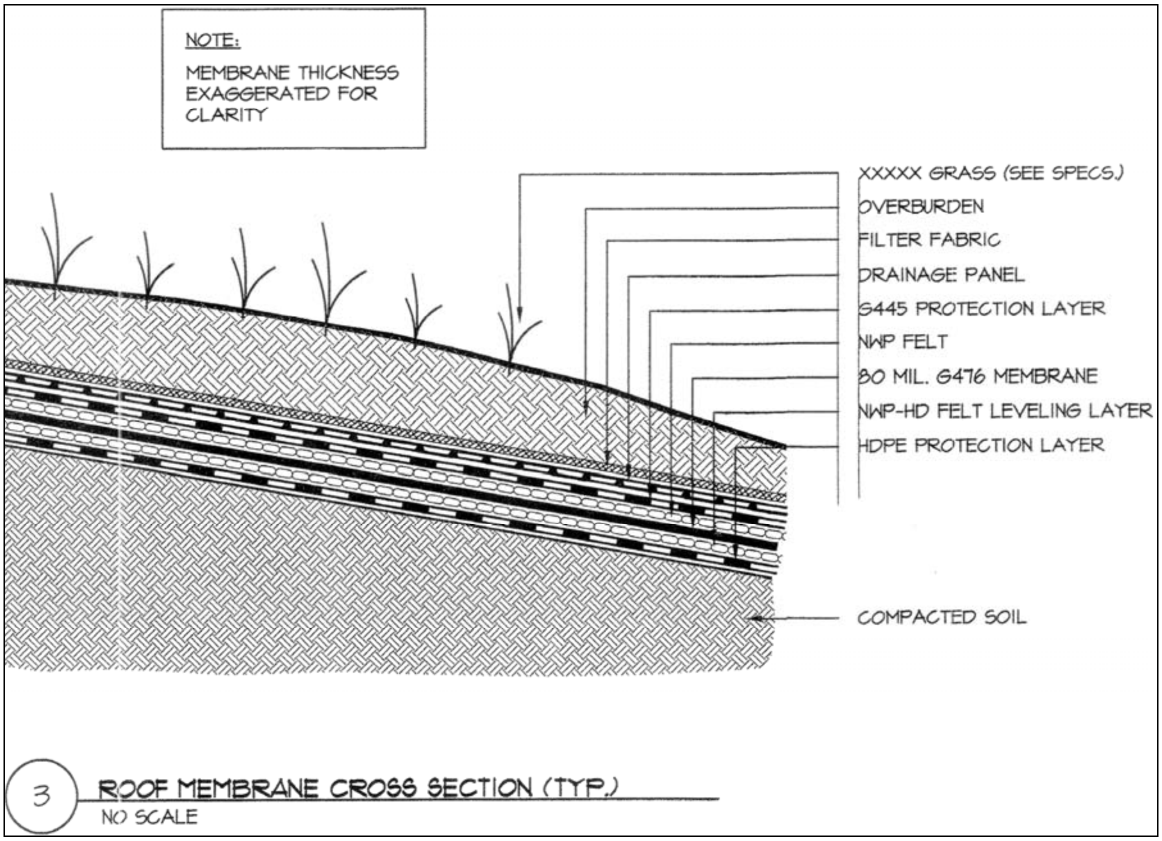

Figure 14: Detailed cross section of the roof membrane.
(Detail from *Terreplein and Rampart Repairs at Fort Adams State Park Newport, Rhode Island*, Newport Collaborative Architects, Inc. Newport, Rhodes Island, 15 July 2004, sheet 9 of 17)

4.3.3 Inspecting the Casemates

The masonry walls of casemates are an important character-defining feature of the structures. Although durable, the brick requires periodic inspection for signs of moisture infiltration. Moisture infiltration is one of the biggest threats to the structural integrity of masonry construction, particularly in areas in which freeze/thaw cycles can be extreme or in areas with high humidity and precipitation. Casemates, by their very nature, are difficult to evaluate as the roof is covered with earth and the stone scarp wall covers one of the exterior walls. As a result, a great deal of casemate evaluations will have to be done by looking at the interior. Examine each of the exterior walls that are exposed and determine if they are level, out of plumb, or if bulges are present. The scarp wall, although not part of the casemate, should also be inspected to determine if there is any unusual or excessive separation from the brick casemate walls. During the 1998-2002 restoration of Fort Macon, North Carolina, engineers discovered that uneven settling of the scarp walls and the brick casemate walls caused gaps to form between the two. It should be remembered, however, that the scarp walls and brick casemates were specifically constructed to be separate elements, so some uneven settling is to be expected. However, any excessive or unusual separation that suggests a structural failure or major water infiltration problem should be identified.

Individual bricks should be examined for presence of uneven settling, cracking, or other forms of deterioration. Most masonry problems occur in areas exposed to moisture or temperature fluctuations, these areas should be scrutinized closely. Mortar should be inspected for failure, particularly in those areas exposed excessive moisture. Areas of efflorescence (crystallization of soluble salts on the surface of masonry) and subflorescence (crystallization of soluble salts beneath the surface of masonry) should be noted. These conditions may indicate the presence of excessive moisture infiltration. Inspect each of the joints around window and doorframes for failure. A qualified professional trade specialist should inspect the masonry at least once every four years.[64] See Appendix E for a copy of the USMA's standard operating procedures for the inspection of masonry walls.

4.3.4 Repairs and Maintenance

First, any intrusive vegetation must be removed. Root systems, in particular, can cause extensive damage to fortifications and masonry. Roots can infiltrate and damage existing drainage systems. When trees fail or collapse, they can cause extensive damage. Vegetation growing against historic masonry serves to retain moisture, and prevents the action of sun and wind to naturally dry the fortification. Historically, fortifications were maintained in a clear and open manner, and all intrusive vegetation should be removed to maintain the historic appearance. It should be noted that this is not the case at either Fort Monroe or Fort Adams. However, other fortifications that have not received regular maintenance are frequently overgrown with intrusive vegetation.

Second, the masonry chimneys or vent caps that protected the vertical smoke vents must be maintained. If these features are not maintained, water will simply pour down the vertical vents into the casemate interior. Where the vents have been sealed, the modifications should be carefully reviewed. If the vents have been completely sealed they will no longer permit air to flow through the casemates, which will exacerbate any humidity or moisture problems in the casemate interior. Additionally, if the vents have been incorrectly sealed, or the seals are not water-tight, then water can still enter through the vents. Although not the case at Fort Monroe, it is recommended that any crude vent covers be carefully reviewed, and where necessary the original chimneys or vent caps be restored. Details of such design features can be obtained from the original design drawings of the National Archives, or from fortifications where such features still survive (such as Fort Adams).

Third, any masonry features such as capstones, cordon stones, rear parapet walls, rear terreplein walls, or the scarp walls must have all masonry properly and soundly re-pointed. All missing flashing must be replaced, and damaged flashing repaired. Any missing capstones or masonry stones/bricks must be replaced.

Fourth, water infiltration through the earth into the masonry of the fortification must be either negated, or controlled. Where the existing drainage system is still functioning, the most cost effective and efficient approach is to maintain and repair the existing drainage system. However, in the case of most surviving military fortifications, decades of neglect and poor maintenance have rendered the original or historic drainage systems inoperative, or in many cases removed them entirely. In these cases, a new water management system must be designed and installed. In the absence of such a system, water infiltration will continue to occur within the masonry structure, causing both masonry (particularly bricks) and mortar to deteriorate and weaken. The amount of damage that unconstrained water infiltration can cause to any structure cannot be underestimated.

The most viable water management system appears to be an adaptation of that developed for Fort Adams by the Fort Adams Trust, Newport Collaborative Architects and the Sarnafil Corporation. This system, in effect, establishes a new roof and water drainage system within the existing fortification.

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[64] Richard Pieper, "Exterior Masonry," in *Caring for Your Historic House*, ed. Charles E. Fisher and Hugh C. Miller (New York: Heritage Preservation and the National Park Service, 1998), 69-79.

Where the fortification is covered by masonry (brick or concrete), new or replacement waterproofing materials can be installed either on top of, or underneath, the existing masonry. In the case of Fort Adams, the deteriorated concrete of the terreplein was removed, and a replacement tar and gravel roof was installed. At the same time, replacement gutters, leaders, downspouts, and water drainage were installed to remove the water from the terreplein. One constraint of this tar and gravel roof is that it cannot be walked upon. In the case of Fort Adams, a wooden walkway was installed where necessary. If access to the terreplein is necessary, a more durable roofing material such as Thoro surface bonding mortar ®or concrete may be utilized. In all cases, water management systems such as gutters, leaders, downspouts, and drains must be repaired, replaced, or installed. Where historic fabric is present, it should be utilized, and repaired where feasible. Where historic material is either absent or so badly deteriorated that it cannot be economically repaired, original plans, design drawings and photographs must be consulted to ensure that all new materials are replacements in kind and match the historic fabric precisely in size, shape, design and materials. The great advantage of this approach is that any competent roof contractor, or in-house roofing maintenance shop where available, can perform this work.

Where the fortification is covered by earth ramparts for historic defensive purposes, or earth is used for any other purpose (e.g. when a structure is constructed into an embankment, or when earth/grass is utilized as a roofing material), a new roof and water drainage system should be installed. At Fort Adams, the system utilized entailed the following:

- Documentation of historic earth and fortification profile;
- Removal of approximately top 24" of earth, minimize amount of earth removal;
- Installation of modern membrane type roof to provide comprehensive waterproofing;
- Connection of modern membrane roof into
  - Repaired historic drainage system (where extant) or;
  - Restoration of historic drainage system (where applicable, and system no longer exists) or;
  - Installation of new, non-intrusive or low-profile drainage system (where no historic system existed).
- Restoration of historic earth and fortification profile;
- Planting of mixture of hot and cold weather grasses appropriate to local region to stabilize earth;
- Installation of appropriate erosion control and soil stabilization measures to retain earth until grass re-growth occurs.

The advantage of such a system is that earth removal is minimized, schedule time is accordingly reduced, and expenses are minimized. If repairs or maintenance investigations are necessary to this roof at some point in the future, aggressive earth removal is not necessary.

It should be noted that installation of this type of new roofing system can be performed in segments, but these segments should be implemented over entire portions of casemates, or where existing drainage systems exist. Historic drainage profiles should be maintained where possible. For example, this may mean that an entire block of casemates, or an entire bastion or curtain wall, should be water-proofed at one time. Otherwise, segmenting an integrated portion of the fortifications will simply transfer water infiltration from the area of the new roof to the area where waterproofing was not implemented.

Fifth, other potential conduits for water infiltration should be addressed. Where fortifications contain windows and doors (within the parade ground walls of casemates, for example) they must be appropriately maintained and repaired so that they are also water-resistant. If thresholds have been permitted to deteriorate or disintegrate such that they permit water to enter a historic interior, they should be repaired or replaced. All exterior masonry walls should be re-pointed. Existing drainage systems should be investigated, and any blockages or breaks repaired. Any existing roofs (over casemate doors to the parade ground, for example) should be inspected, and repaired or maintained as appropriate. Exterior landscape grades, and adjacent storm water drains, should be investigated. If the landscaping has been altered, water may no longer be draining away from a historic structure, or the storm water drains may be blocked or no longer functioning properly. At Fort Monroe, the ramps to the parapets of the fortification contained brick-lined drainage channels, which originally drained water away from the terreplein. These brick-lined channels have been maintained today, and are still functioning. However, landscaping has been added at the parade ground level, and the bottoms of the drainage channels are now obstructed with soil and vegetation, and water is now prevented from exiting at the bottom of the drainage channels. When water is obstructed it backs up, and percolates into the earth of the fortification. If any vegetation has been planted adjacent to historic structures, the vegetation may be holding moisture against the building, and should be removed.

Once installed, maintenance of this system is identical to maintenance of any roof. Gutters, leaders and downspouts must be regularly cleaned and inspected to ensure that debris does not block them. Downspouts must be positioned to prevent water from flowing directly into structural foundations. Care must be taken that the roof membrane is not penetrated by other projects or installation. (e.g. signage installation). Vegetation must be monitored, and any intrusive vegetation with root systems such as brush or trees must be removed, vegetation must be maintained at an appropriate density and height. Mortar pointing must be maintained as previously described.

Funding constraints prevented implementation of a demonstration project at Fort Monroe, but a Scope of Work has been developed for the Building 22 Storage Casemates, based upon an adaptation of the Fort Adams approach. Because specific design of the terreplein differed between Fort Monroe and Fort Adams, a different drainage approach had to be formulated specifically for Fort Monroe. This highlights that each fortification will have to be individually evaluated, although the general approach remains valid for all of this type of historic resource.

As previously noted, although this preservation strategy has been formulated specifically for casemates and ramparts/terreplein of historic fortifications, the approach is valid for other types of structures and military fortifications. This approach can be utilized for any integrated masonry/earth fortification, or for any structure where earth is used against the side or top of a building for whatever reason.

4.3.5 Demonstration Project, Storage Casemates (Building 22), Fort Monroe, Virginia

Materials: Brick structural arches, with earth and sod ramparts, and an earth and sod terreplein above. Earth ramparts are sloped, and sod covered. Rear of parapet is supported by a masonry wall; rear of terreplein is supported by a masonry wall. Brick casemates are double casemates, closed at the parade ground side. Casemates were historically used as family housing quarters.

Location: Fort Monroe Parade (Building 22), Fort Monroe, Virginia

Owner: Fort Monroe, Virginia

Site History: Old Point Comfort at Hampton Roads, Virginia was identified as a strategic location for fortifications as early as 1609, when Fort Algenourne was constructed here. A succession of forts followed throughout the Colonial period. When the early American military initiated a formal series of coast defenses, Old Point Comfort was selected as one of the top priorities for a major fortification. Fort Monroe was one of the first forts of the Third Series of American Seacoast

Defenses to be constructed. Construction began in 1819, and was essentially completed in 1837. Fort Monroe is the larges of all Third Series forts ever constructed, occupying no less than 63 acres. The fort was a six-sided irregular work with large, open bastions. As originally designed, an external casemated water battery was also constructed which no longer exists. Four of the seven sea-facing curtain walls contained casemates, and flanking casemates were also constructed on one of the land-facing curtain walls. The fort is constructed of a mixture of granite and brick, and contains a wet ditch. The fort has been continuously occupied by the U.S. Army since the initiation of construction in 1819; and Fort Monroe today serves as Headquarters to the U.S. Army Training and Doctrine Command. The casemates have undergone a series of uses, being initially utilized as family housing quarters, and subsequently for various community support functions including the Post Religious Facility and Chaplain's Offices; and the Casemate Museum. Maintenance has been recurring, but intermittent, and at times poorly implemented. Water infiltration within the casemates has been a continuous complaint dating back to the early 19^{th} century.

Conditions: As previously described, the Fort Monroe casemates suffer from various amounts of water infiltration. Casemates 22 has deteriorated to the point that it is now only used for low-value storage. Several areas of the Chaplain's Casemate (Building 21) are particularly prone to water infiltration. Residents of both the Chaplain's Casemate and Casemate Museum (Building 20) complained of high humidity and moisture levels, and frequent water infiltration problems of various extents, and at various locations. The parapets do not appear to have had any regular maintenance, and almost no mortar or mortar joints was observed to remain within the rampart and terreplein walls. Grass on the terreplein and ramparts is an ornamental fescue grass which is cut extremely short on a regular basis, mowing height is so low, and mowing is conducted so frequently, as to preclude the grass providing any meaningful protection against water infiltration or erosion.

Scope of Work:

1) Perform complete photographic documentation and record drawings of site conditions following removal of vegetation and miscellaneous debris, to Historic American Building Survey (HABS) Level III.
2) The grading of the parapet and terreplain must be confirmed by the contractor previous to any excavation being performed. The existing height of soil must be marked using chalk or similar permeable material at critical points.
3) The terreplain is used by military personnel for physical training and by civilians for exercise and sightseeing. The contractor must coordinate the schedule well in advance of any excavation work with Fort Monroe CRM, so public notices can be issued of the closure of a terreplain segment. Excavations shall be marked with barriers and warnings.
4) Remove and store in a secure location artillery footers and rails, and stones of parapet facing wall. All removed objects should be clearly labeled or marked with chalk or similar permeable substance so that they can be re-assembled and re-installed in their original location at the conclusion of the demonstration project.
5) Excavate terreplain and the earthen rampart to a depth determined by the contractor to be appropriate.
6) Place pennies dated to the year of implementation at top of extant soil.

The use of dated pennies provides a clear line of demarcation between original features of a fortification, and any restoration work. The pennies will survive and provide a definitive record of dating in the future. Pennies are relatively inexpensive, and will not introduce any discordant elements into the fortification.

7) Re-point the mortar on the scarp wall to the cordon stone. Mortar should be type "N" (one part cement, one part hydrated lime or lime putty and five to six parts sand). The new mortar must match as close as possible the historic mortar in color, texture, and tooling.
8) Re-point entire rampart wall to the base of the excavation. Mortar should be type "N" (one part cement, one part hydrated lime or lime putty and five to six parts sand). The new mortar must match as close as possible the historic mortar in color, texture, and tooling.
9) Re-point parade wall to the depth of the excavation. Mortar shall be type "K" (one part cement, three parts hydrated lime or lime putty, and ten to twelve parts sand). The new mortar must match as close as possible the historic mortar in color, texture, and tooling.
10) Place compacted, clean fill dirt to a level determined by the contractor and Sarnafil Corporation representative on the earthen rampart side and on the terreplein.
11) Install Sarnafil System 1000 ® impermeable layer on the earthen rampart portion of the casemate and over the compacted fill dirt. The Sarnafil layer should be securely attached (per manufacturers instructions) to the top of the rampart wall and slope towards the scarp wall. Lead sheeting shall be placed over the Sarnafil system and the capstone on both the scarp wall and the rampart wall. This lead sheeting will keep moisture from infiltrating the walls during periods of precipitation. Although not a historic feature of the original scarp wall, the lead sheeting over the capstone will better preserve the scarp wall.
12) Install Sarnafil System 1000 ® impermeable layer on the terreplein portion of the casemate and over the compacted fill dirt. The system should have an adequate slope from the rampart wall to the parade ground wall and it should tie into the existing gutter system. The existing portion of the gutter system that is to be re-used should be repaired and maintained where necessary.
13) Once the Sarnafil System ® is installed, place soil on top of the impermeable layer. The topsoil should be carefully graded to ensure that moisture is efficiently drained away from the rampart wall and towards the scarp wall. Re-install all artillery footers and rails, and stones of parapet facing wall.
14) All new sand and topsoil should be sifted to ensure that it is clean, or can be certified to be clean fill dirt. Care must be taken that archaeological or historic artifacts are not inadvertently introduced to the redoubt from an outside source.
15) A soil reinforcement layer shall be installed within the rampart wall at a location to be determined by the contractor.
16) A long-term erosion control blanket, or similar erosion protection, shall be installed over the rampart wall.
17) The entirety of the ramparts and terreplein should be planted with a mixture of Creeping Red Fescue (Festuca rubra) mixed with Annual Rye Grass.
    a. Seed mix should include eighteen pounds per acre of Creeping Red Fescue and fifteen pounds per acre of Annual Rye Grass.
    b. Prepare the seed by mixing it with an extender, such as vermiculite, sand, sawdust or cat litter. Combine four pounds of extender with every pound of seed. Dampen the mix slightly and mix thoroughly;
    c. Distribute seed by hand-passes; walking and sowing in parallel rows, then repeating the process perpendicular to the first passes. Ensure thorough seed distribution;

d. After seed is scattered, the area should be lightly raked so that about ¼" of soil covers the seeds.
e. Use hand roller to lightly press the seeds into the soil.
f. Scatter a light covering of clean wheat or oat straw across the top of the seeded areas and shake out any clumps;
g. Water seeded areas with one inch of water. Use of drip irrigation is preferred, but may not be feasible given location of parapet. Use of a transportable water tank may be necessary.

This seed mix was identified by the Fort Monroe for the specific soil and climatic conditions of the Hampton Roads vicinity. A local expert should be consulted for each specific locale.

18) Once the terreplain and parapet has been re-seeded, mowing should be reduced in frequency and intensity. The grass should be permitted to grow to a minimum of a six inch height, and mowed only when necessary to maintain that height. All mowing should be done by hand only.

Cutting the grass too low will damage it, and harm the protective benefits of the vegetation on the ramparts.

19) A careful record of all work performed must be maintained. A weekly progress report with photographic documentation will be required. Digital photographs are acceptable.

In addition to the work at the fortification itself, it must be recognized that any government construction team or contractor will require a staging/lay-down area to store and service equipment, stockpile supplies, etc. Such a location must be designated in advance, should be reasonably close to the fortification, and should be sited in such a manner that no historic or archaeological resources would be endangered. Identification of such a work area is an important component of any construction project at or in the vicinity of a historic property.

4.4 Concrete and Earth

Nearly all late 19th and 20th century permanent military fortifications employ some combination of concrete and earth. Concrete specific inspection, repair and maintenance procedures have already been discussed in Section 2.0. The construction of earth parapets or ramparts to impart additional defensive strength immediately adjacent to concrete structures introduces another potential source of water infiltration into the concrete fortifications. The single greatest complication is that the introduction of earth parapets hides the concrete, so that faults or failures in the concrete cannot be detected. The second complication is that the earth parapets do not readily dry out, and tend to retain large quantities of moisture for an extended period of time, thus providing an opportunity for moisture to enter through the concrete.

4.4.1 Inspections

First, the vegetation cover of the earth must be carefully inspected. As with the previous discussions for earthworks in Chapter 2.0, retaining a complete growth of grass on top of the earth parapets is critical, as this will permit much of normal rainwater to drain off instead of percolating through the soil. Large trees should not be permitted to grow on the earth ramparts, as the ramparts are rarely substantial enough to support their weight, and when they fail or are toppled by severe weather they cause catastrophic damage to the earthworks. The presence of comparatively large trees growing in proximity so that their canopies provide protective cover to the earthworks should be encouraged. Generally, management practices previously discussed for earthworks should be adhered to, as they minimize water infiltration into the earthen component of these integrated works. Second, the concrete itself must be inspected, per the previous guidance.

The most important element of the inspection should be landscaping and grading around the fortification. Quite frequently, the original grading around the fortifications has been changed. This frequently occurs when roads are added or modified in the vicinity, sidewalks are added or modified nearby, or landscaping or beautification projects occur [see Photograph 53 for an example]. The addition of new features has the potential to block or interfere with natural drainage routes and intended grading [see Photograph 54 for a representative case]. When obstructed, drainage conduits no longer function, and water backs up or pools. Such features should be identified, and must either be altered with the use of conduits or French drains to permit drainage to occur, or must have their grading adjusted back to original profiles. If new storm water drains or drainage channels have been added in the vicinity of the fortifications, drainage from the fortifications may have to be modified accordingly. Any modifications to drainage should receive appropriate environmental review, to insure that the storm water system can accommodate increased water flows from the surface of the fortification.

Photograph 53: View looking at the groove that leads water away from the base of the foundation at Battery DeRussy, Fort Monroe, Virginia. The slope of the earth at the junction of the concrete foundation has been raised, and water can no longer drain away from the fortification. These slopes should be re-graded to ensure that moisture flows away from the battery.
(Photograph by T. Beckwith, June 2005)

Photograph 54: Installation of a new sidewalk in the rear of Battery DeRussy at Fort Monroe altered drainage patterns, and separated the battery from the storm water drain in the foreground. The result is water pooling and failing to drain from this Endicott Series Battery.
[photograph: D. Cubbison, August 2005]

An additional inspection item is the location of gun pits or similar depressions in the fortification. In many cases, because of safety fears, the gun pits have been filled in. When earth is used, the soil frequently results in vegetation growing out of the pit, which artificially creates root pressures within the fortification, and roots can also damage and destroy the concrete. Additionally, the earth tends to completely obstruct drainage installed at the bottom of the gun pit, and holds water and moisture within the fortification [Photograph 55].

Photograph 55: View looking at one of the gun pits at Battery DeRussy, Fort Monroe, Virginia. This gun pit is entirely filled in with soil, which allowed a considerable amount of vegetation to grow. The presence of vegetation is a clear indication that there is a significant moisture infiltration issue. Vegetation and soil needs to be removed from all of the gun pits. Once this task is complete, the drain in the center of the pit should be cleared of debris and inspected to ensure that the drain lining is intact.
(Photograph by T. Beckwith, June 2005)

Inspections should carefully look for any water infiltration routes leading from the earth parapets into the fortifications. Obvious pooling or drainage of water should be noted. Some minor water infiltration is to be expected, but substantial and regular water problems suggests that the vertical concrete has suffered a fracture or failure and is permitting water to enter.

4.4.2 Repairs

In any case where gun pits have been artificially filled with soil, any vegetation should be removed first at root level, followed by hand or careful machine excavation to remove all soil. The original drainage system at the bottom of the firing pit should then be inspected, and repaired if necessary. A preferred alternative to filling in the gun pits with soil would be the placement of safety rails around them, as this would permit drainage within the fortification to occur. If safety railings cannot for any reason be utilized, the gun pits should be filled with an impermeable material such as concrete that is poured and graded to drain away from the gun pits onto the horizontal surface of the fortification. Only filling a portion of the gun pit with concrete should be strongly discouraged, as this will again encourage pooling and infiltration of water. Another alternative would be to fill the gun pits with gravel, loose rock or similar permeable material that would provide safety, while permitting natural water drainage to simultaneously occur. In any case, soil should absolutely never be used for this purpose, or permitted to remain where it has been placed.

In cases where water infiltration is particularly severe, it may be necessary to install a new water drainage system between the earth parapet and concrete structure. This would require excavation of a portion of the parapet. Obviously careful measurements and documentation of the extant earth parapet would be required previous to any excavation being performed. Once the parapet is removed, a drainage system should be installed at the bottom of the natural grade, and tied into an existing storm drain system. Then, gravel or similar permeable material should be installed between the concrete vertical wall and the new earth parapet. This gravel creates a French drain that will permit water to move from the earthen parapet down into the new drainage system, rather than into the concrete fortification. Any obvious fractures or failures in the vertical wall of the concrete fortification should be patched or repaired using an appropriate impermeable material when the parapet is removed. Where possible, such repairs should be performed on the exterior of the fortifications wall (that portion that will be re-covered by the earth parapet), so that water remains on the outside of the concrete fortification. At the conclusion of this effort the earth parapet should be restored to its historic profiles and re-seeded.

4.4.3 Maintenance

Previously described maintenance procedures for concrete and earth fortifications should be followed. Existing drainage systems, or new drainage systems, must be maintained to be open and functional.

4.4.4 Demonstration Project

Battery DeRussy, Endicott Series Battery, Fort Monroe, Virginia was selected as a demonstration project. A SOW has been developed which should be adequate to remove excessive moisture and water from this or other Endicott series coastal defense fortifications within requiring substantial financial investment. Essentially, the SOW is intended to restore the existing water drainage and management systems at the existing Endicott fortifications. Schedule constraints precluded this demonstration project from being implemented.

Battery DeRussy has had its earthen parapet removed at some point in the past to facilitate the construction of adjacent family housing. However, inspections of a number of Endicott series fortifications at Fort Monroe indicated that vertical water infiltration from earthen parapets is not a serious source of water damage. Rather, it appears that the overwhelming majority of water infiltration into these fortifications is through the horizontal (rather than the vertical) surfaces. Accordingly, the SOW was developed to validate that a cost effective approach can be developed to resolve horizontal water infiltration in this type of fortifications.

This approach has three components: re-establishing the historic drainage system of the gun emplacement; re-establishing the waterproof integrity of horizontal surfaces of the battery; and re-establishing a system of ventilation within the battery through opening solid doors and windows and installing doors and windows that permit natural ventilation to occur. This approach's major endorsement is that all work can be performed by a general contractor, or any roofing firm or roofing maintenance shop at an established installation.

Placing a waterproof system on top of Endicott series batteries was recommended by Engineer Major W.E. Winslow:

> …in any batteries that I may build I intend to place on top of this concrete waterproof surface a layer of several thicknesses of tarred paper bound together with coal-tar pitch. This can do no harm, and will probably do much good, for it is

> known that seep water affects coal-tar pitch to a very slight extent, if any, and that…I have seen coal-tar layers removed from the roof of a demolished battery at Fort Monroe, where it had been for over fifty years, and it was apparently as good as new and still impermeable by water.[65]

This system of ventilation was also fully endorsed by Winslow, who noted:

> …in all recently constructed batteries, there have been installed a double set of doors…one a grating door, and one a solid door. If it is desired to ventilate the battery, the solid door can be opened, and the grating door can be locked. The ventilation is thus secured without risking the safety of the material… Grating doors have recently been installed in many of the older batteries…. Indeed, in the ventilation system…it is believed that simplicity rather than complication should be aimed at, and that the introduction of very complicated apparatus, or apparatus requiring frequent and skilled manipulation, is not only unnecessary and a waste of money, but frequently does more harm than good. [66]

Winslow subsequently also noted:

> It is a well known-fact that in many cases batteries that had been notoriously wet and uncomfortable, when provided with solid doors habitually kept closed, have been made fairly dry by the mere expedient of adding gratings and leaving the solid doors and windows open all the time.[67]

Materials: Poured Portland Cement, some reinforced concrete on roofs

Location: Battery DeRussy, Fort Monroe, Virginia

Owner: Fort Monroe, Virginia

Scope of Work:

1. Remove major vegetation by cutting at ground level; remove minor vegetation by spraying with herbicide, remove miscellaneous debris such as wooden pallets and railroad ties from fortification, including debris inside areas visible through doors and window openings but not accessible to the general public. This work to be performed by Fort Monroe DPW, not by the contractor.
2. Perform complete photographic documentation and record drawings of site conditions following removal of vegetation and miscellaneous debris, to Historic American Building Survey (HABS) Level III.
3. Repair gutters and drainage systems
    a. Remove vegetation, silt/dirt/sand, and miscellaneous debris from all drainage channels, approximately six hundred lineal feet. Repair drainage channels with new Portland cement as necessary. Open all channels so that new leaders and downspouts can be installed.
    b. Remove two representative sections of historic cast iron leaders with brackets, mark with location and date using impermeable ink, and provide one each to Fort

[65] Winslow, *Lectures on Seacoast Defense*, 64.
[66] Ibid., 74, 75.
[67] Winslow, *Notes on Seacoast Fortification Construction*, 257.

Monroe, Virginia, Cultural Resources Manager and Fort Monroe Casemate Museum for permanent curation. Where possible re-use historic cast iron pipe. If not usable remove and take to the Fort Monroe recycling yard. Contractor shall coordinate with recycling yard prior to the work to ensure that pipe sections fit in the available dumpsters. Assume to be covered with Lead Based Paint.

   c. Remove intrusive concrete at ten downspouts. Use of handheld power equipment is authorized, but must be carefully supervised to avoid damaging or harming adjacent historic concrete. Contractor should assume a maximum of one square foot of concrete removal per downspout.
   d. Re-grade all landscaping around north elevation of battery (wherever sheet runoff occurs), so that all water drains into east storm sewer. All soil must be removed a minimum of four inches below surface level of drainage channels. Contractor should assume that an area of approximately 30’ x 450’ requires re-grading. Lower sidewalk grade as appropriate to ensure full drainage, approximately 450 lineal feet. Grading must be adequate to drain water into adjacent east storm sewer. Re-seed or re-sod all areas of soil disturbed by grading. Install silt protection where determined to be appropriate, until new grass grows.
   e. Install new cast iron leaders at seventeen locations, Ten of these locations are located on the front of the battery, four around the Signal (Mechanical) Building, and three on the Command Posts Building. Approximately ten lineal feet of down pipe will be required per each location. Replacement cast iron brackets should be utilized, similar to original examples recovered under Section 3.b**.** All installations into concrete must be performed using stainless steel hardware (to ensure that no corrosion will occur from installation hardware).
   f. All Cast Iron downspouts and leaders should be painted white.

4. Demonstration Approach No. 1 – Repairs to Top of Battery
   a. Remove all spalled, delaminated or deteriorated concrete from farthest eastern portion of battery top. Approximately 50’ x 60’ (three thousand square feet) of concrete must be removed. Use of mechanical means is authorized; care should be taken not to damage historic concrete that remains sound underneath the damaged and/or spalled concrete.
   b. Place pennies dated to the year of implementation at top of extant concrete.
   c. Cover top of battery with three layers of tarpaper and coat with tar.

5. Demonstration Approach No. 2- Repairs to Top of Battery

   a. Remove all spalled, delaminated or deteriorated concrete from middle portion of battery top. Approximately 55’ x 55’ (3,025 square feet) of concrete must be removed. Use of mechanical means is authorized; care should be taken not to damage historic concrete that remains sound underneath the damaged and/or spalled concrete.
   b. Place pennies dated to year of implementation at top of extant concrete.
   c. Cover top of battery with ½” of Thoro Surface Bonding Mortar ® or similar material.

6. Demonstration Approach No. 3 – Repairs to Top of Battery
   a. Remove all spalled, delaminated or deteriorated concrete from western portion of battery top Approximately 55’ x 60’ (3,300 square feet) of concrete must be removed. Use of mechanical means is authorized; care should be taken not to

damage historic concrete that remains sound underneath the damaged and/or spalled concrete.
    b. Place pennies dated to year of implementation at top of extant concrete.
    c. Cover top of battery with ½” of Thoro Surface Bonding Mortar ® [or similar material].
    d. Cover top of battery with three layers of tarpaper and coat with tar.

The use of dated pennies provides a clear line of demarcation between original features of a fortification, and any restoration work. The pennies will survive and provide a definitive record of dating in the future. Pennies are relatively inexpensive, and will not introduce any discordant elements into the fortification.

7. Demonstration Approach No. 1 – Stabilize Corroded Reinforcing Steel
    a. Remove all spalled, delaminated or deteriorated concrete from immediate vicinity of steel reinforcing rods located west of Command Post Building, three bars are exposed, remove concrete from area approximately ten feet by nine inches in size.
    b. Repair missing concrete with epoxy resin.
8. Demonstration Approach No. 2 – Stabilize Corroded Reinforcing Steel
    a. Remove all spalled, delaminated or deteriorated concrete from immediate vicinity of steel reinforcing rods , located west of Signal (Mechanical) Building, three bars are exposed, remove concrete from area approximately teen feet by nine inches in size.
    b. Repaint steel reinforcing rod with commercial corrosion arresting agent.
9. Demonstration Approach No. 3 – Stabilize Corroded Reinforcing Steel
    a. Remove all spalled, delaminated or deteriorated concrete from immediate vicinity of steel reinforcing rods, located east of Command Post Building, three bars are exposed, approximately ten feet by nine inches in size.
    b. Remove corrosion from steel reinforcing rods using naval jelly or similar commercial agent.
    c. Paint exposed steel with commercial “Rustoleum©” or similar corrosion preventive paint.
10. Remove six modern or replacement doors and three modern or replacement doors.
11. Open eight historic steel doors; weld steel brackets in place to keep doors open. Doors should be opened to near, but not touching, the concrete wall.
12. Demonstration Approach Number 1- Enable Passive Ventilation into farthest east portion of battery.
    a. Install stainless steel grated closures across the following openings:
        1. Four doors eight feet high x 32” wide;
        2. One window 57” high x 20.5” wide; and
        3. One ammunition door, eight feet high x 6’ 2” wide.
    b. Installation hardware into concrete must be stainless steel (non-corrosion).

13. Demonstration Approach Number 2 - Enable Passive Ventilation into middle portion of battery.
    a. Install welded steel grated closures, painted black, across the following openings:
        1. Four doors eight feet high x 32” wide;
        2. One window 57” high x 20.5” wide; and
        3. One ammunition door, eight feet high x 6’ 2” wide.
    b. Installation hardware into concrete must be stainless steel (non-corrosion).

14. Demonstration Approach Number 3- Enable Passive Ventilation into farthest western portion of battery.
    a. Install stainless steel frames with quarter-inch (1/4") stainless steel hardware cloth across the following openings:
        1. Four doors eight feet high x 32" wide;
        2. One window 57" high x 20.5" wide; and
        3. One ammunition door, eight feet high x 6' 2" wide.
    b. Installation hardware into concrete must be stainless steel (non-corrosion).
15. All reconstruction work must be done is small segments, that can be accomplished in one or two working days.

Work areas must be minimized. If concerns are identified with procedures, or the quality of the contractor's work, then the entire fortification will not be compromised.

16. A careful record of all work performed must be maintained. A weekly progress report with photographic documentation will be required. Digital photographs are acceptable.
17. Contractor is responsible for verifying all dimensions and field measurements.

3.0 Special Conditions **-** In addition to the work at the fortification itself, it must be recognized that any government construction team or contractor will require a staging/lay-down area to store and service equipment, stockpile supplies, etc. Such a location must be designated in advance, should be reasonably close to the fortification, and should be sited in such a manner that no historic or archaeological resources would be endangered. Identification of such a work area is an important component of any construction project at or in the vicinity of a historic property.

4.0 Statement of Qualifications

4.1 The Contractor must demonstrate previous experience with performing restorations of late 19th and/or early 20th century concrete structures.
4.2 The Contractor must demonstrate familiarity, and that contractor is trained and skilled in historic concrete construction techniques.

5.0 Conclusions

5.1 Fact Sheets

This study prepared fact sheets on inspection procedures, and typical materials, to facilitate preservation and stabilization of these military fortifications.

Military Fortification Inspections Checklist:

1. Evaluate and Document Existing Conditions
   - Prepare Surveyed Drawing of Feature
   - Use Digital Camera to Document Conditions
2. Evaluate Vegetation Cover of Earthworks
   - Vegetation Cover should be continuous
   - Brush and Shrubs that do not hold soil should be removed
   - Aggressive Mowing should be avoided
   - Trees that provide canopy cover should be encouraged
3. Identify Inappropriate Vegetation
   - Trees that are dead or rotten should be removed
   - Trees that block important historic vistas should be removed
   - Trees growing on earthworks or fortifications should be removed
4. Evaluate Visitor Use
   - Pedestrian routes
   - Parking areas
   - Vehicle access
   - Inappropriate uses (bicycles, dirt bikes, etc.)
   - Military training opportunities
   - Community recreational use
5. Evaluate Areas of Active Erosion
   - Dirt washing away
   - Exposed rocks or soil
   - Obvious water routes
   - Water pooling or standing water
6. Look for Bulges or Areas of Imminent Collapse in Walls or Structures
   - Fallen Stones
   - Missing Chink stones
   - Missing Mortar Joints
   - Wet or Damaged Brick
   - Cracks
7. Evaluate Animal Activity
   - Deer Trails
   - Burrowing Animals
   - Pests (bees, hornets, wasps, snakes, etc.)
8. Look for Evidence of Vandalism or Relic Hunting
   - Small Dug Holes
   - Fire pits for parties
   - Garbage

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References for Materials Treatment:

Brick or Mortared Masonry- Refer to National Park Service Preservation Brief #2 – "Re-pointing Mortar Joints in Historic Brick Buildings" http://www.cr.nps.gov/hps/tps/briefs/brief02.htm and USMA Cultural Resources SOP No. 4, "Masonry Repointing and Repair Procedures."

Concrete- Refer to National Park Service Preservation Brief #15- "Preservation of Historic Concrete Problems and General Approaches" http://www.cr.nps.gov/hps/tps/briefs/brief15.htm and National Park Service Golden Gate National Recreational Area "Seacoast Fortifications Preservation Manual" http://www.nps.gov/goga/history/seaforts/index.htm.

Earthworks- Refer to National Park Service Guidance "Sustainable Military Earthworks Management" http://www.cr.nps.gov/hps/hli/currents/earthworks/index.htm

Dry-stacked Stone- Refer to DoD Legacy Report, "Preservation and Stabilization of Military Fortifications" Section 2.2.

Dry-Laid Stone and Earth- Refer to DoD Legacy Report, "Preservation and Stabilization of Military Fortifications" Section 4.1, West Point Redoubt No. 2.

Complex Fortifications (combinations of mortared masonry, brick and earthworks) - Refer to DoD Legacy Report, "Preservation and Stabilization of Military Fortifications" Section 4.2, West Point Romans' Battery and Magazine.

Brick and Earthworks- Refer to DoD Legacy Report, "Preservation and Stabilization of Military Fortifications" Section 4.3, Casemates.

Concrete and Earth- Refer to DoD Legacy Report, "Preservation and Stabilization of Military Fortifications" Section 4.4, Endicott Series Batteries.

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5.2 Findings

The purpose of this study was to evaluate the effects that combinations of different building materials have upon the preservation and stabilization of military fortifications. A succinct historic context for military fortifications from the 18th century through Endicott series (early 20th century) was developed. Inspection, maintenance and repair procedures for those construction materials routinely used in military fortifications were reviewed:

- Earthworks;
- Mortared masonry; and
- Concrete.

This study then presented the procedures used at West Point to perform routine inspections of general site conditions for military fortifications. These procedures are applicable to military fortifications at any DoD installation or public facility, and provide a standardized "checklist" type format that easily documents recurring preservation and maintenance problems that occur at military fortifications.

This study then developed inspection, maintenance and repair procedures for dry-stacked stone, a historic construction methodology widely utilized in the 18th century. Dry-stacked stone is documented to have been used at military fortifications dating from the Seven Years War at Fort Crown Point, Crown Point State Historic Site, New York and Fort Ticonderoga Museum, Ticonderoga, New York. Dry-stacked stone is documented to have been used at Military Fortifications dating from the War for American Independence at West Point; and Fort Griswold, Fort Griswold State Historic Site, New London, Connecticut. All of these sites were evaluated during the performance of this study. Dry-stacked stone is a construction method that is widely used throughout New England, the northeastern United States, and the southeastern United States. Examples of dry-stacked stone can be seen on other DoD installations and historic sites such as Hanscom Air Force Base, Lexington, Massachusetts; Perryville State Historic Site, Perryville, Kentucky; and Stones River National Battlefield, Murfreesboro, Tennessee. The inspection, maintenance and repair procedures developed for dry-stacked stone at military fortifications can be applied to any dry-stacked stone feature.

Military fortifications are typically constructed of a combination of different materials, which normally include earth as it provides low-cost, highly-effective, relatively flexible defensive strength. The use of earth when used in conjunction with traditional building materials such as brick, wood, mortared masonry, concrete or dry-laid stone introduces a significant increase for water infiltration and heightened moisture levels that have the potential to cause substantial damage to other materials. The following combinations of materials were examined and served as a demonstration by this study:

- Dry-stacked stone and earth (Revolutionary War and Civil War, West Point Redoubt No. 2 served as the demonstration project);
- Complex interaction consisting of Mortared masonry, mortared brick, and earth (Revolutionary War through 19th Century, West Point Romans' Magazine and Battery served as the demonstration project);
- Mortared brick and earth (18th and 19th century casemates, Fort Monroe, Virginia served as the demonstration project); and
- Concrete and earth (Endicott Series Batteries, Battery DeRussy, Fort Monroe, Virginia served as the demonstration project).

For these four combinations, potential sources of maintenance problems and maintenance failures were identified. Previous maintenance and repair efforts and activities were evaluated for function and effectiveness. Finally, integral components of preservation and stabilization at these types of historic properties were researched and identified. A particular effort was made to develop procedures that were economically feasible, and that could be implemented by general contractors rather than requiring specialized preservation of construction skills.

Findings of this study were that:

- An effective preservation and stabilization approach consists of integrated inspections, maintenance, and repairs;
- An established program of recurring and routine inspections, maintenance and repairs can minimize or eliminate the need for expensive restorations or rehabilitation projects;
- Previously prepared National Park Service preservation and maintenance studies on earthworks, brick, concrete, and mortared masonry provided the background for this study;
- Combinations of different materials, and particularly the use of earth in conjunction with other materials, is not a major contributor to deterioration or damage caused to military fortifications;
- Management of water and erosion is the single most critical factor in preservation and stabilization of military fortifications; and
- Considerable maintenance and preservation efforts can be accomplished through cost-effective techniques that do not require the services of specialized vendors.

These military fortifications are important historical resources that can be used to directly support military training and education. For example, the Revolutionary War fortifications at West Point directly support historic academic instruction and military training of the U.S. Military Academy Corps of Cadets. However, it was apparent during the conduct of this study that the DoD is not performing an effective job at fulfilling their responsibilities to preserve and maintain these important historic properties. It is hoped that this study will provide an impetus to DoD and other public and private institutions to initiate more effective preservation and stabilization of these historic properties.

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Appendices

Appendix A
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Appendix B
Applicable West Point Cultural Resources Standard Operating Procedures (SOP)

USMA Cultural Resources SOP No. 3

Inspection Procedures for Masonry Walls (Structural and Retaining)

General Procedures

1. Inspect overall condition annually.
2. Records should be kept, in the form of a logbook and a systematic filing of invoices, detailing the masonry wall inspection and repair history.

Routine Inspection Procedures

1. Cracks
    - Cracks can be horizontal, vertical, diagonal, hairline, or major. Document the nature of the crack, explaining as best as possible the causes of the cracks (see below):

        a. Foundation erosion
        b. Decay and/or improper use of materials
        c. Structural failure
        d. Change in materials or geometry
        e. Changes in moisture content
        f. Thermal changes:
            i. Horizontal or diagonal cracks near the ground at piers in long walls: due to horizontal shearing stresses between the upper wall and the wall where it enters the ground.
            ii. Vertical cracks near the ends of walls.
            iii. Vertical cracks near the top and ends of the façade.
            iv. Cracks around stone sills or lintels: due the expansion of the masonry against both ends of the tight fitting stone piece that cannot be compressed.
    - What directions are the cracks going and where are they the widest?
    - Note sloped floors, bulging walls, and doors that do not fit.
2. Mortar
    - Inspect mortar joints to determine if they are loose or missing and evaluate their condition as good (no deterioration, disintegration, cracking, or spalling, evident; no moisture penetration; masonry units undamaged and stable), fair (some deterioration evident, localized minor disintegration, cracks, or spalling; minimal moisture penetration of the masonry wall; masonry units still undamaged and stable), or poor (major deterioration evident, large portions missing, completely disintegrated, or very loose, often in combination with loose or cracked masonry units and serious moisture penetration of the masonry wall).

3. Brick
    - Check for stains, wet spots, bulges, spalling, efflorescence, and missing brick.
4. Stone
    - Inspect stonework for wet spots, stains, spalling, bulges, and efflorescence.

Monitoring and Evaluating Cracks in Masonry

Some causes of cracking include: settlement or foundation erosion, decay of materials, incorrect restoration practices, structural failure, change in materials or geometry, and moisture and temperature changes:

1. In foundation piers and piles, general cracking is often due to settlement or rotation of the pier footing.
2. Vertical cracking or bulging of masonry foundation wall is often due to physical deterioration of the pier from exposure, poor construction, or overstressing.
3. Horizontal cracking or bowing of a masonry foundation wall may be caused by improper backfilling, or by swelling or freezing and heaving of water saturated soils adjacent to the wall.
4. Differential settlement of a masonry foundation wall may be caused by many different things including soil consolidation, soil shrinkage, soil swelling, soil heaving, soil erosion, or soil compaction.
5. Differential settlement of a chimney is often caused by inadequate foundations that may cause the chimney to lean and crack.

Crack Monitoring Techniques and Applications:

Monitoring Cracks Using Tape and Pencil:

1. Place a piece of tape on each side of the crack.
2. Draw one short line on each piece of tape at a convenient distance apart (2 inches) and parallel to the crack.
3. If there is movement in the crack, the distance between the lines on the tape will vary; if the crack is long, several monitors will be needed.
4. Make a record chart of the distance between the marks on the tape at weekly intervals.
5. Keep accurate records of these measurements and place them along with photographs in file.
6. If significant widening occurs, report this with back-up data and copies of photographs to the Cultural Resources Manager.

Cracks may also be monitored using glass and epoxy (a microscope slide fastened with epoxy, bridging the crack; if the glass breaks, it is an indication that the masonry is moving) or by using a commercial crack monitor (Avongard Crack Monitor ®). More complex and sophisticated non-destructive evaluation techniques (NDE) for masonry construction are increasingly available and applicable for use on historic structures, given the non-invasive nature of NDE. NDE available for use on historic masonry structures include radar (also referred to as impulse radar), impact echo, ultrasonic pulse velocity, spectral analysis of surface waves, electromagnetic detection, infrared thermography, and fiber optics.

Cracks may be serious and should be evaluated to determine if they are active/inactive and what the structural implications are. Thermal expansion cracks in masonry units should only be repaired to retard moisture penetration if active and/or of sufficient width. Hairline thermal expansion fractures usually need no repair. Inactive cracks may be repaired, but structural cracks should be examined by a structural engineer. Consult with an experienced structural engineer and the Cultural Resources Manager where questions exist over appropriate treatments. All work requiring repointing, patching masonry cracks, removing and replacing deteriorated masonry units, and reattaching or patching loose or spalled masonry units must be accomplished by a qualified mason with a minimum of 5 years experience repairing historic masonry buildings or features.

References:

Technical References:

United States General Services Administration Historic Preservation Technical Procedures
(Available at http://w3.gsa.gov):

United States General Services Administration Historic Preservation Technical Procedures, No. 01800-01, “Checklist for the Routine Inspection of Buildings”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04200-02, “Monitoring and Evaluating Cracks in Masonry”.

National Park Service Resources:

For general consideration and reference prior to inspection of historic masonry walls:

The Secretary of the Interior’s Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings: “Exterior Materials: Masonry”.

Available at http://www2.cr.nps.gov/tps/standguide/index.htm

Kaplan, Marilyn E., Marie Ennis, and Edmund P. Meade. "Non-destructive Evaluation Techniques for Masonry Construction." Washington, D.C.: U.S. Department of the Interior; Technical Preservation Services Division, Preservation Tech Notes, Masonry No. 4, 1997.

Available at http://www2.cr.nps.gov/tps/technotes/PTN40/intro.htm

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General Procedures and Considerations

3. Inspect overall condition annually.
4. Records should be kept, in the form of a logbook and a systematic filing of invoices, detailing the masonry repointing and repair history.
5. Root cause of mortar or masonry deterioration (leaking roofs, flashing, or gutters, differential settlement of building, capillary action, extreme weather exposure, etc.) should be dealt with **prior to beginning repointing and masonry repairs**.
6. Consult with Cultural Resources Manager prior to any masonry repointing or repair work.
7. Use of silicone or rubber caulking in masonry work is prohibited at USMA, except for use between dissimilar materials, e.g., metal and stone.
8. Follow Manufacturer's instructions and specifications for use of specific commercial products.

Repointing Procedures

5. Repoint only those areas that require work rather than an entire wall. But, if 25 percent or more of a wall needs to be repointed, repointing the entire wall is necessary.

6. In scheduling, seasonal aspects must be considered first. Wall temperatures between 40° F and 95° F will prevent freezing or excessive evaporation of the water in the mortar. The relationship of repointing to other work proposed for the historic building and building use must also be recognized.

7. Appropriate Mortar Matching

    - Preliminary research is necessary to ensure that the proposed repointing work is both physically and visually appropriate to the building.
    - The actual specification of a particular mortar type should take into consideration all of the factors affecting the life of the building including: current site conditions, present condition of the masonry, function of the new mortar, degree of weather exposure, and skill of the mason.
    - Mortar found in masonry structures built between 1873 and 1930 can range from pure lime and sand mixes to a wide variety of lime, Portland cement, and sand combinations.

- During the early stages of the project, it should be determined how closely the new mortar should match the historic mortar. Will "quite close" be sufficient, or is "exactly" expected?
- It is important to remember that mortar joints are intended to be sacrificial and will probably require repointing some time in the future.
- A simple, non-technical, evaluation of the masonry units and mortar can provide information concerning the relative strength and permeability of each (critical factors in selecting repointing mortar), while a visual analysis of the historic mortar can provide the information necessary for developing the new mortar mix and application techniques (see below).

- New mortar must conform to the following criteria:

  - The new mortar must match the historic mortar in **color, texture, and tooling** (if a laboratory analysis is undertaken, it may be possible to match the binder components and their proportions with the historic mortar, if those materials are available).
  - The **sand must match the sand** in the historic mortar (the color and texture of the new mortar will usually fall into place if the sand is matched successfully).
  - The new mortar must have **greater vapor permeability** and be **softer** (measured in compressive strength) than the masonry units.
  - The new mortar must be **as vapor permeable** and **as soft or softer** (measured in compressive strength) than the historic mortar (softness or hardness is not necessarily an indication of permeability; old, hard lime mortars can still retain high permeability).

- A mortar strong in compressive strength might be desirable for a hard stone (such as granite), whereas a softer, more permeable lime mortar would be preferable for a historic wall of soft brick.
- Preblended masonry cements produce high strength mortars that can damage historic masonry and are generally not recommended for use on historic masonry buildings.
- Generally, chemical additives to mortar and bonding agents may have detrimental effects on historic masonry, and should be avoided. Proper joint preparation should ensure a good bond between new mortar and adjacent surfaces.
- Use of cement based grouting as an alternative to repointing brick buildings is not recommended as the change in joint appearance can alter the historic character of the structure to an unacceptable degree.
- If the mortars have been properly matched, the best way to deal with surface color differences is to let the mortars age naturally.

Mortar Types (Measured by volume)			
Designation	Cement	Hydrated Lime or Lime Putty	Sand
M	1	1/4	3 - 3 3/4
S	1	1/2	4 - 4 1/2
N	1	1	5 - 6
O	1	2	8 - 9
K	1	3	10 - 12
"L"	0	1	2 1/4 - 3

Suggested Mortar Types for Different Exposures			
	Exposure		
Masonry Material	Sheltered	Moderate	Severe
Very durable: granite, hard-cored brick, etc.	O	N	S
Moderately durable: marble, limestone, durable stone, molded brick	K	O	N
Minimally durable: soft hand-made brick	"L"	K	O

Table reprinted from NPS Technical Preservation Services Preservation Brief No. 2, 1998; ASTM Standard

Repointing Step Procedures

6. **Test Panels**: Test panels, preferably not on the front or other highly visible location, should be prepared by personnel/contractor using the same techniques that will be used on the remainder of the project. Usually a 3 foot by 3 foot area is sufficient for brickwork, while a larger area may be required for stonework. Cleaning tests should be carried out in the same locations. If test panels cannot be utilized, then personnel/contractor must first do sample work within a small, inconspicuous or severely damaged area of the building. The sample work will subsequently be evaluated by USMA before permitting full repointing or repairs to proceed.
7. **Joint Preparation**: Old mortar should be removed to a minimum depth of 2 to 2½ times the width of the joint to ensure an adequate bond and to prevent mortar "popouts". For most brick joints, this will require removal of the mortar to a depth of approximately ½ to 1 inch; for stone masonry with wide joints, mortar may need to be removed to a depth of several inches. Any loose or disintegrated mortar

beyond this minimum depth should also be removed. Old mortar should be removed using hand chisels and mash hammers, in the traditional manner; **the use of power tools is prohibited at USMA**. Mortar should be removed leaving square corners at the back of the cut. Before filling, the joints should be damp, but with no standing water. For walls that are extremely absorbent (limestone, sandstone, common brick) a continual mist of water should be applied for a few hours prior to beginning repointing.

8. **Mortar Preparation**: Dry ingredients are measured by volume and thoroughly mixed before the addition of any water. Sand must be added in a damp, loose condition to avoid over sanding. Half the water should be added, followed by mixing for approximately 5 minutes. The remaining water should then be added in small portions until the mortar reaches the desired consistency. A drier mortar is cleaner to work with and can be compacted tightly into joints; with no excess water to evaporate, mortar cures without shrinkage cracks. Mortar should be used within 30 minutes of final mixing and adding more water (retempering) should not be permitted.
    a. **Lime Putty**: Mortar made with lime putty and sand should be measured volume, and may require slightly different proportions from those used with hydrated lime. No additional water is needed to achieve a workable consistency as enough water is contained in the putty. Sand is proportioned first, followed by the lime putty, then mixed for 5 minutes or until all the sand is thoroughly coated with the lime putty. Lime putty and sand can be mixed together ahead of time and stored indefinitely, on or off site.
    b. **Portland Cement**: If Portland cement is specified in a lime putty and sand mortar (Type O or Type K), the Portland cement should first be mixed into a slurry paste before adding it to the lime putty and sand. Any color pigments should be added at this stage and mixed for a full 5 minutes. The mortar should be used within 30 minutes to 1½ hours and should not be retempered. Once Portland cement has been added, the mortar cannot be stored.
9. **Filling the Joint**: Deeper areas (greater than 1 inch) should be filled in first. The back of the entire joint should be filled by successively compacting the new mortar in ¼ inch layers, allowing each layer to dry to thumb-print hardness before applying the next layer of mortar. Layering reduces overall shrinkage. When the final layer of mortar is thumb-print hard, the joint should be tooled to match the historic joint. If the old bricks or stones have worn, rounded edges, it is best to recess the final mortar slightly from the face of the masonry and avoid a joint that is visually wider than the actual joint and to avoid featheredging that is easily damaged and admitting water. After tooling, excess mortar can be removed by brushing with a natural bristle or nylon brush. Metal bristle brushes should never be used on historic masonry.
10. **Curing Conditions**: The preliminary hardening of high-lime content mortar (Type O, Type K, Type L) takes place fairly rapidly and if occurs too quickly, can result in chalking, poor adhesion, and less durability. Misting the new mortar using a hand sprayer with a fine nozzle every 1 – 4 hours for 1 to 2 days after repointing (depending on local conditions) is recommended. Walls should be covered with

burlap for the first 3 days after repointing (plastic may be used but should be tented out and not placed directly against the wall).

Mortar and Masonry Unit Visual Examination Procedures

Mortar samples should be chosen carefully, and picked from a variety of locations on the building to find unweathered mortar, if possible. Variations should be noted which may require developing more than one mix.

1. Remove with a chisel and hammer three or four unweathered samples of the mortar to be matched from several locations on the building. Set the largest sample aside as this will be used later for comparison with the repointing mortar. Removing a full representation of samples will allow selection of an average mortar sample.
2. Mash the remaining samples with a wooden mallet, or hammer if necessary, until they are separated into their constituent parts. There should be a good handful of material.
3. Examine the powdered portion: the lime and/or cement matrix of the mortar. Note the color. Not all historic mortars are white; grey Portland cement was available by the last quarter of the 19^{th} century and traditional lime mortars sometimes are grey. The mortar may also have been tinted to create a colored mortar and this color should be identified at this point.
4. Carefully blow away the powdery material.
5. With a low power (10x) magnifying glass, examine the remaining sand and other materials such as lumps of lime or shell.
6. Note and record the wide range of color as well as the varying sizes of the individual grains of sand, impurities, or other materials.
7. New mortar should match the unweathered interior portions of the historic mortar. Make a small sample of the proposed mix and cure at 70° F for one week. Break open the dried proposed mix sample following the above procedure and compare with the surface of the largest “saved” sample of historic mortar.
8. If a proper color match is impossible using natural sand or colored aggregates like crushed marble or brick dust, it may be necessary to use a modern mortar pigment.

The masonry units should also be examined so that any replacement units will match the historic masonry. Within a wall there may be a wide range of colors, textures, and sizes, particularly with hand-made brick or rough-cut, locally quarried stone. Replacement units should blend in with the full range of masonry units rather than a single brick or stone.

Masonry Repair Procedures (missing, spalled, deteriorated, eroded, or cracked masonry units)

Brick

Materials: Salvaged brick, approved by Cultural Resources Manager, sound, crack free, and clean, without face chips larger than ½ inch, or replacement brick also approved by Cultural Resources Manager, and mortar to match existing mortar.

1. Carefully remove deteriorated brick units by hand using a hammer and chisel.
2. Rebuild back-up and substrate as required to replace any unsound material that was removed.
3. Clean the cavity of loose mortar and other debris by hand using a chisel and stiff bristle brush.
4. Lightly wet the exposed brick surfaces.
5. Lay brick units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place.
6. If adjustments are required, remove units, clean off mortar, and reset in fresh mortar.
7. Blend new work into existing work smoothly with no lines of demarcation and no change of pattern, coursing, and pointing style.
8. Brush off all excess mortar from the wall surface frequently during the work; protect all existing surfaces from mortar dripping and splashing.

Cast Stone

Drilled holes, mechanically damaged corners, and occasional small spalls from rusting reinforcement bars and anchors are often repairable conditions that do not warrant replacement of cast stone. Small "composite" repairs to damaged masonry units can be made with mortar formulated to visually match the original material. However, widespread deterioration, spalling, or cracking, and damage to figurative sculpture or unique building elements, may require major repair using mechanical anchoring or pins, epoxy adhesive injection, or possible replacement. The weathering of cast stone, although different from that of natural stone, produces a patina of age, and does not warrant large-scale repair or replacement unless severe cement matrix problems or rusting reinforcement bars have caused extensive scaling or spalling. Consult with the Cultural Resources Manager.

1. Cement matrix color and the aggregate size, angularity, and coloration must match that of the historic unit.
2. Additional crushing and sieving may be necessary to obtain aggregate of an appropriate size. Half or more of a weathered cast stone surface is exposed aggregate, so careful aggregate selection and size grading is important for patching. If more than one aggregate was used in the cast stone, the ratio of selected aggregates in the new mix is important.
3. If additional color tinting is required, only inorganic, alkali-resistant masonry pigments should be used.
4. To repair a small spall caused by deterioration of a ferrous reinforcement bar or anchorage, remove all cracked cast stone adjacent to the spall; grind and brush the

reinforcement to remove all rust and scale; paint the metal with a rust-inhibiting primer prior to applying new composite. Consult with Cultural Resources Manager and structural engineer to determine whether severely eroded portion of reinforcement bar can be removed prior to patching or new reinforcement bar needs to be spliced to the old.

5. Where spalls have a featheredge, cut back the repair area to a uniform depth (½ inch or more).
6. If adjacent cast stone is tooled or weathered, it will be necessary to scribe or brush the repaired area to give it a matching surface texture.
7. Adding enough aggregate to match adjacent original cast stone will sometimes interfere with adhesion of the new composite repair. A bonding agent may assist adhesion, or it may be necessary to press additional aggregate into the applied patch prior to finishing (avoid creating a "mosaic" appearance).

Concrete

Repair of historic concrete may consist of either patching the historic material or filling in with new material worked to match the historic material. The correction and elimination of concrete problems can be difficult, time-consuming, and costly. Resorting to temporary solutions should be avoided. Widespread concrete erosion, spalling, or cracking, and damage to figurative treatments or unique building elements, may require major repair using a combination of mechanical anchoring, epoxy adhesive injection, or possible replacement. Consult with the Cultural Resources Manager.

Cracks

1. Hairline, nonstructural cracks that show no sign of worsening normally need not be repaired.
2. Cracks larger than hairline cracks, but less than approximately 1/16 of an inch can be repaired with a mix of cement and water. If the crack is wider than 1/16 of an inch, fine sand should be added to the mix to allow for greater compactibility, and to reduce shrinkage during drying. Field trial should determine whether a crack should be routed prior to patching.
3. When it is desirable to reestablish the structural integrity of a concrete structure involving dormant cracks, epoxy injection should be considered.
4. If cracks are active due to load changes or thermal fluctuations, expansion-contraction joints may have to be introduced prior to any repairs.
5. Random (map) cracks throughout a structure are difficult to correct and present continuing maintenance problems as original concrete will ultimately contaminate new concrete installations.

Scaling and Spalling

1. Cut back damaged area to stable material. Roughen the surface with a hammer and chisel.

2. Remove all rust from any exposed reinforcement bar.
3. Consult with structural engineer and Cultural Resources Manager prior to cutting out any reinforcement bar that is severely eroded and splicing in new reinforcement bar.
4. Paint freshly cleaned reinforcement bar with an epoxy coating to prevent further rusting.
5. If patch is unusually large, drill holes into sound substrate and insert stainless steel pins anchored with epoxy.
6. Remove all dust and debris by water blasting, air blasting, or with a broom and vacuum.
7. Square off the perimeter of the area to be patched, so that a feathered edge will not be necessary.
8. About 1 hour prior to the repair, moisten the surface of the area to be patched.
9. To ensure a good bond between patch and substrate, brush substrate surface with either a cement wash, or a bonding agent.
10. Apply patching material, with a trowel, in ¾ inch layers, compacting thoroughly after each layer.
11. Work the finished surface carefully making sure to match texture and appearance of surrounding original surface. Patching mix should match as closely as possible, the texture and color of the original surface.

Granite

Repointing and Filling Cracks

1. Rake out all stone joints in designated areas by hand using a chisel. Remove all unrequired metal fasteners from granite and granite joints.
2. Clean all mortar from surfaces within the joint or crack so that new pointing mortar bonds to the building material, not the old mortar. Do not chip or spall edges of the stone.
3. Joint depth should be at least ¾ inch, but in all cases rake back to expose sound mortar.
4. Brush, vacuum, or flush joints to remove all dirt and loose debris.
5. Reduce initial absorption of the stone by thoroughly wetting the stone surface with clean water just prior to repointing. Do not allow water to pool on the surface of the stone.
6. Pack joints with mortar, leaving no voids. Place mortar in layers not exceeding ¼ inch in depth. Apply successive layers only after preceding layer has taken initial set.
7. Clean excess mortar from stone and joints, removing splashed mortar and droppings immediately.
8. Do not retemper or use mortar that has partially set, is caked, or lumpy.
9. Tool horizontal and vertical face joints flush, dense, and smooth after mortar has taken initial set. Do not allow mortar to extend over stone surfaces.
10. Curing: Keep joints damp for at least 72 hours or until surface is cured. Protect joints from rapid drying due to wind.

Patching Chips and Small Holes in Granite

1. Remove loose dirt and debris from the hole and the surrounding stone surface using a stiff bristle brush (do not use metal brushes). Flush with clean, potable water if necessary, and allow to dry.
2. Mix patching material following manufacturer's instructions and recommendations (a two part polyester resin adhesive colored to match existing granite such as Akemi ® Transparent knife grade, or approved equal). Mix coloring agent with mastic before adding hardener. Mixes should be tested to determine finish color after curing, to achieve best color match with surrounding stone.
3. Apply patching material to stone following manufacturer's instructions.
4. When the patching material becomes rubbery, carefully remove excess material using a razor blade. Finish patch surface to match surrounding stone surfaces.

Reattaching Loose or Spalled Granite

Reuse any fragments that are still sound; reuse such stone in its original position and location. Replacement stone should match existing granite in color, texture, and type. Consult with Cultural Resources Manager.

1. Carefully remove all loose fragments of stone. Set aside all pieces in good condition for reuse.
2. Clean exposed metal anchors. Remove corrosion by scraping with a stiff wire bristle brush.
3. Remove unsound metal anchors and replace with new stainless steel anchors of similar size and shape. Bed the new anchors in epoxy grout.
4. Remove dust and debris from building stone and fragments using a stiff bristle brush (non-metal).
5. For small fragments (0.5 cubic feet or less):
    a. Coat exposed building stone sub-surface with adhesive (a two part polyester resin adhesive colored to match existing granite such as Akemi ® Transparent knife grade, or approved equal). Be sure to cover the entire surface, filling all voids. Colored adhesive mix should be pre-tested to determine color match after drying.
    b. While adhesive is still tacky, set stone fragment in place. Prevent fragment from moving until adhesive is fully cured.
    c. Clean any residual adhesive from the stone surface using water and a stiff (non-metal) bristle brush. Wet stone and fill any cracks with matching patching mortar. Tool surface level with surrounding stone surfaces.
6. For large fragments (greater than 0.5 cubic feet):
    a. Follow procedures in step No. 5 above.
    b. After adhesive has cured, anchor fragments with ¼ inch smooth stainless steel rods.
    c. Drill ¼ inch holes at a 45° downward angle through the face of the newly set stone fragment. Drill hole should extend at least 2 inches into the

backing stone, 2 inches into the fragment, and should allow for the rod to be countersunk at least ¾ inch from the face of the stone fragment.

   d. Space the anchor rods between 3 and 5 inches apart and no less than 2 inches from any edge.
   e. Clean any residual adhesive from the stone surface using water and a stiff (non-metal) bristle brush. Wet stone and fill holes from countersunk rods with matching patching mortar. Tool surface level with surrounding stone surfaces.

Limestone

Reattaching Loose or Spalled Limestone

Reuse any fragments that are still sound; reuse such stone in its original position and location. Replacement stone should match existing limestone in color, texture, and type. Consult with Cultural Resources Manager.

1. Carefully remove all loose fragments of stone. Set aside all pieces in good condition for reuse.
2. Clean exposed metal anchors. Remove corrosion by scraping with a stiff wire bristle brush.
3. Remove unsound metal anchors and replace with new stainless steel anchors of similar size and shape. Bed anchors in epoxy grout.
4. Remove dust and debris from building stone and fragments using a stiff (non-metal) bristle brush.
5. For small fragments (0.5 cubic feet or less):
   a. Coat exposed building stone sub-surface with adhesive (a two part polyester resin adhesive colored to match existing granite such as Akemi ® Limestone Super light knife grade, or approved equal). Be sure to cover the entire surface, filling all voids. Colored adhesive mix should be pre-tested to determine color match after drying.
   b. While adhesive is still tacky, set stone fragment in place. Prevent fragment from moving until adhesive is fully cured.
   c. Clean any residual adhesive from the stone surface using water and stiff (non-metal) bristle brush. Wet stone and fill any cracks with lime based patching mortar of appropriate color, texture, and composition. Tool surface level with surrounding stone surfaces.
6. For large fragments (greater than 0.5 cubic feet):
   a. After adhesive has cured, anchor fragments with ¼ inch smooth stainless steel rods.
   b. Drill ¼ inch holes at a 45° downward angle through the face of the newly set stone fragment. Drill hole should extend at least 2 inches into the backing stone, 2 inches into the fragment, and should allow for the rod to be countersunk at least ¾ inch from the face of the stone fragment.
   c. Space the anchor rods between 3 and 5 inches apart and no less than 2 inches from any edge.

d. Clean any residual adhesive from the stone surface using water and a stiff (non-metal) bristle brush. Wet stone and fill holes from countersunk rods with lime based matching patching mortar. Tool surface level with surrounding stone surfaces.

Patching Spalled Limestone

1. Cut back to sound stone with chisel and hammer. Score surface to receive patch with chisel to provide a mechanical key with patching material.
2. Thoroughly clean all stone dust and debris from areas that to be repaired by air brushing and then with a soft brush and water.
3. Pre-moisten stone with clean water and a stiff natural bristle brush to prevent patching mortar from drying out prematurely. Avoid over wetting the stone, which inhibits adhesion.
4. Use cementitious patching material such as Jahn® M70 Stone Restoration Mortar, or approved equal.
5. First mix the cementitious patching material well in a dry state, then add water as per manufacturer’s instructions, depending on the porosity of the limestone; between 150-200cc of water to one kg of dry patching material. Patching mortar should be shapable without using molds and as it is being applied should hold its shape right away. Do not mix more patching material than can be used within 30 minutes.
6. Apply with trowel so that patch is slightly higher than adjacent surfaces. Jahn® patching mortar can be put on from 3mm to any required thickness at once. Allow to harden for 7 days, then carefully cut back and tool to match adjacent stone surfaces.

Marble

Repointing Marble

1. Rake out all stone joints in designated areas by hand using a chisel. Remove all unrequired metal fasteners from granite and granite joints.
2. Clean all mortar from surfaces within the joint or crack so that new pointing mortar bonds to the building material, not the old mortar. Do not chip or spall edges of the marble.
3. Joint depth should be at least ¾ inch, but in all cases rake back to expose sound mortar.
4. Brush, vacuum, or flush joints to remove all dirt and loose debris.
5. Reduce initial absorption of the stone by thoroughly wetting the stone surface with clean water just prior to repointing. Do not allow water to pool on the surface of the stone.
6. Pack joints with mortar, leaving no voids. Place mortar in layers not exceeding ¼ inch in depth. Apply successive layers only after preceding layer has taken initial set.

7. Clean excess mortar from stone and joints, removing splashed mortar and droppings immediately.
8. Do not retemper or use mortar that has partially set, is caked, or lumpy.
9. Tool horizontal and vertical face joints flush, dense, and smooth after mortar has taken initial set. Do not allow mortar to extend over stone surfaces.
10. Curing: Keep joints damp for at least 72 hours or until surface is cured. Protect joints from rapid drying due to wind.

Repairing Hairline Cracks and Small Gouges in Marble

Selected filler should NOT contain materials that may absorb into the marble and cause staining. Test in an inconspicuous area. Use polyester-based adhesives such as Akemi® knife grade adhesive, or available from the Eastern Marble Supply Company®, or approved equal. Polishing compounds should be acid-free and containing no caustic or harsh fillers or ingredients with natural resins added, and formulated specifically for polishing interior marble surfaces, such as Eastern Marble Supply Company® R52B, or approved equal.

1. Using a chisel or hacksaw blade, carefully remove unsound marble material and old patching material from cracks and holes to expose sound marble material for contact with polyester resin patch.
2. Brush, vacuum, or flush cracks and holes to remove dirt and loose debris.
3. Allow to dry thoroughly.
4. Using a caulking gun or spatula, fill narrow cracks, holes and gouges with polyester filler, colored to match adjacent marble and honed or polished to match marble finish. Tape work to prevent staining of the marble during filling operation. Surfaces shall be true and level. Remove tape residue with appropriate solvent to produce the specified finish.
5. Allow patching material to cure for period recommended by manufacturer.
6. Grind marble down until an even plane is achieved. Feather out to unaffected surface as required to avoid marble having a dished appearance. Use right angle water feed grinder with successively finer diamond disks (#60 to #3500) or silicon carbide grinding stones (36 to 400 grit).
7. Polish to match existing sheet of marble. Use acid-free aluminum oxide polishing compound with felt pads.

References:

Technical References:

United States General Services Administration Historic Preservation Technical Procedures
(Available at http://w3.gsa.gov):

United States General Services Administration Historic Preservation Technical Procedures, No. 03732-02, “Patching Scaling Concrete Masonry”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04211-02, “Removing and Replacing Deteriorated Brick Masonry”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04455-08, “Repairing Hairline Cracks and Small Gouges in Marble”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04455-20, “Repointing Marble”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04460-07, “Reattaching Loose or Spalled Limestone”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04460-09, “Patching Spalled Limestone”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04465-10, “Patching Chips and Small Holes in Granite”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04465-11, “Reattaching Loose or Spalled Granite”.

United States General Services Administration Historic Preservation Technical Procedures, No. 04465-12, “Pointing Granite and Filling Cracks”.

National Park Service Resources:

For general consideration and reference prior to repointing and repairing of historic masonry:

The Secretary of the Interior’s Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings: “Exterior Materials: Masonry”.
Available at http://www2.cr.nps.gov/tps/standguide/index.htm

Mack, Robert C. and John P. Speweik. "Repointing Mortar Joints in Historic Masonry Buildings." Washington, D.C.: U.S. Department of the Interior; Technical Preservation Services Division, Preservation Briefs, No. 2, 1998.

Available at http://www2.cr.nps.gov/tps/briefs/brief02.htm

Coney, William B. "Preservation of Historic Concrete: Problems and General Approaches." Washington, D.C.: U.S. Department of the Interior; Technical Preservation Services Division, Preservation Briefs, No. 15, 1987.

Available at http://www2.cr.nps.gov/tps/briefs/brief15.htm

Pieper, Richard. "The Maintenance, Repair, and Replacement of Historic Cast Stone." Washington, D.C.: U.S. Department of the Interior; Technical Preservation Services Division, Preservation Briefs, No. 42.

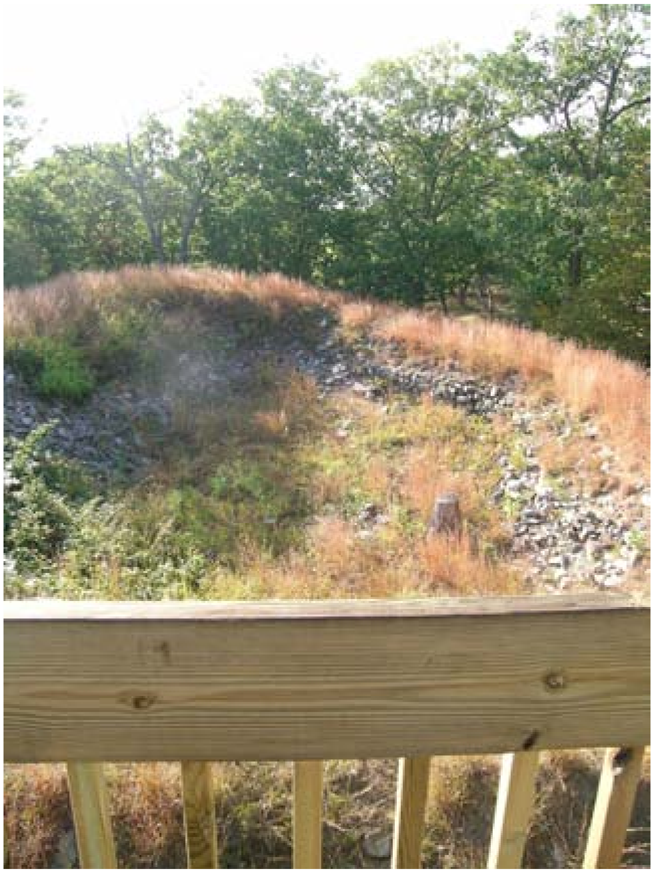
Available at http://www2.cr.nps.gov/tps/briefs/brief42.htm

Appendix C
Redoubt No. 2 Demonstration Project

In the spring of 2006 the Redoubt No. 2 demonstration project was performed at West Point. Removal of the sand bags from the interior proved to be more challenging than originally anticipated as the sand bags had totally disintegrated. It was determined that attempting to remove the large quantity of sand from the interior of the redoubt would result in an unacceptable level of traffic across the rampart of the redoubt, exacerbating already serious erosion conditions. Accordingly, the decision was made to remove the sand from the historic interior wall, and to spread it across the floor of the redoubt. During the evaluation of the redoubt, the southeastern corner of the battery was determined to be too badly eroded to be restored. This corner appeared from a careful examination of the battery to be a natural water drainage route, and this water drainage had removed all vestiges of the original battery walls. The initial approach had been to construct a French drain in this location to facilitate water drainage, and to reconstruct the walls as indicated in the previous documentation of the redoubt. However, because all vestiges of the walls had vanished by the time that this demonstration project was started, the decision was made to permit natural water drainage, and to not perform any restoration of the walls. Additionally, during stabilization of the redoubt walls, small stones that had collapsed from the walls outside of the redoubt were used to fill in the area behind the walls, thus creating a French drain to facilitate collection of natural drainage from the redoubt walls, and permitting it to naturally percolate through the dry-stacked stone walls. This will also serve to relieve pressure from the earth rampart upon the dry-laid stone interior wall. The mason and West Point Cultural Resources Manager believed that this approach will facilitate water drainage within the redoubt. Additionally, although measures will be taken to restrict pedestrian traffic to the interior of the redoubt, it was recognized during site visits that some level of pedestrian traffic to the interior of the redoubt would continue to occur. Accordingly, a simple set of stone stairs was integrated into the east interior wall when it was restored, so that pedestrians would not climb over the dry-laid stone walls and accelerate their disintegration. At the time of the preparation of the final report, the final re-seeding of the redoubt had not occurred due to winter conditions in the Hudson Highlands. The demonstration project was a success, and validated the approach for preservation and stabilization of integrated dry-laid stone and earth as presented in this report.

Interior of Redoubt No. 2 previous to demonstration project.
Note total collapses of stone ramparts and numerous areas of active erosion.
[D. Cubbison, September 2005]

Interior of Redoubt No. 2 following demonstration project.
Note stone used as “French Drains” around dry-laid stone wall.
[D. Cubbison, February 2006]



Detail, Interior of Redoubt No. 2, previous to demonstration project.
[D. Cubbison, September 2005]

Detail, Interior of Redoubt No. 2, following demonstration project.
[D. Cubbison, January 2006]


Stairs added to Interior of Redoubt No. 2, demonstration project.
[D. Cubbison, January 2006]

Use of Previously Lost Stone as “French Drain” in Redoubt No. 2 Demonstration Project
[D. Cubbison, January 2006]

Appendix D
Viewing Platform Design

<u>Introduction:</u>

Redoubts are stone, wood and earth fortifications built during the Revolutionary War time period. West Point Redoubts 1 and 2 were built as part of the network of defensive fortifications constructed on this post by the Continental Army. These landmarks are literally in the backyard of Stony II Housing residents. Since the construction of this housing, increased pedestrian traffic has caused serious erosion of the redoubts. Our mission was to design viewing platforms at each site to allow sight into the redoubts, as well as over the redoubts into gun fortifications on the far side of each redoubt. Hopefully, these platforms will lure pedestrians away from walking on the redoubts as they enjoy the stunning views of the Hudson River Valley. Additionally, the platforms will provide space on which to place signage telling the story of the redoubts and providing historic information on the area to the curious observer.

Assumptions:

During the design process, we made many assumptions.

1) The platforms would experience identical loading, thus we only designed Redoubt 2 and simply made Redoubt 1 have shorter column footers.
2) The footers would either tie into rock or soil, and we designed for both.
3) We would use Southern Pine, such as available at a local lumber yard.
4) Wind and snow loads would result from normal wind and snow conditions in this area of New York
5) Seismic loads would not be a factor.

Design Process:

a. Design Constraints.

Before we could begin a schematic design prototype for both platforms, we gathered as much information as possible on the redoubt locations and surroundings, intent of the project, and other pertinent information. We then analyzed and compiled constraints to our designs into four main categories: client, landscape / surroundings, cost, and constructability issues.

Mr. Cubbison, representing the Directorate of Housing and Public Works (DHPW), asked that we design both platforms entirely out of timber so that the structures blend in with the wooded surroundings and accent the redoubts' earth, rock, and timber original appearance. He also specified that the platforms must be tall enough to see into the redoubts, into the artillery fortifications in front of the redoubts, and also have a clear view of the opposite redoubt (see maps for locations of redoubts and artillery fortifications).

The layout and makeup of the landscape created more limitations to our design. Because of the sharp drop-offs in front and on the right sides of the redoubts as well as the locations of the trails leading up to the redoubts, the only reasonable location for both platforms is to the left side of both redoubts (see maps). However, since the artillery fortifications at both locations are approximately 25 feet lower than the redoubts themselves, the platforms have to be much taller than originally anticipated in order to see into both locations. Also, both suggested platform locations are situated on gently sloping rock shelves with little or no soil besides a thin organic layer. However, because we did not have funds to conduct a complete soil excavation (besides a quick recon / archaeological dig at each proposed footer location) the depth of the soil at each possible footer location could not be verified. For more information on how we remedied this problem see further discussion in the footer design process section.

Another constraint to our design was future possible sources of funding. Minimizing cost is always a priority; Mr. Cubbison is taking our designs and analysis and briefing USMA Association of Graduates (AOG) to possibly acquire funds necessary (approximately $11,000) to complete both platform project designs.

Constructability was one of the most important aspects of our design. The intent of our design is to have a cadet company or DHPW staff undertake both projects as some sort of community service project and be able to complete construction in a few weeks for each platform. To make the project as easy as possible to continue, it was necessary that we design members with readily available materials either already at the USMA lumber yard or easily purchased from a local Home Depot.

b. Schematic Design.

Once we determined our basic design constraints, we came up with schematic designs (without sizing any members or performing any loads analysis) for both platforms. The terrain at the redoubt 1 platform site (closest to Hudson river, see map) dictated that we create a total height of 15 feet above ground in order to see into both the redoubt and adjacent fortifications. The redoubt 2 platform site needed to be 19 feet for similar reasons. We determined both heights by standing on the top of a 10 foot ladder at both proposed locations and estimating the needed heights by moving the platform closer to (and therefore higher elevation and better angle) the redoubts and by visual estimation.

Mr. Cubbison suggested a 9 x 13 foot platform (not including stairs area) in order to accommodate approximately 20-25 spectators at any given time. We ended up enlarging this slightly to a 9 x 15 foot design for constructability purposes. We created a wood model to help visualize our platforms and to help us visually in order to work through constructability issues. See model pictures for schematic designs.

c. Design process – gravity loads.

Once we determined a schematic design for both platforms, we began the process of designing members first with gravity load analysis. For all loads analysis we decided to use the Load and Resistance Factor Design (LRFD) method since we have used this method the last three years in the CE department.

We determined the maximum live, dead, and snow loads (and later wind loads for lateral design) for our structure according to ASCE 7-02 codes:

Dead Loads (pcf)	Live Loads (psf)	Snow Loads (psf)	Wind Loads (psf)
36.7	100	31.8	22

See attached calculations for more information. We then combined these loads in different Load Case Combinations (LCC's) according to the LRFD methodology, factoring each load differently to determine a worst case combined loading. We then designed both platforms using top-down methodology to transfer these loads from our decking (or railing) to our beams, then girders, columns, footers, and finally soil or rock.

We first designed our beams (also known as wood joists) knowing that typical joist spacing is 16 inches from center. Using this as our maximum tributary area, we then designed our beams to withstand shear and moment forces across a 9 foot span since we decided to run our joists parallel to the 9 foot side of the 9'x15' deck. We then checked maximum deflection (to be smaller than L/360) and determined a typical beam size of 2x10 wood beams (nominal size). We then performed a point load analysis on the decking (2x6 members spanning 15 foot length) to withstand a 300 lb point load between beams. We then adjusted the exterior beams and center beams to fit within the 15 foot girder length (see model plan view or auto cad plan view).

Next, we designed our girders for shear, moment and checking deflection, knowing that 12 beams acted as point loads on our girders. We decided on 2 composite 2x12 members for each girder so that our girders framed our columns, allowed room for the railing posts to be bolted securely between the girders, and allowed us to bolt each 2x12 girder to the columns with one connection. We designed our joists to hang off the interior 2x12 girder member (see auto cad details) for easy constructability purposes. This created a potential problem however, because we calculated the girders to withstand our loads based on the girders acting completely in a composite manner. In reality, if the beams hang off only the interior girder and the girders are spaced apart 3.5 inches (size of columns, explained later), the interior girder supports more load than the exterior. In order to combat this we added spacers every 2 feet to bolt all the way through both girders and ensure more complete composite action between each girder system.

We designed our railing to support a 200 lb point load (according to ASCE 7-02 codes) with a 4x4 vertical member every 4 feet, along with 2x2 members every 3.25 inches (code minimum 4 in.), with a 2x4 base plate member and a vertical 2x4 member to resist maximum moments caused by people leaning on the rail (and causing moments in the railing system). Mr. Cubbison suggested that we do not cap the top of the railing system (a fairly typical design) since it would make it easier for people to sit on the railing and create a safety hazard.

We then designed our columns to support the loads transferred by the girders. Our largest loaded column was the middle column on the stairway side so we determined the maximum factored loads on that column and designed all columns to withstand the compressive forces caused by those factored loads.

After our column analysis we designed our footers for two different cases: bearing on rock and bearing on soil. Since we did not conduct a complete excavation of each site we were unable to verify that all columns would be bearing on rock (although this is likely what will happen when actually constructed). Therefore we created a first design for bearing on rock. For easy constructability purposes we used circular sonotubes to be filled with concrete (mixed on site by working crew). We estimated the largest angle the sonotubes would experience on the rock shelf as 30 degrees (conservative assumption) and designed steel to drill and anchor into the rock to withstand the maximum shear forces caused by the sloped rock support. We also designed this rock-embedded steel (see typical footer details) to withstand maximum shear forces transferred from our lateral bracing due to lateral wind loads (discussed in detail in lateral design process section). For our footer bearing on soil design (controlling design for diameter of footer), we analyzed the soil for bearing (withstanding max column compressive forces) with a settlement of less than .25 inches and determined a 2 foot diameter for all sonotubes. See lateral design process section for more information on resisting lateral loads. We used conservative values for soil calculations using Stony II soil data (gravelly loam soil) given to us by Mr. Cubbison. For both footer designs we then determined the minimum amount of longitudinal steel as well as horizontal steel ties required by ACI 318 code for temperature and shrinkage requirements for the concrete (see typical footer details).

d. Design process – lateral loads.

Once we sized our gravity members, we then designed both platforms to resist our maximum 22 psf wind load. We created 2 tiers of cross bracing for each column since our members would have been too long otherwise. This created a maximum unbraced length of all columns of 7.5 feet (which we used in our gravity analysis to size our columns using Euler's buckling equation). The most accurate way to estimate the lateral loads on our platforms due to winds would have been to sum the areas of all wooden members and multiply this by our maximum 22 psf lateral load. This is not reasonable and also does not account for wind not being able to fully penetrate the open regions in all the closely spaced 2x2 railing members (which increases the actual wind loads on the structure). Therefore we enveloped the lateral loads on our structure by treating our railings on top as solid vertical members resisting wind (3.5' high x 15' long) and multiplying this area by two to account for similar wind loadings on the stairway side of our structure. We modeled these wind loads as acting completely on top railing area, which is conservative because this adds additional moments to our structure (longer distance structure must resist lateral loads over; see hand calcs). We then split these forces to be supported evenly by both 9 foot side columns (worst case loaded members) and designed our lateral bracing to withstand these forces in compression. In reality the lateral bracing acting in tension will carry the vast majority of these lateral loads but we designed the bracing to withstand these loads in compression (more conservative), meaning the members would therefore support the same loads easily in tension. We also designed our lateral bracing to be connected in the center with spacers (see auto cad details elevations) since we had to place the bracing on opposite sides of the columns for constructability purposes and to ensure that we had concentric force systems. Our maximum lateral loads can be carried by 2x4 members in compression.

Once we designed our 2x4 lateral bracing we then determined the maximum shear forces transferred to the bottom of the column, baseplate, footer, and finally to either rock or soil. We also determined the maximum forces transferred to our column baseplate / footer connection due to overturning moments (which create tension in columns on one side and additional compressive forces on opposite side) and designed our connections and steel reinforcement (grouted into the rock for footer bearing on rock design) to withstand these additional forces. We calculated the maximum lateral earth pressure (passive pressure) to resist the shear forces transferred from the bracing down through the footers to ensure no significant horizontal settlement.

e. Design Process – connections.

We had MAJ James McDonald, a reserve officer and practicing structural engineer in California, help us determine practical ways to construct connections for our lateral bracing, girder and column design, stairs design etc. We attempted to minimize bulky connections by placing lateral bracing, vertical railing members etc. on both sides of our girders and columns, and bolting through all members to ensure one solid connection. See auto cad drawings for connection details.

f. Design Process – Stairs.

We designed our stairway according to suggested dimensions in the *Sunset* Deck book, as well as minimum stair widths and turn-around areas from BCI. We created three total turn-around areas in order to keep the stairway system contained within the 15 foot length of the deck and to create a more rigid design. We used the same minimum dead, live, and snow loads to size the girders (2x12 members), which we cut to allow the rise and tread members to bear directly on the girders. We designed our railing system for the stairs similarly to the deck railing system, with the vertical 2x2 and 4x4 members bolting directly into the girders and columns. See auto cad details for stair design for more information.

Results and Discussion:

The platforms are exceptionally high for the type of construction being done. However there are many advantages to our design. Our design is very safe, top rails are on edge to prevent people from sitting/climbing on them. The rails are also 42 inches tall, necessary because of the height of the platforms. With regard to serviceability, we have a very rigid design. The footers are designed to keep differential settlement at a minimum. We wanted to be able to design a structure that could be built by cadets as a community service project. Thus we have similar member sizes and dimensions and connections are simple and uniform, which should minimize errors in construction. Our design is aesthetically pleasing, timber design blends into surroundings and accents original rock and timber redoubt design.

There are also several disadvantages. The lateral bracing is connections are somewhat complicated and difficult but necessary. Timber design does not have an extremely long life span and requires more maintenance, having a lower strength over time. Weathering of stairs, rails, column at the base plate will drive maintenance costs up. We also did only an incomplete soil analysis due to our inability to completely excavate and explore the site. We have 2 different footer designs, that builders must choose from when they do a complete excavation.

Listed on the next page is a table of member sizes and costs.

Member Costs and Sizes

Member	Size / Type	Cost ($/ft)	Length (ft)	Total Cost per member	# members	Total Cost
Decking	2x6	$1.24	15	$18.60	55	$1,023.00
Joists	2x10	$2.08	10	$20.80	14	$291.20
Girders	2x12	$3.74	15	$56.10	4	$224.40
Columns	4x4	$0.41	15	$6.15	14	$86.10
Footers - sonotube	2 ft. diameter sonotubes	$1.00	4	$4.00	14	$56.00
Footers - long. Reinforcement	#9 bars (English)	$2.74	4	$10.96	84	$920.64
Footers - steel ties, rock imbedment	#3 bars (English)	$2.07	6	$12.42	4	$49.68
Footers - Concrete Mix	25 ksi strength	$15.00	4	$60.00	14	$840.00
Railing - large vert. posts	4x4	$0.41	4	$1.64	20	$32.80
Railing - small vert. posts	1x1	$1.05	4	$4.20	120	$504.00
Railing - floorboard / top horiz.	2x4	$0.93	15	$13.95	8	$111.60
Stairs - girders	2x12	$3.74	10	$37.40	6	$224.40
Stairs - beams	2x4	$0.93	3.5	$3.26	90	$292.95
Joist Hangers	54	$0.69	1	$0.69	54	$37.26
Column Baseplates	CBSQ44	$8.00	1	$8.00	14	$112.00
Bolts	7/8inx10in	$2.50	1	$2.50	70	$175.00
Washers	7/8in	$0.21	1	$0.21	140	$29.40
Nuts	7/8in	$0.19	1	$0.19	70	$13.30
Nails (50lb unit)	16D	$100.00	1	$100.00	2	$200.00
Screws (100/box)	#8x3in	$4.48	1	$4.48	17	$76.16
					Total Cost Per Platform:	$5,299.89
					Total Cost Materials:	$10,599.78

Conclusions:

These platforms must be constructed with great care in order to ensure they are safe and usable. If they are constructed they will accomplish the stated mission of guiding pedestrians away from the redoubts in order to enjoy the surrounding views as well as the view into the redoubt. We recommend that these platforms be constructed and appropriate signage placed on them to greatly enhance the worth of the sites to all interested viewers and historians. Total estimated cost is about $11,000.00 Total estimated labor hours to construct is two weeks per platform for a cadet company and two skilled laborers.

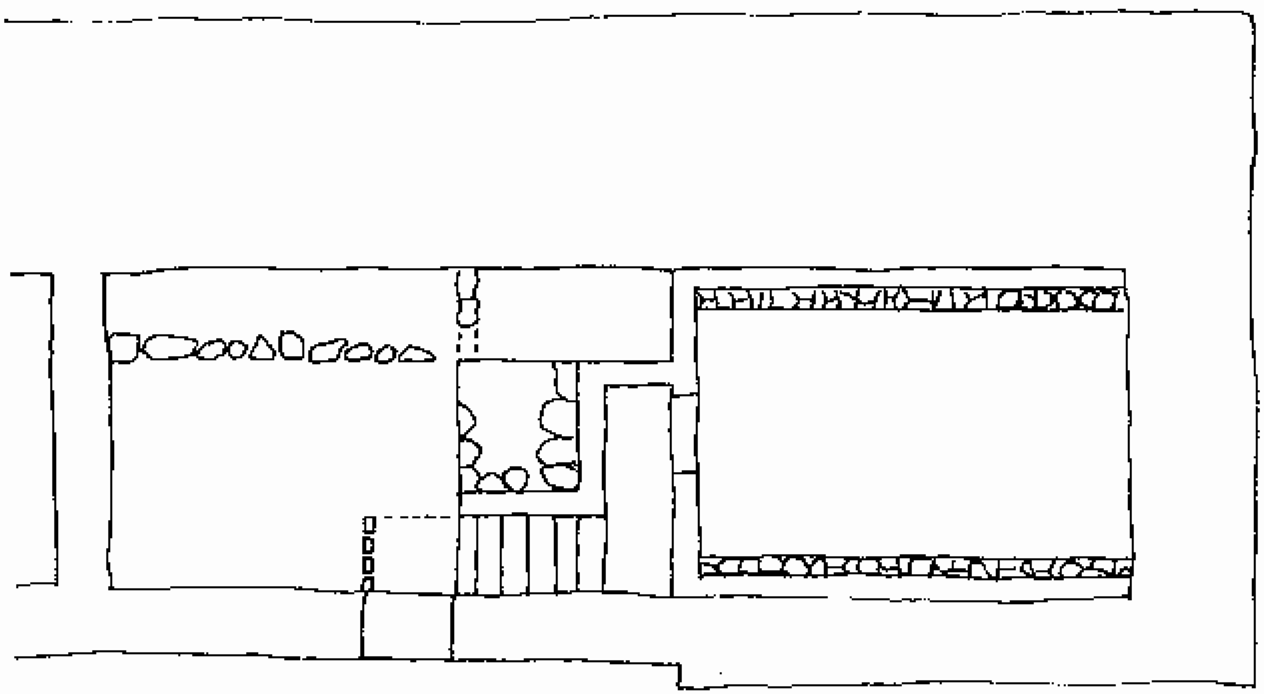
Appendix E
Romans Magazine Protective Roof Design

ROMANS BATTERY

EXISTING SITE PLAN

NOTES:

- HISTORIC BATTERY SITE (UNDER CURRENT CONDITIONS SUBJECT TO FULL EXPOSURE TO THE ELEMENTS INCL. WATER RUN-OFF FROM HIGHER ELEVATION POINTS.
- PROPOSAL FOR OPEN STRUCTURE TO PROTECT BATTERY RUINS FROM ADVERSE CONDITIONS.



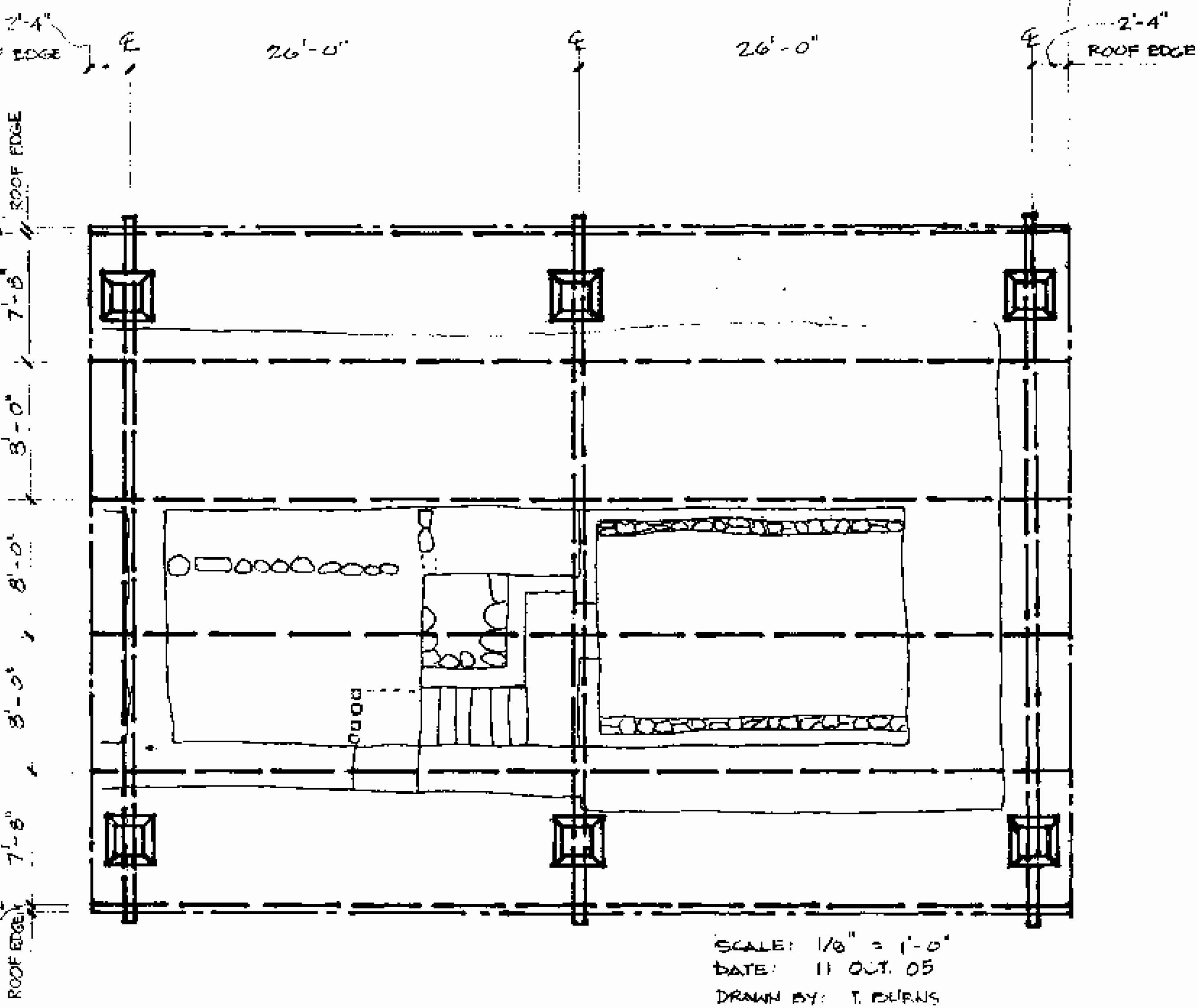
SCALE: 1/8" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

ROMANS BATTERY

ROOF STRUCTURE FRAMING

NOTES:

- CONC. COLUMN W/ RE BARS & 4 ANCHOR BOLTS AT TOP TO RECEIVE BEAM BASE PLATE.
- CONCRETE COL. TO BE TAPERED AT TOP (3' SQ. BASE - 2' SQ. TOP)
- CONC. COL. TO HAVE STONE VENEER 6" BELOW GRADE TO 8" EXPOSED TOP (SEE COLUMN DETAIL).
- MAIN BEAMS (3) CLEARSPAN 32' W/ 4'-6" OVERHANG EA. END (TOTAL LENGTH 41'-0") GLU LAM BEAM
- SECONDARY BEAMS (12-TOTAL) W/ 26' CLEARSPAN & 2'-0" OVERHANG @ OUTER END. AT CENTER MAIN BM. SECONDARY GLU LAM BM. TO BE LAP JOINTED 18" L.



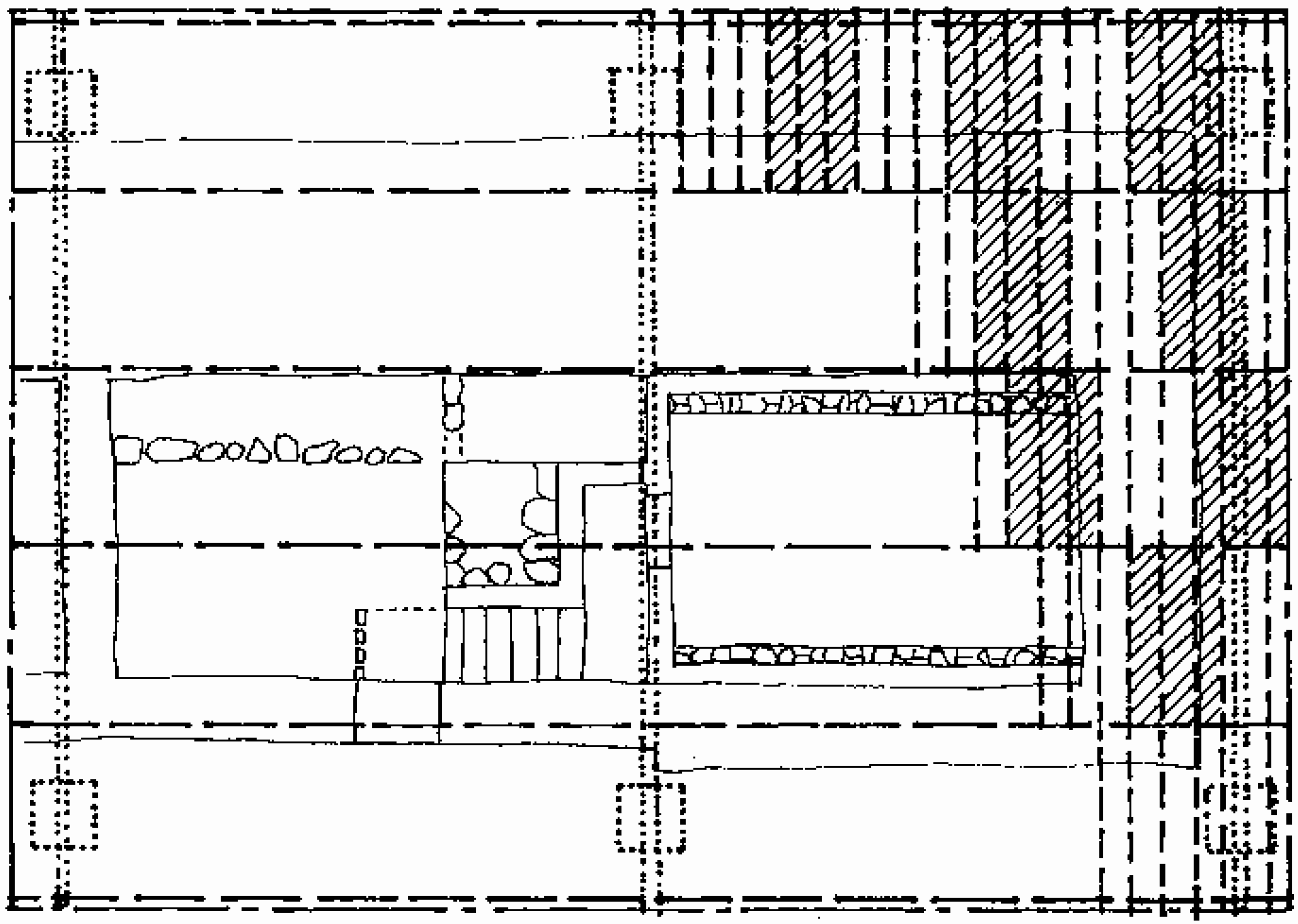
SCALE: 1/8" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

ROMANS BATTERY

ROOF SHEATHING PLAN

NOTES:

- DIAGONAL HATCHED AREA IS 4 × 8 × 3/4 T & G PLYWD. SHEATHING - TO BE INSTALLED IN A STAGGERED PATTERN
- SHEATHING FASTENED W/ 3" SS SCREWS TO 2×6 JOISTS @ 8" OC. (TYP.)



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

DATE: 11 OCT. 05

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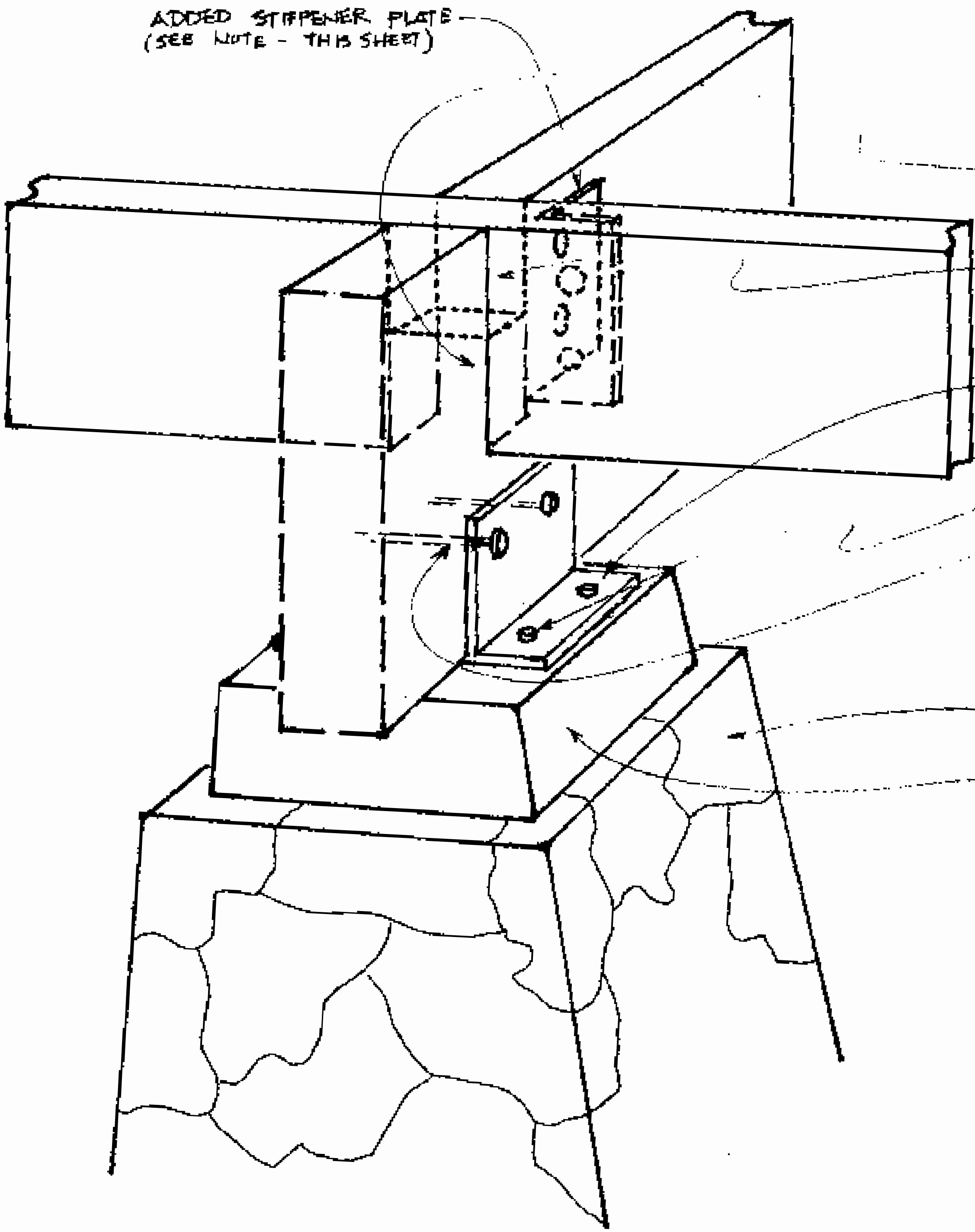


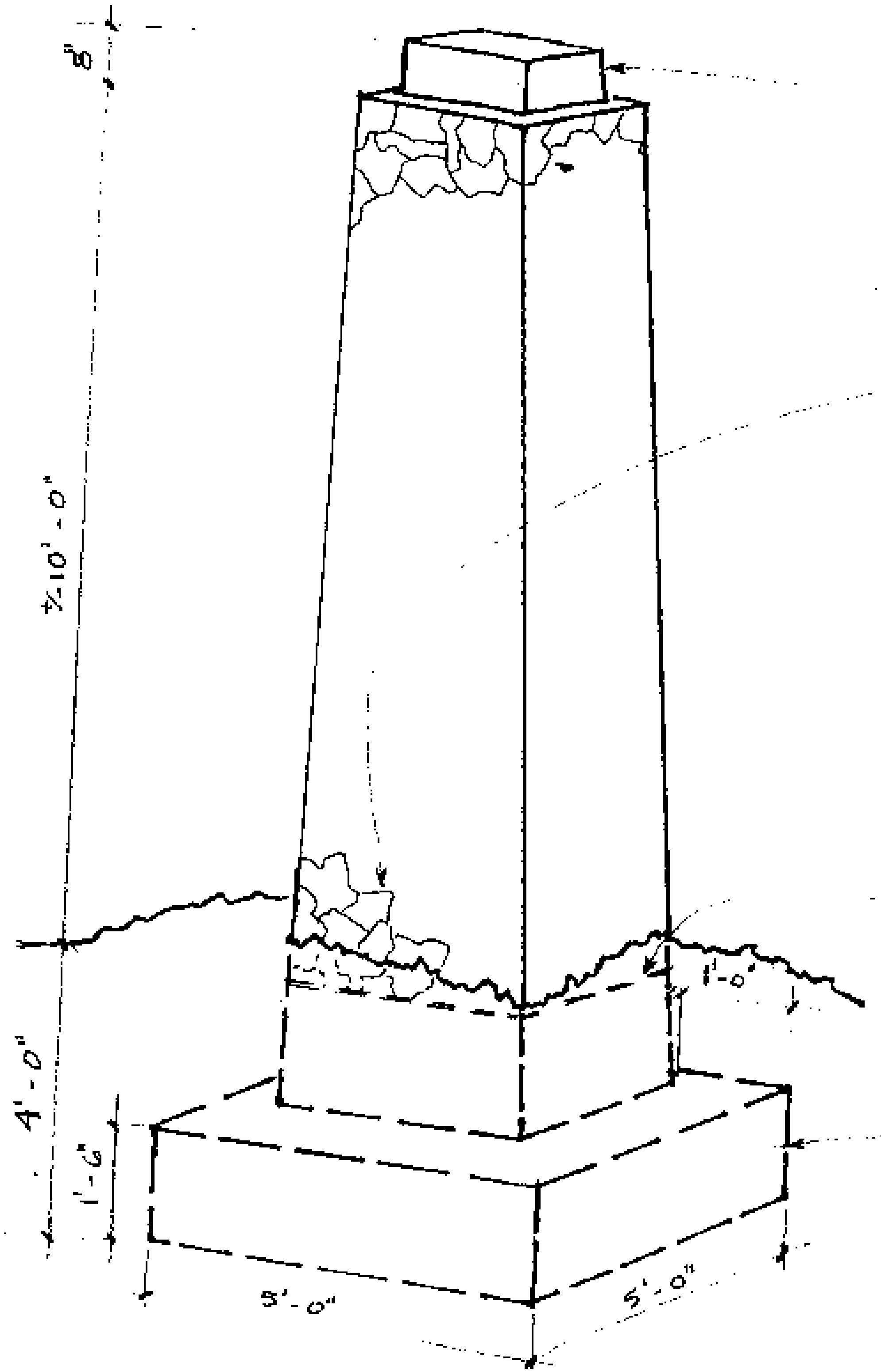
ROMANS BATTERY

DETAILS - MAIN BEAM & COL.
#2 CONNECTION

NOTES

- SECONDARY BEAM (+/- 6½" x 16") GLUE-LAM NOTCHED ONE HALF BEAM DEPTH (+/- 8").
- MAIN BEAM (+/- 8½" x 32") GLU-LAM NOTCHED +/- 8" TO RECEIVE SECONDARY BEAM (TYP. @ OUTER EDGES OF SECONDARY BEAM).
- BASE PLATE CUSTOM FABRICATED. (BEAM SITS DIRECTLY ON PLATE - NO CONTACT W/ CONCRETE.
- FASTEN BASE PLATE TO 4 ANCHOR BOLTS IMBEDDED IN CONC. COL.
- THRU BOLTS AT PLATE - BOTH SIDES OF MAIN BEAM
- STONE VENEER (+/- 3") OVER TAPERED CONC. COL. W/ 8" EXPOSED CONC AT TOP OF PIER.
- ALL PLATES CUSTOM FABR. (SIZE, THICKNESS & CONFIGURATION) AS PER MANUF. SPECS - TYP.
- ADDED STIFFENER PLATE (TYP. AT ALL 4 INTERNAL CORNERS OF CORNER PIERS & ONE STIFFENER PL. AT ONE OF TWO INT. CORNERS AT MID-SPAN PIERS), W/ THRU BOLTS GALV OR SS, AS PER MANUF. SPECS/ RECOM. (SEE ALSO DETAIL #3)

SCALE: 1" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS



ROMANS BATTERY

DETAILS - COLUMN PIER & FOOTING
#1

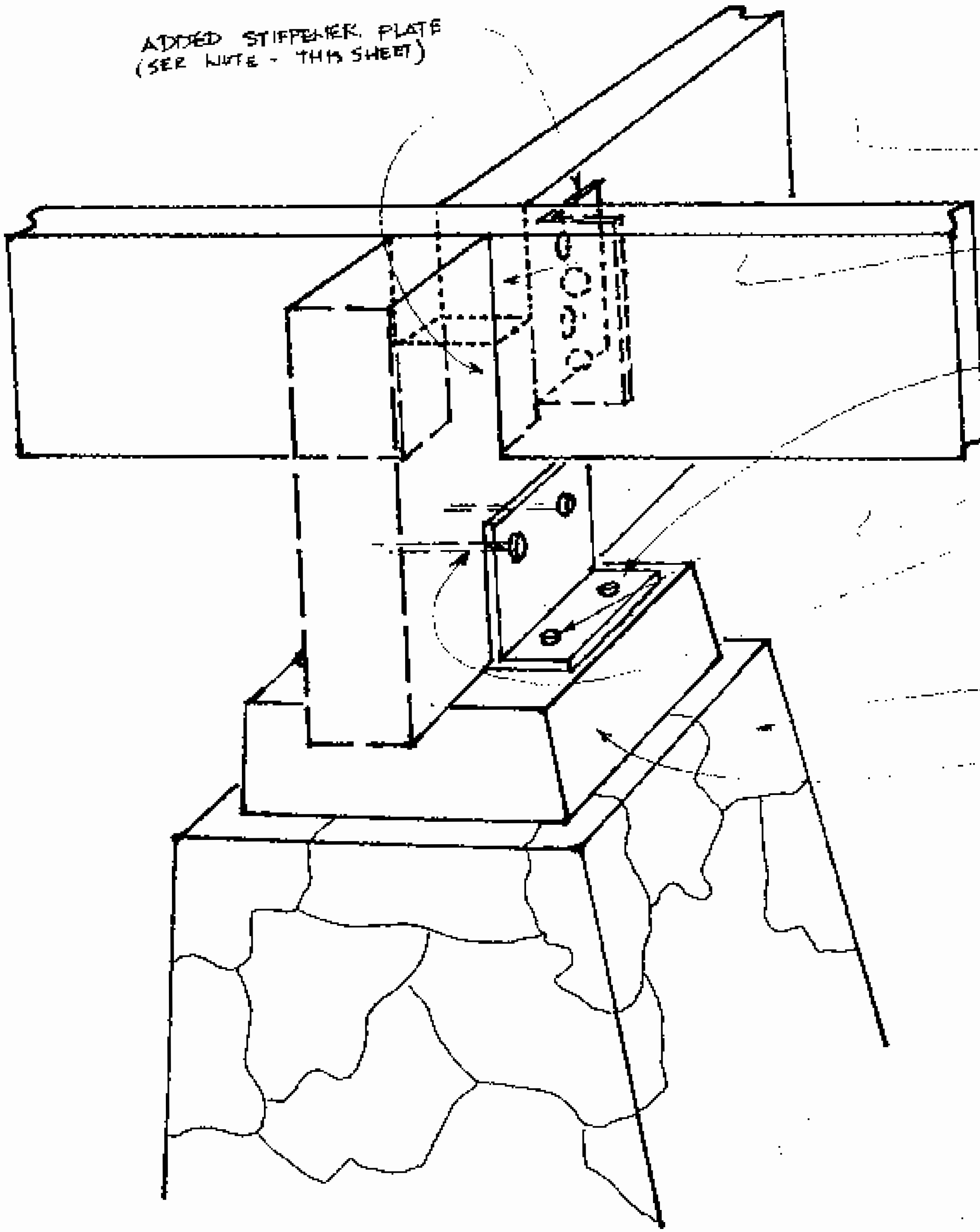
NOTES

- PROTRUDING CONC. CAP AT TOP OF COL.
- STONE VENEER TO APPROX. 6" BELOW GRADE TO BUILT IN SILL EDGE
- BUILT IN SILL EDGE (+/- 1½") TO RECEIVE STONE VENEER
- MONOLITHIC CONC. FOOTING (5'x5'x1'-6"DP W/ RE-BARS)

SCALE: 1/2" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

ROMANS BATTERY

DETAILS #2 - MAIN BEAM & COL. CONNECTION



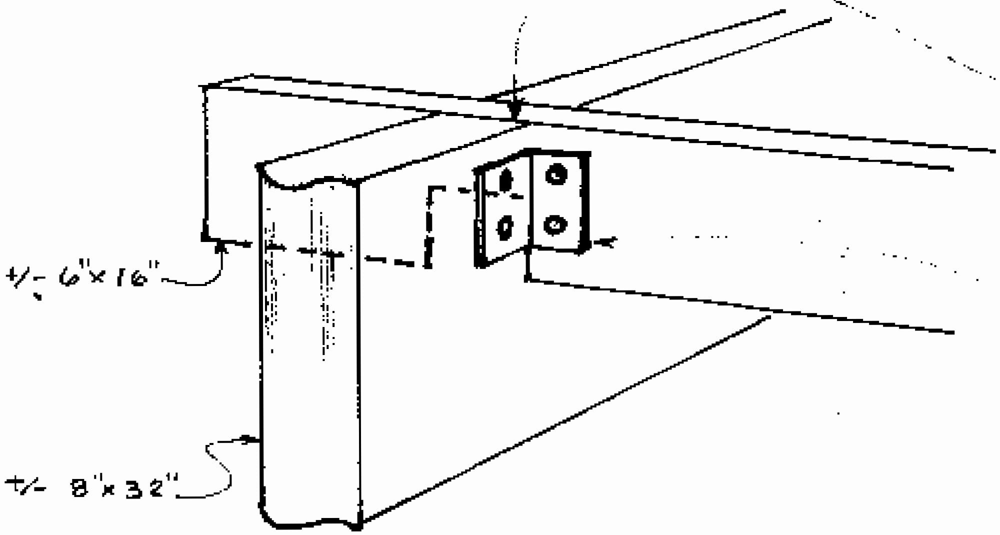
NOTES

- SECONDARY BEAM (+/- 6½" x 16") GLUE-LAM NOTCHED ONE HALF BEAM DEPTH (+/- 8").
- MAIN BEAM (+/- 8½" x 32") GLU-LAM NOTCHED +/- 8" TO RECEIVE SECONDARY BEAM (TYP @ OUTER EDGES OF SECONDARY BEAM).
- BASE PLATE CUSTOM FABRICATED (BEAM SITS DIRECTLY ON PLATE - NO CONTACT W/ CONCRETE.
- FASTEN BASE PLATE TO 4 ANCHOR BOLTS IMBEDDED IN CONC. COL.
- THRU BOLTS AT PLATE - BOTH SIDES OF MAIN BEAM
- STONE VENEER (+/- 3") OVER TAPERE CONC. COL. W/ 8" EXPOSED CONC. AT TOP OF PIER.
- ALL PLATES CUSTOM FABR. (SIZE, THICKNESS & CONFIGURATION) AS PER MANUF. SPECS - TYP.
- ADDED STIFFENER PLATE (TYP. AT ALL 4 INTERNAL CORNERS OF CORNER PIERS & ONE STIFFENER PL AT ONE OF TWO INT. CORNERS AT MID-SPAN PIERS), W/ THRU BOLTS GALV OR SS, AS PER MANUF. SPECS/ RECOM. (SEE ALSO DETAIL #3)

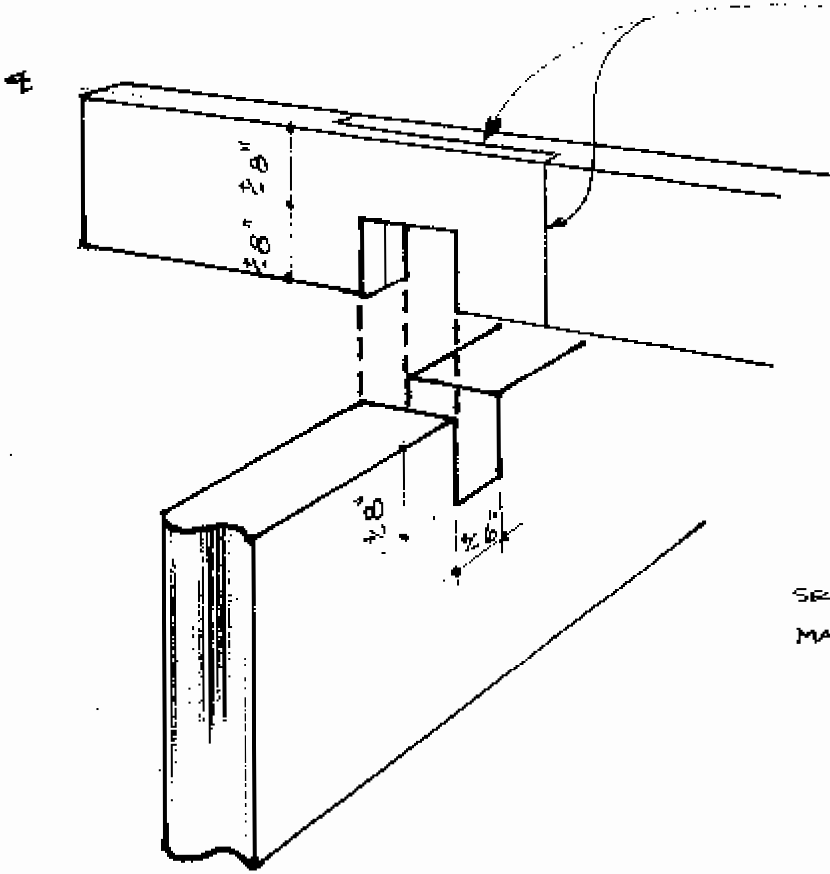
SCALE: 1" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

ROMANS BATTERY

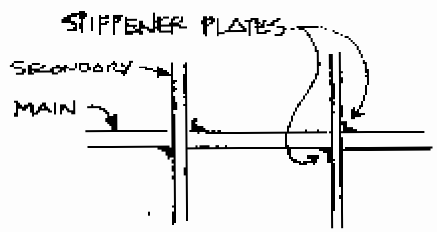
DETAILS - MAIN & SECONDARY BEAMS
#3 CONNECTION



- NOTCHED MAIN & SECONDARY BEAMS IN PLACE
- MANUF. CUSTOM MADE STIFFENER PLATES W/ THRU BOLTS AT ALL OUTER EDGE CONDITIONS
- NOTE: SEE PLANS FOR TYP. BEAM OVERHANGS.
  MAIN BEAM = 4'-6" OH FROM ℄ OF PIER
  SECONDARY BM. = 2'-0" OH FROM ℄ OF MAIN BEAM



- AT MIDDLE MAIN BEAM - SECONDARY BEAMS TO BE SPLICED (POSSIBLY OVERLAPPED) AS PER GLU-LAM MANUF. (NOTE: THIS CONDITION EXISTS ONLY AT CENTER MAIN BEAM W/ SECONDARY BEAM CONNECTION
- ILLUSTRATION INDICATES NOTCHED MAIN & SECONDARY BEAMS (PRIOR TO ASSEMBLY) FOR A COMMON TOP CHORD SURFACE.
  NOTE: TWO FOLD RESULTS - SHALLOW DEPTH OF ROOF STRUCTURE & ELIMINATES POTENTIAL BIRD NESTING AREAS.

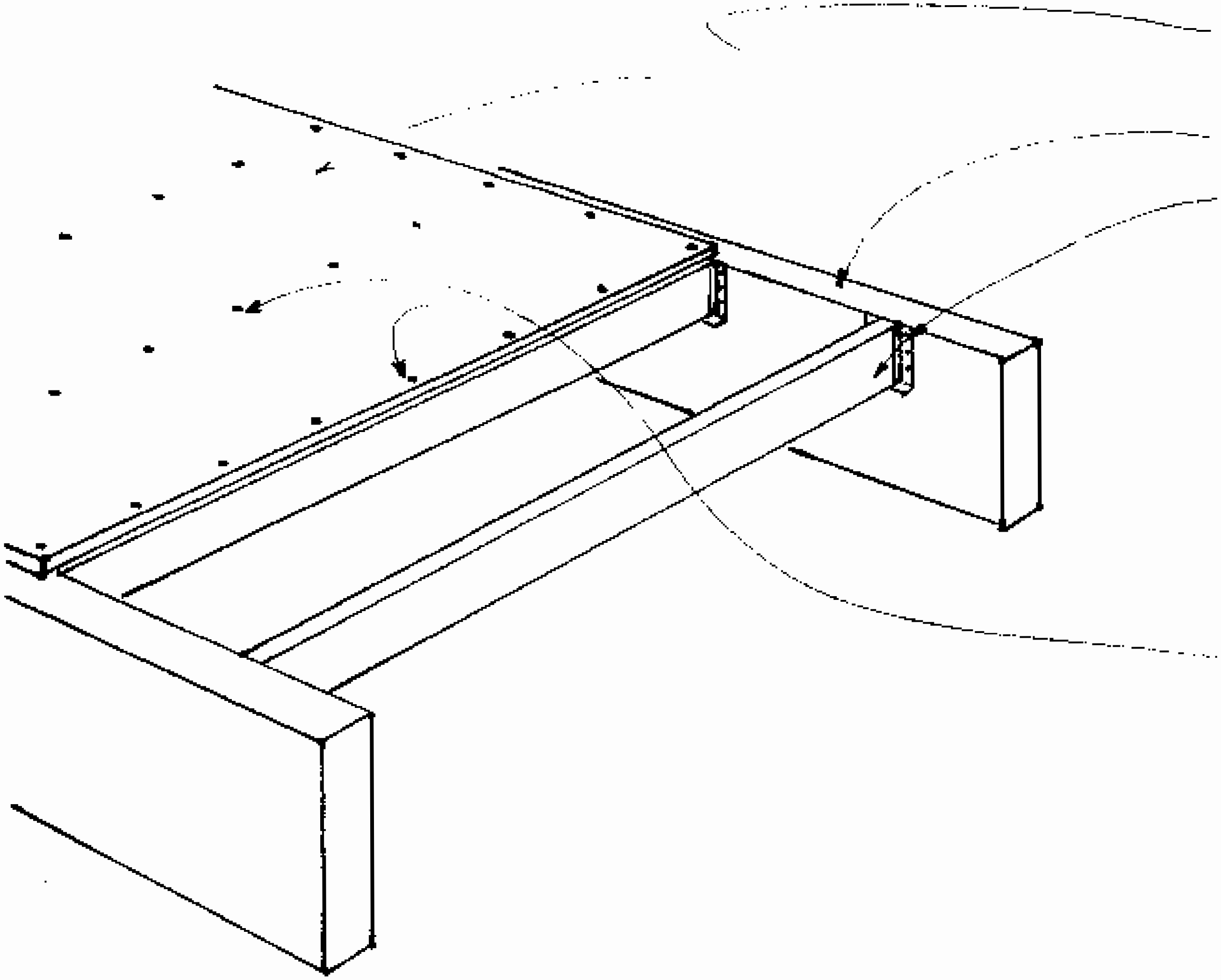


PLAN - NO SCALE

SCALE: 3/4" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

ROMANS BATTERY

DETAILS - ROOF SHEATHING & SUB FRAME
#4

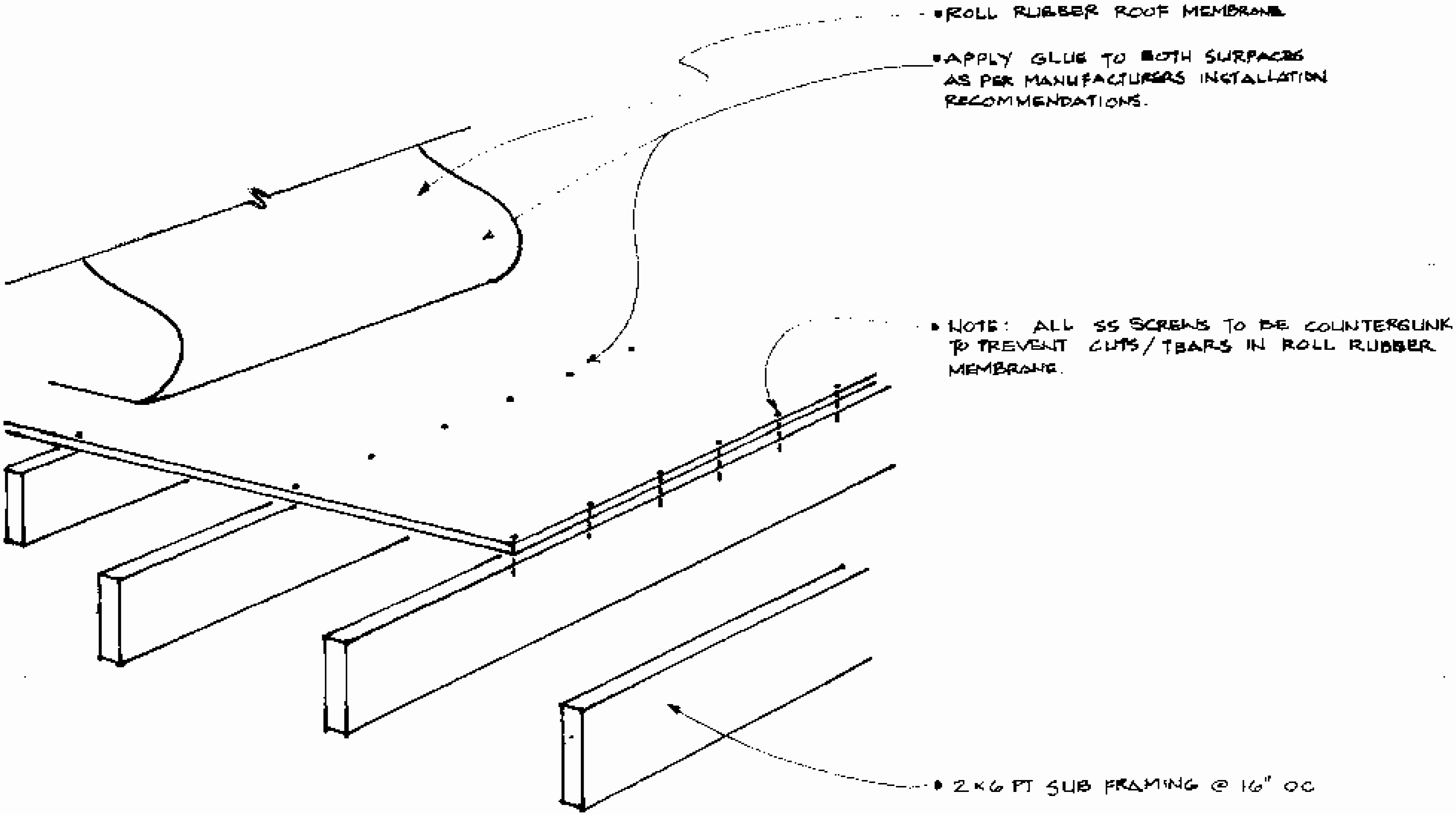


- 4 x 8 x 3/4 T&G PLYWD. FASTENED TO JOISTS/ BEAMS W/ 2 1/2" x 1/4" S.S. SCREWS MAX 8" APART
- SECONDARY BEAM (6" x 16' GLU-LAM)
- 2 x 6 x 8 PT FRAMING CUT TO FIT W/ STD. GALV. 2x6 JOIST HANGERS, USING 12 D x 3" GALV. NAILS - TOE IN AT HANGERS
- NOTE: STAINLESS STEEL SCREWS (3"L) TO BE USED TO FASTEN PLYWD. ROOF SHEATHING TO SUB FRAME JOISTS & SECONDARY BEAMS AT MAX 9" OC (TYP.) ALL SS SCREWS TO BE COUNTERSUNK - SEE DETAIL #5

SCALE: 3/4" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

ROMANS BATTERY

DETAILS – ROOFING MEMBRANE INSTALLATION
#5



SCALE: 1 1/4" = 1'-0"
DATE: 11 OCT. 05
DRAWN BY: T. BURNS

Appendix F
Bibliography

Historic Construction Techniques

LeCointe, Jean Louis. *The Science of Military Posts; For the use of Regimental Officers, who Frequently Command Detached Parties, In which is Shown the Manner of Attacking and Defending Posts, With Cuts, Explaining the Construction of Field-Forts and Intrenchments*. London: Printed for T. Payne, at the Mews Gate, 1761. USMA Special Collections UG400.L4513.1761.

Lochlee, Lewis. *Elements of Field Fortification*. London: 1783. USMA Special Collections UG403.L8

Muller, John. *A Treatise Containing the Elementary Part of Fortification, Regular and Irregular*. London: J. Nourse, 1746.

Muller, John. *A Treatise Containing The Practical Art of a Fortification, In Four Parts*. London; J. Millan, 1755.

Pleydell, Lieutenant J.C. *An Essay on Field Fortification: Intended Principally for the use of Officers of Infantry, showing how to trace out on the ground and construct in the easiest manner, all sorts of Redoubts and other field works, translated from the original manuscript of an officer of experience in the Prussian Service*. London: Printed for F. Wingrave, 1790. USMA Special Collections UG400.E77.1790.

Young, Sir James. *An Essay on the Command of Small Detachments*. London: 1766. USMA Special Collections UB210 .E83 1766.

Historic Reports

Brookshire, Captain Jerry H. "Preservation/Stabilization of Constitution Island Ruins." Constitution Island Association Papers. Archives and Special Collections, USMA Library, West Point, New York.

John Milner Associates, Inc. *Preservation, Interpretation and Resource Management Plan for Fort Griswold, Fort Griswold Battlefield State Park, Groton, Connecticut.* Hartford, Connecticut: State Parks Division, Department of Environmental Protection, 1999.

Harrington, J.C. and Virginia S. *Excavation of The Powder Magazine, Romans' Battery, Constitution Island.* West Point, New York: The West Point Fund, United States Military Academy, 1973.

Harrington, J.C. "Romans' Battery: Early Revolutionary War Fortification." *Pennsylvania Arhaeologist* 49, no. 3 (September 1979), 31-41.

Jelks, Edward B. "Recommendations for Stabilizing 18th Century Ruins on Constitution Island." Constitution Island Association Papers. Archives and Special Collections, USMA Library, West Point, New York.

John Milner Associates, Inc. *Preservation Plan, Redoubts No. 1 and 2 at the Stony Lonesome II Housing Facility, United States Military Academy, West Point, Orange County, New York*. U.S. Army Corps of Engineers, New York District: 1996. Copy with DHPW, USMA.

LANDSCAPES. *West Point Military Academy Revolutionary War Earthworks Conditions Assessments and Recommendations*. U.S. Army Corps of Engineers; New York District, n.d. Copy with DHPW, USMA.

Pan-American Consultants, Inc. *Maintenance Plan for Redoubts Nos. 1 and 2 and their Associated Batteries, U.S. Military Academy at West Point, Orange County, New York*. West Point, New York: U.S. Military Academy, May 2003. Copy at DHPW, USMA.

Coast Defense- General

Baldwin, Thomas Williams, Editor. *The Revolutionary Journal of Colonel Jeduthan Baldwin, 1775-1778.* Bangor: Printed for the DeBurians, 1906.

Bolton, Reginald P. *Fort Washington, An Account of the Identification of the Site…with a History of the Defense and Reduction of Mount Washington.* New York: Empire State Society of The Sons of the American Revolution, 1902.

Brackenridge, Hugh M. "The Siege of Fort Mifflin." *Pennsylvania Magazine of History and Biography* XI, No. 1 (1887), 82-88.

Bruchey, Stuart R. and Eleanor S. Bruchey. "A Brief History of Commercial Banking in the Old Line State" in *Money and Banking in Maryland.* Baltimore, Maryland: Maryland Historical Society, 1996.

Calef, Colonel John H, Editor. "Extracts from the Diary of a Revolutionary Patriot." *Journal of the Military Service Institution of the United States* 39 (July-August 1906), 123-130.

Clary, David A. *Fortress America, The Corps of Engineers, Hampton Roads, and United States Coastal Defense.* Charlottesville, Virginia: University Press of Virginia, 1990.

Coast Defense Study Group Press, "Conference Notes for the 17th Annual Conference of the Coast Defense Study Group, The Harbor Defenses of Chesapeake Bay, October 18-22, 2000." Bel Air, Maryland: Coast Defense Study Group Press.

Cubbison, Douglas R. "Historic Structures Report- The Redoubts of West Point." West Point, New York: Directorate of Housing and Public Works, U.S. Military Academy, January 2004.

Cubbison, Douglas R. “Historic Structures Report- The Hudson River Defenses at Fortress West Point, 1778-1783.” West Point, New York: Directorate of Housing and Public Works, U.S. Military Academy, January 2005.

Diament, Lincoln. *Bernard Romans, Forgotten Patriot of the American Revolution.* Harrison, New York: Harbor Hill Books, 1985.

DuCoudray. “Du Coudray’s Observations on the Forts Intended for the Defense of the Two Passages of the River Delaware, July 1777.” *Pennsylvania Magazine of History and Biography* XXIV, No. 3 (1900), 343-347.

Floyd, Dale E. *Defending America's Coasts, 1775-1950 : a Bibliography.* Alexandria, Virginia: Office of History, U.S. Army Corps of Engineers, 1997.

Frost, Robert I. *The Northern Wars, 1558-1721*. Essex, England: Pearson Education Limited, 2000.

Gatchel, Theodore L. “The Rock on Which the Storm Will Beat: Fort Adams and the Defenses of Narranganset Bay.” *Newport History* 67 (Summer 1995), 1-36.

Jones, Gilbert S. *Valley Forge Park, An Historical Record and Guide Book.* Valley Forge Park Commission: 1947.

Kajencki, Francis Casimir. *Thaddeus Kosciuszko, Military Engineer of the American Revolution.* El Paso, Texas: Southwest Polonia Press, 1998.

Ketchum, Richard M. *Decisive Day, The Battle for Bunker Hill*. Garden City, New York: Doubleday and Company, 1974.

Lawry, Nelson W. “Foundations for the Endicott System: A Question of Cement.” *Coast Defense Study Group News* 5, no. 1 (February 1991), 11-14.

Lewis, Emanuel. *Seacoast Fortifications of the United States- An Introductory History*. Annapolis, Maryland: 1979.

Mahan, Professor Dennis Hart. *An Elementary Course of Military Engineering* or *Summary of the Course of Permanent Fortification and of the Attack and Defence of Permanent Works: for the Use of the Cadets of the U.S. Military.* Volume 1 of 2. New York: J. Wiley, 1862.

Miller, Charles E., Jr., Donald V. Lockey and Joseph Visconti, Jr. *Highland Fortress, The Fortification of West Point During the American Revolution, 1775-1783.* West Point, New York: Department of History, U.S. Military Academy, 1979.

Musicant, Ivan. *Empire by Default, The Spanish-American War and the Dawn of the American Century*. New York: Henry Holt and Company, 1998.

Newport Historical Society. "Historical Preservation Award Recipients, 2004 Award Winners." accessed on-line at http://newporthistorical.org/historic3.htm on August 29, 2005.

"Orderly Book, West Point Garrison, July-August 1779 and August- December 1779." WPA Transcript, Special Collections and Archives, U.S. Military Academy Library, West Point, New York.

Palmer, Dave R. *The River and the Rock.* New York: Greenwood Publishing Corporation, 1969.

Price, Russell Reed. *American Coastal Defense: the Third System of Fortification, 1816-1864***.** Thesis (Ph. D.)--Mississippi State University, 1999.

Ranson, Edward. "The Endicott Board of 1885-1886 and the Coast Defenses." *Military Affairs* XXXI, No. 2 (Summer 1967), 74-84.

Records of the Office of the Chief Engineer, U.S. Army, Record Group 77. National Archives and Records Administration II, College Park, Maryland.

Riling, Joseph R. *The Art and Science of War in America, A Bibliography of American Military Imprints, 1690-1800.* Alexandria Bay, New York: Museum Restoration Service, 1990.

Sheffield, Merle G. *The Fort That Never Was, A Discussion of the Revolutionary War Fortifications Built on Constitution Island, 1775-1783*. West Point, New York: Constitution Island Association, 1969.

Sizer, Theodore, Editor. *The Autobiography of Colonel John Trumbull, Patriot-Artist, 1756-1843.* 1841: reprint edition New Haven: Yale University Press, 1953.

Smith, Samuel S. *Fight for the Delaware, 1777.* Monmouth Beach, New Jersey: Philip Freneau Press, 1970.

Snell, Charles W. *A Brief General History of the Construction of the Endicott System of Seacoast Defenses in the Continental United States, 1885-1912*. Denver, Colorado: National Park Service, 1975.

Sprock, Phyllis, Ecologist, Fort Monroe. "Memorandum For Record: Casemate Drainage System." Fort Monroe, Virginia: March 6, 1981.

Stanley, John Henry. *Preliminary Investigation of Military Manuals of American Imprint Prior to 1800.* M.A. Thesis: Brown University, 1964.

"The War of 1812 Extracted from American Military History, Army Historical Series, Office of the Chief of Military History, United States Army" accessed on-line at http://www.army.mil/cmh-pg/books/amh/amh-06.html on August 31, 2005.

United States Board on Fortifications or Other Defenses (Endicott Board). *Report of the Board on Fortifications or Other Defenses appointed by the President of the United States under the provisions of the act of Congress approved March 3, 1885* **.** Washington, Govt. Print. Office: 1886.

United States Engineers Office. *Emplacement for 3 Twelve Inch Guns, Notes & Instructions for Garrison in Caring for the Drainage System etc. at these Emplacements.* Norfolk, Virginia: U.S. Engineers Office, 1901.

Wade, Arthur Pearson. *Artillerists and Engineers: The Beginnings of American Seacoast Fortifications, 1794-1815***.** Manhattan, Kansas: Kansas State University, 1977.

Ward, Christopher. *The War of the Revolution.* 2 volumes. New York: The Macmillan Company, 1952.

Winslow, Major Eben E. *Lectures on Seacoast Defense, Number 35 Occasional Papers, Engineer School, U.S. Army.* Washington Barracks, District of Columbia: Press of the Engineer School, 1909.

Winslow, Col. Eben E. *Notes on Seacoast Fortification Construction*. Number 61 Occasional Papers Engineer School United States Army. Washington D.C.: Government Printing Office, 1920.

Earthworks Management

American Battlefield Protection Program, National Park Service. "Sustainable Military Earthworks Management." Accessed on-line at http://www.cr.nps.gov/hps/hli/currents/earthworks/index.htm on April 18, 2005.

Azola, Anthony. *The Effect of Management on Erosion of Civil War Battlefield Earthworks*. Virginia Polytechnic Institute; M.S. Thesis, February 2001.

Eyring, Shaun and Lucky Lawliss. "Preserving Battlefield Terrain: Technologies for Earthworks Management." *Association for Preservation Technology Bulletin* XXXI, no. 4 (2000), 13-20.

Johnson, Dr. James. E. *Managing Earthworks Under Forest Cover*. Washington, D.C.: National Park Service, U.S. Department of the Interior, 1998.

National Park Service, U.S. Department of the Interior. *Earthworks Landscape Management Manual*. DRAFT. Washington, D.C.: 1989.

Petersburg National Battlefield Park. *Environmental Assessment for the Preservation of Civil War Earthen Fortifications at Petersburg National Battlefield*. Petersburg, Virginia: National Park Service, U.S. Department of the Interior, 2001.

Dry –Stacked Stone

Editors of Readers Digest. *Back to Basics, How to Learn and Enjoy Traditional American Skills*. Pleasantville, New York: The Readers Digest Association, 1981.

Murray-Wooley, Carolyn. “The Stone Age, Still With Us, Dry Stone Masonry in the United States.” *Stonexus* (Summer 2001).

Murray-Wooley, Carolyn and Richard Tufnell. “The DRY Stone Age- The Dry Stone Conservancy Promotes An Ancient Craft.” *Cultural Resources Management Magazine* No. 12 (1997).

Wooley, Jane M. “The Logic of Stone, An Advocate Looks at the Benefits of Dry Stone Masonry.” *Stonexus* (Summer 2001).

Brick Masonry

McKee, Harley J. *Introduction to Early American Masonry.* Washington D.C.: National Trust for Historic Preservation and Columbia University, 1973.

Concrete

Pan-American Consultants, Inc. *Comprehensive Resource Inventory and Preservation Planning Study for World War II Cultural Resources at the United States Army Kwajalein Atoll.* Huntsville, Alabama: U.S. Army Space and Strategic Defense Command, 1994. DoD Legacy Project, 1992. Copy at DHPW, USMA.

Ashurst, John and Nicola. *Practical Building Conservation, vol. 4, Brick, Terracotta and Earth.* New York: Halsted Press, 1988.

Condit, Carl W. *American Building: Materials and Techniques from the Beginning of the Colonial Settlements to the Present.* Chicago: The University of Chicago Press, 1968.

Coney, William B. *Preservation Briefs No. 15: Preservation of Historic Concrete: Problems and General Approaches.* Washington, D.C.: National Park Service, Technical Preservation Services, 1987.

Friedman, Donald. *Historical Building Construction: Design, Materials and Technology.* New York: W.W. Norton and Company, 1995.

Friedman, Donald. *The Investigation of Buildings: A Guide for Architects, Engineers, and Owners.* New York: W.W. Norton and Company, 2000.

Jester, Thomas C. ed. *Twentieth Century Building Materials: History and Conservation.* Washington D.C.: National Park Service, 1995.

Park, Sharon C. *Preservation Briefs No. 31: Mothballing Historic Buildings.* Washington, D.C.: National Park Service, Technical Preservation Services, 1993.

Park, Sharon C. *Preservation Briefs No. 39: Holding the Line: Controlling Unwanted Moisture in Historic Buildings.* Washington, D.C.: National Park Service, Technical Preservation Services, 1996.

Sarnafil Corporation. "Sarnafil – World Class Roofing and Waterproofing." Accessed on-line at http://www.sarnafilus.com/ on August 29, 2005.

Appendix G
Monitoring Casemate 21 and Battery DeRussy

Appendix G: Monitoring Casemate 21 and Battery DeRussy

As part of this study, project team members sought to gather data on the environmental conditions of Battery DeRussy and Casemate 21 at Fort Monroe, Virginia.

Objectives

- Determine the level of moisture infiltration within the masonry walls of Battery DeRussy and Casemate 21.
- Obtain data on the climactic conditions of the building interiors.
- Provide a baseline for future studies.

Methodology

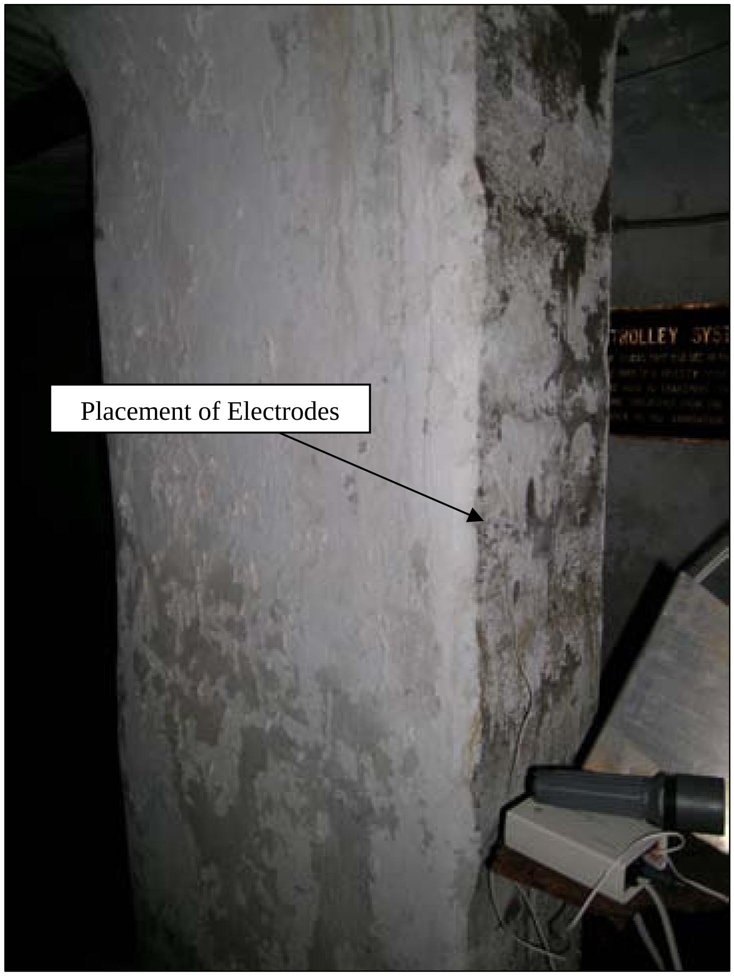
In order to gather data, project team members installed monitoring equipment in both Casemate 21 and Battery DeRussy. For this study, the Humilog System Model 4100 from General Electric was chosen. Each unit was calibrated and set to measure relative humidity, ambient temperature, dew point, and the wood moisture equivalent (WME) percentage of selected locations of the interior masonry walls. Dew point measures the temperature at which air would have to cool in order to reach a level of moisture saturation. When a temperature drops below the dew point, water vapors in the air will begin to condense. This can cause moisture to collect on wall surfaces, a situation that has the potential to cause degradation of building materials. The WME rating is the moisture level of wood when placed in equilibrium with the material being tested. WME levels provide a good indication of the amount of moisture within a masonry wall. These figures provide a baseline in the future to determine if any measures to reduce moisture within the structure are having a desired effect. The data recorders were placed in both Casemate 21 and Battery DeRussy on 3 August 2005. Ideally, leaving the recorders in the casemates for an entire year would provide better data. This would provide data on how seasonal changes affect the moisture levels within the building. Given time constraints however, we were only able to gather data for approximately four months.

The project team placed two Humilog data recorders in Casemate 21. This casemate currently serves as the home of the Post Chaplain’s Offices for Fort Monroe. The casemates now serve as classrooms, offices, and are also used to conduct religious services. They currently experience significant moisture infiltration problems during periods of intense precipitation. The problem is particularly noticeable in the casemate under the earthen rampart. Prior to the placement of the recorders, we took some general measurements of the moisture levels within the malls using a General Electric Survey Master Protimeter. This device is a handheld unit that gives building investigators a general idea as to the extant and location of moisture infiltration. The Protimeter features two modes, in search mode it simply detect levels of moisture beneath the surface of the material being tested. The result is given in relative terms and assigned a value of green, yellow and red. Green represents a relatively safe level of moisture, yellow represents a borderline condition and red indicates a significantly damp condition. Use of the unit indicated that moisture infiltration was significantly more pervasive on the earthen rampart side of the casemate. Generally, the readings taken on the terreplein side reflected safe or borderline moisture conditions. Nearly all of the preliminary readings taken on the rampart side reflected unsafe moisture levels. The data recorders were set to gather data at twelve-hour intervals, once at approximately noon and again at midnight. A data recorder was placed in both the casemate underneath the earthen rampart and the terreplein. Small holes were drilled into the mortar joints at both locations. Metal electrodes were placed into these holes, which were used to measure WME levels within the walls. The mortar joints were chosen rather than the masonry units themselves to prevent unnecessary damage to the interior walls.

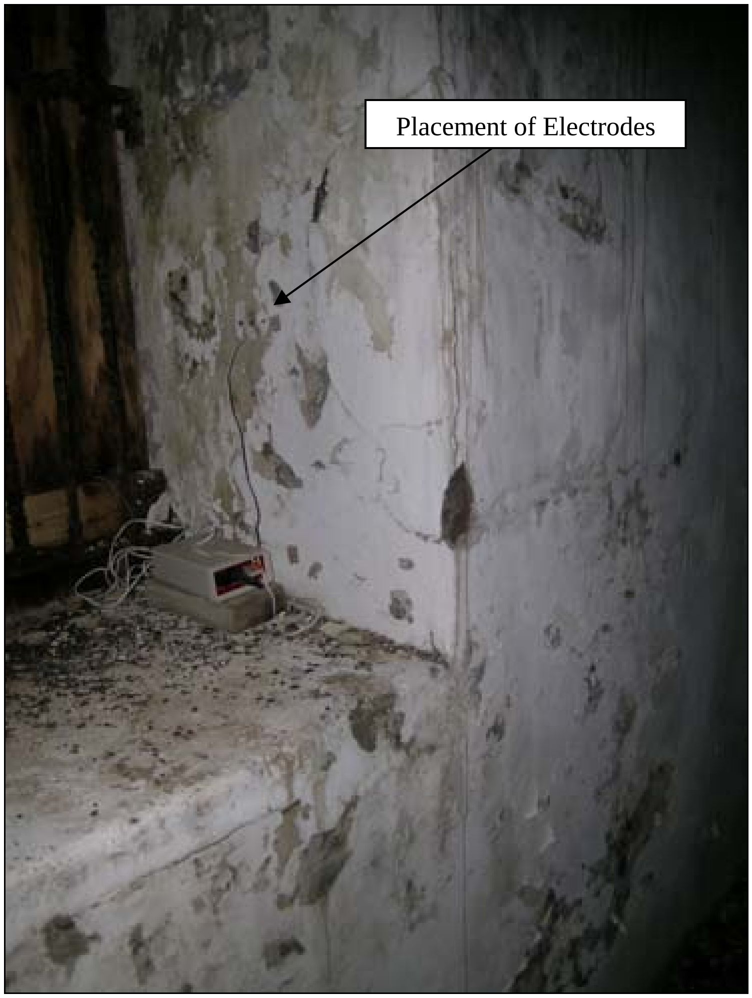
Photograph 1: Photograph of the placement of the GE Humilog System data recorder. This recorder measured data on the terreplein side of the casemate. The electrodes used to measure the WME are not visible in this photograph but they were placed in the mortar joints in the brick vault portion of the casemate.

Photograph 2: View of the data recorder placed on the earthen rampart side of the terreplein. The arrow indicates the location of the electrodes. These electrodes placed within the wall and measure WME levels within the masonry. In this location, the electrodes were placed within the mortar joint and not the masonry unit. This was done to prevent any unnecessary damage to the wall.

Data recorders were also placed in Battery DeRussy in two different locations. The first was located in an interior portion of the battery, in the area of the ammunition magazine. The second location was in the plotting room on one of the exterior walls. Prior to the placement of the data recorders we took a number of readings using the Protimeter. Readings were taken in the rooms where the recorders were placed as well as all of the adjacent rooms. Readings taken on 3 August indicated the presence of unsafe moisture levels in all areas of the interior. The readings taken in all locations registered a WME of well over 20%. A cursory inspection of the interior walls also indicated that the building suffered from significant moisture infiltration problems. Efflorescence, spalling, and biological growth are all present in Battery DeRussy. Small pools of standing water were also observed at many locations within the battery.



Photograph 3: View looking at the data recorder placed in the plotting room. The arrow indicates the placement of the electrodes within the wall. Note the efflorescence and biological growth on the vertical surfaces (Photograph by T. Beckwith, 3 August 2005).



Photograph 4: View looking at the data recorder placed in the plotting room. Note the significant spalling of the walls as well as the presence of biological growth and efflorescence. These are all clear indications that moisture levels within the batteries is contributing to a rapid deterioration of the structure (Photograph by T. Beckwith, 3 August 2005).

The Results

The data recorders were collected on 6 December 2005. Prior to removal of data recorders, each was checked to ensure that they functioned properly. Both of the devices placed in Casemate 21 recorded data properly. However, the unit installed in the plotting room of Battery DeRussy did not gather any data. The moisture conditions in the room were likely beyond the capabilities of the unit. However, the recorder placed near the ammunition hoist did function, and the data gathered provides a good concept of the conditions within the Battery. The data gathered is included in the following tables along with a brief analysis of the data.

Casemate 21

Figure 1 contains a graphic illustration of the environmental changes over time and the amount of moisture that is contained within the walls. As stated previously, Casemate 21 serves as the Post Chaplain’s Offices. Over the years, many environmental controls have been installed in the building. These environmental controls include a modern heating system, air conditioning units, and a series of dehumidifiers. All of these systems are necessary in order to make the casemates habitable.

Because of these environmental controls, the temperature remains relatively stable in the casemates, at least during the summer and fall months. Beginning in late October the temperature within the Casemates begins to fluctuate a bit, but this fluctuation is still relatively minor, hovering between 70°F and 75°F. Both the dew point and the relative humidity fluctuated but the fluctuations were relatively insignificant. Neither of these levels are considered to be outside an acceptable range for building interiors. The fluctuations are likely due to the inconsistent use of the humidifiers. All of these units are manually operated and none of the units runs consistently. What is significant in the data, is that there is no apparent relation to the interior environmental conditions and the amount of moisture within the wall. Moisture levels within the walls vary significantly and do not appear to be related to interior conditions.

What is much more significant is the comparison of precipitation totals with moisture levels of the casemate walls (Figure 2). It is clear that during periods of intense precipitation that moisture leaks through the vaults of the casemates. It was assumed that this was caused by a total failure of the gutter system underneath the parapet. The data however suggests otherwise. From 3 August to 21 September, there were four instances in which daily precipitation totals exceeded one inch (and two days that registered 0.9 inch of precipitation). In each of these instances, there was no increase in the amount of moisture within the walls. In fact from 5 August to 5 October, the WME fell from 51.8% to 43%, a decrease of approximately 17%. However, beginning on 7 October, a major precipitation even began with approximately ½ inch of rain falling. On 8 October, the amount of rain increased with 2.68 inches of rain falling in a twenty-four hour period. The data recorder registered a WME reading 42.2% on 8 October (at 1315), twelve hours later, the reading spiked to 68.1%. It peaked on 9 October (at 1315) when the level hit 72.8%. In a three-day period, the rainfall total amounted to 3.8 inches.

While the gutter system that exists underneath the rampart may be damaged, it is entirely possible that even when functioning, it does not have the capacity to shed moisture under heavy or exceptional rainfall. It in interesting to note that on 21 November, Fort Monroe experienced another precipitation event when 2.35 inches fell in a twenty-four hour period. In fact, for the three-day period beginning on 20 November, Fort Monroe received 2.76 inches of rain. However, there was no corresponding increase in the moisture level of the interior walls. Over the next ten-day period, the WME level in this location remained relatively stable or dropped slightly. What the data suggests is that simply repairing the existing system may not increase the capability of the roof to shed moisture. The historic record suggests that moisture was always a problem in these casemates and that the original system was of a faulty design. As section 4.3.1 discussed, Fort Macon used a different gutter system than Fort Monroe, and the Fort Monroe casemates were historically plagued by leaks and high moisture levels. Quite likely, the Fort Monroe gutter system was determined to be ineffective, and the deficiencies of the original system are still apparent.

The terreplein side of Casemate 21 did not exhibit the same problems that the parapet side did. Temperature levels remained relatively stable, as did the relative humidity and the WME levels (Figure 3). Relative humidity levels did vary widely, the cause is not entirely clear but it is likely due to the erratic use of the de-humidifiers and other environmental controls. The moisture levels within the wall remained relatively stable during the monitoring period, generally in the 16% to 17% range. The rains of 8, 9 & 10 October appear to have caused a modest rise in the level of the WME within the masonry walls. On 8 October the WME level registered 17.2 percent, after a few days of precipitation that level rose to 18.5 percent on 14 October. Although a modest increase, this does suggest that some of the precipitation is making its way into the masonry walls, a condition that could worsen over time (Figure 4). Although the moisture levels are stable in the terreplein side of the casemates, the percentages are at the upper ranges of what is considered acceptable.

Battery DeRussy

Battery DeRussy exhibits nearly every moisture infiltration problem possible. A faulty roof system, failed gutters, poor drainage, and meager ventilation are all present in this Endicott Series fortification. The data reflects the poor conditions under which Battery DeRussy is subject to. The temperature, dew point and relative humidity all varied widely during the monitoring period (Figure 5). The WME level in the wall however, experienced some significant changes. Initial readings registered in the 65% to 69% range but rose as high as 80.6% after a few days of heavy rain (1.73 inches on 9 August and 1.61 inches on 12 August). After this however, the WME dropped to the level of approximately 30%. It is not entirely clear why the initial WME readings dropped precipitously from 3 August to September. It may be that by drilling into the wall to install the electrodes allowed the masonry to dry out in that particular area. It is possible to install monitoring equipment further into the wall, but the potential for causing irreversible damage to historic fabric is much higher. It is likely that the WME levels are significantly higher deeper in the wall than on the surface layers.

The heavy rains of 7 to 9 October caused the level to rise again to 35.3% but after that precipitation event, the levels seemed to remain constant at that 22% to 25% range (Figure 6). What is interesting about the rise in the level after the rains of 7 to 9 October is the amount of time that it took for the levels to rise. Although 2.68 inches of rain fell on 8 October, the WME level did not rise until 11 October when it registered 34.8%. It did not peak until a day later when it rose again to 35.3%. The data shows that the precipitation is essentially seeping through the entire structure toward the foundation. This condition, along with the extreme changes in relative humidity, temperature and lack of ventilation are quickly deteriorating the structure.

What is clear from the data is that the moisture levels within the walls of Battery DeRussy are well outside the acceptable ranges for concrete structures. It appears that the concrete does dry out as the summer turns to fall and it is likely that this trend would continue during the winter months.

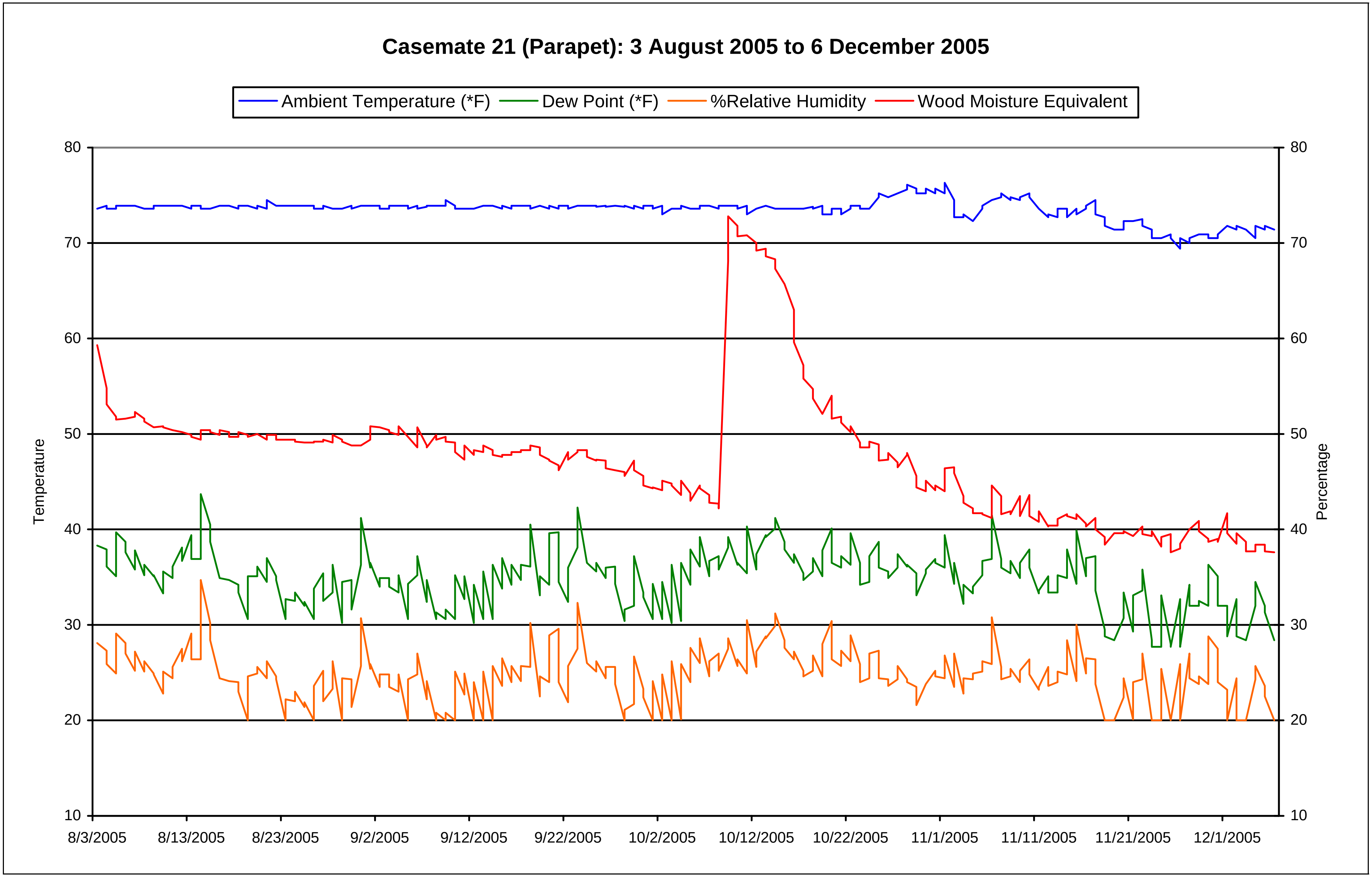


Figure 1: Data gathered from Casemate 21 (Parapet Side).

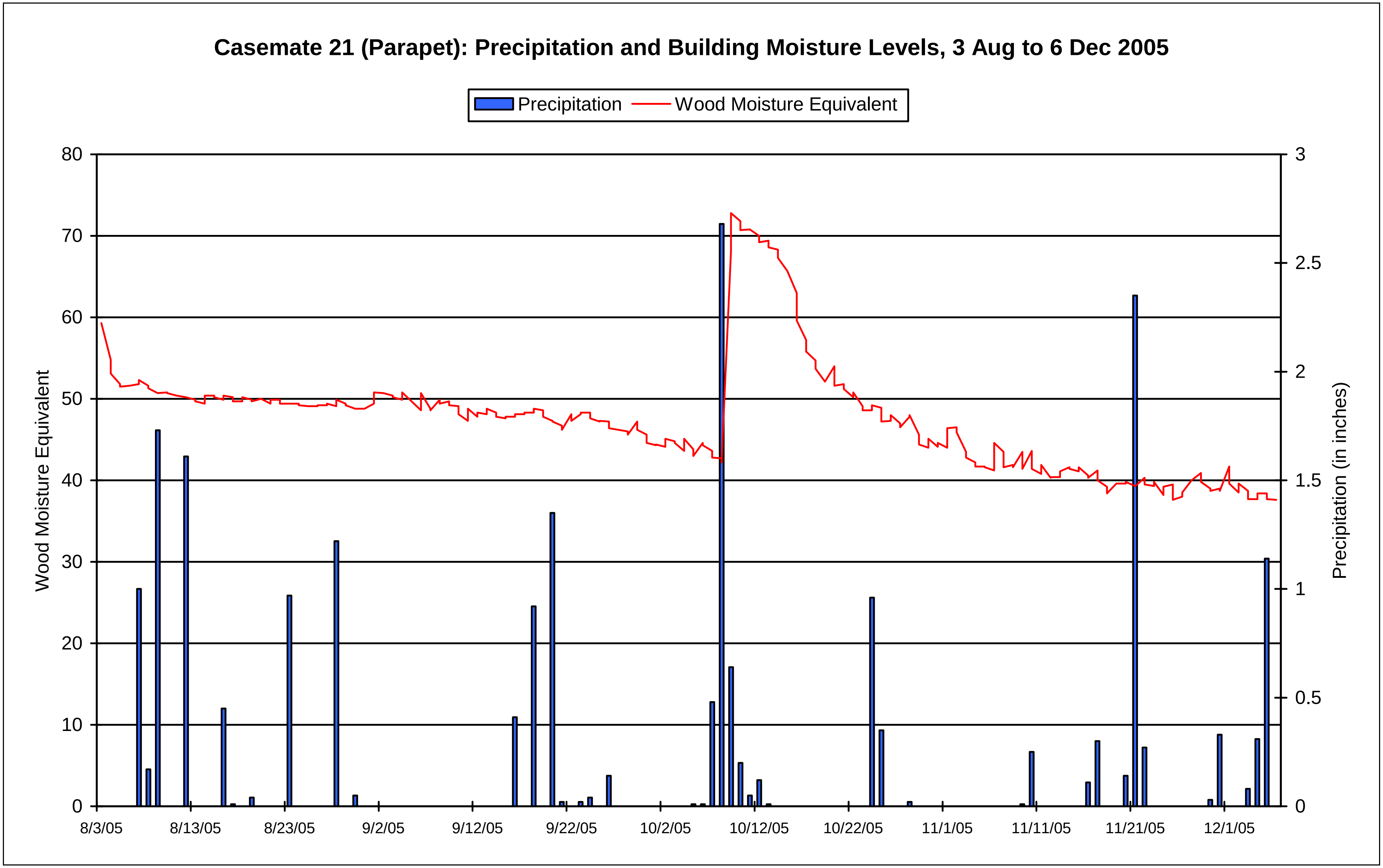


Figure 2: Data gathered from Casemate 21 (Parapet side).

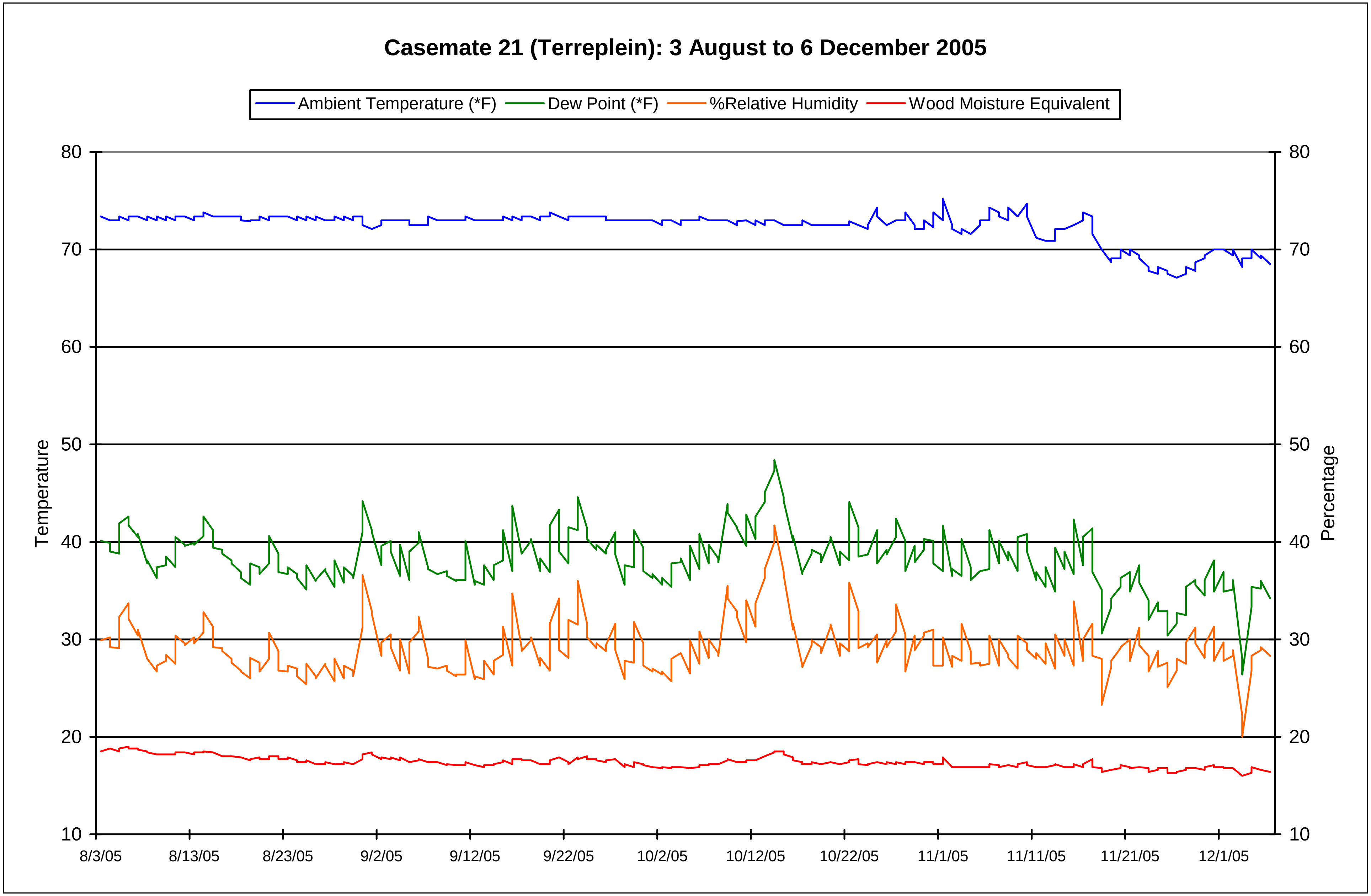


Figure 3: Data gathered from Casemate 21 (Terreplein side)

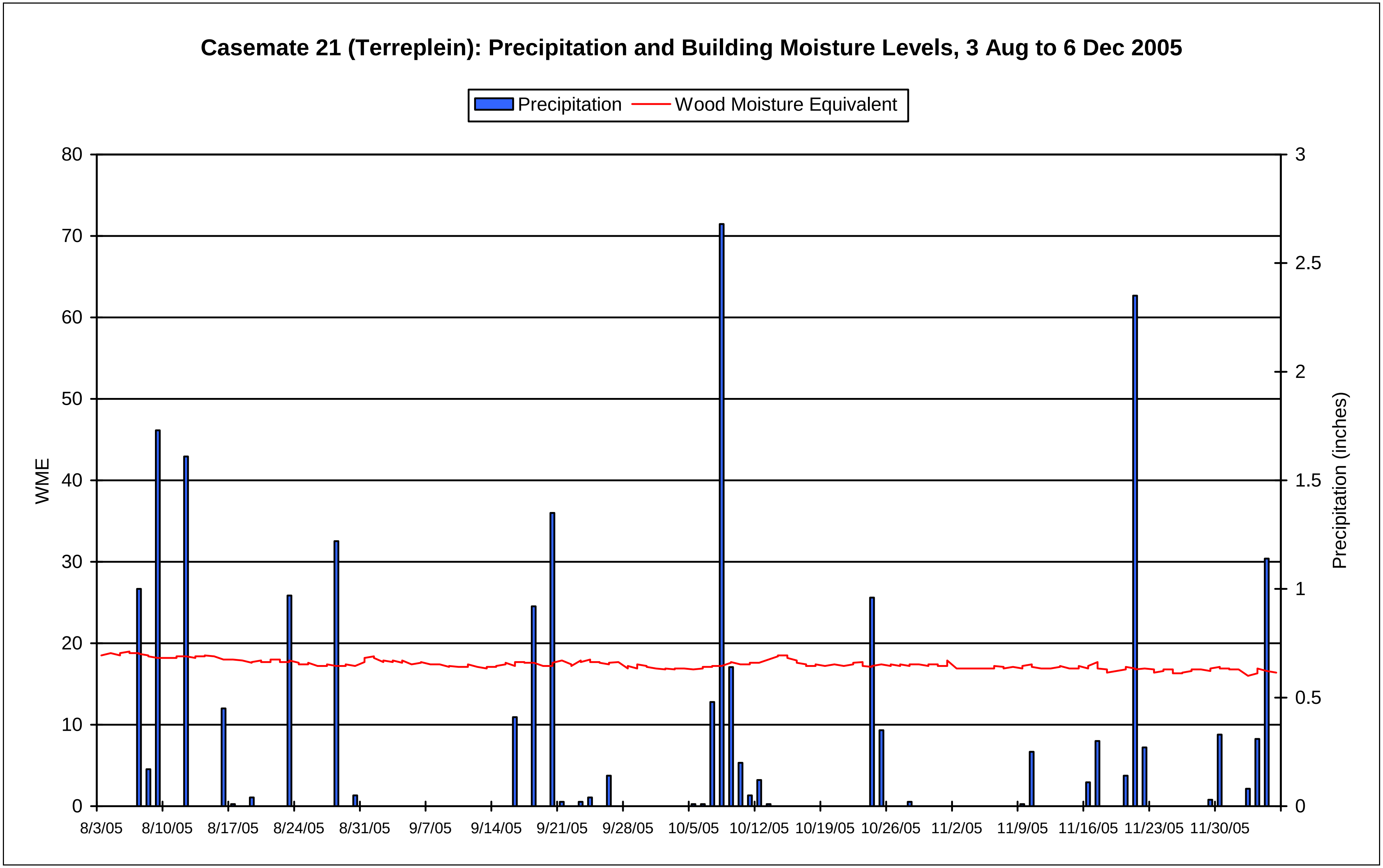


Figure 4: Data gathered from Casemate 21 (Terreplein side)

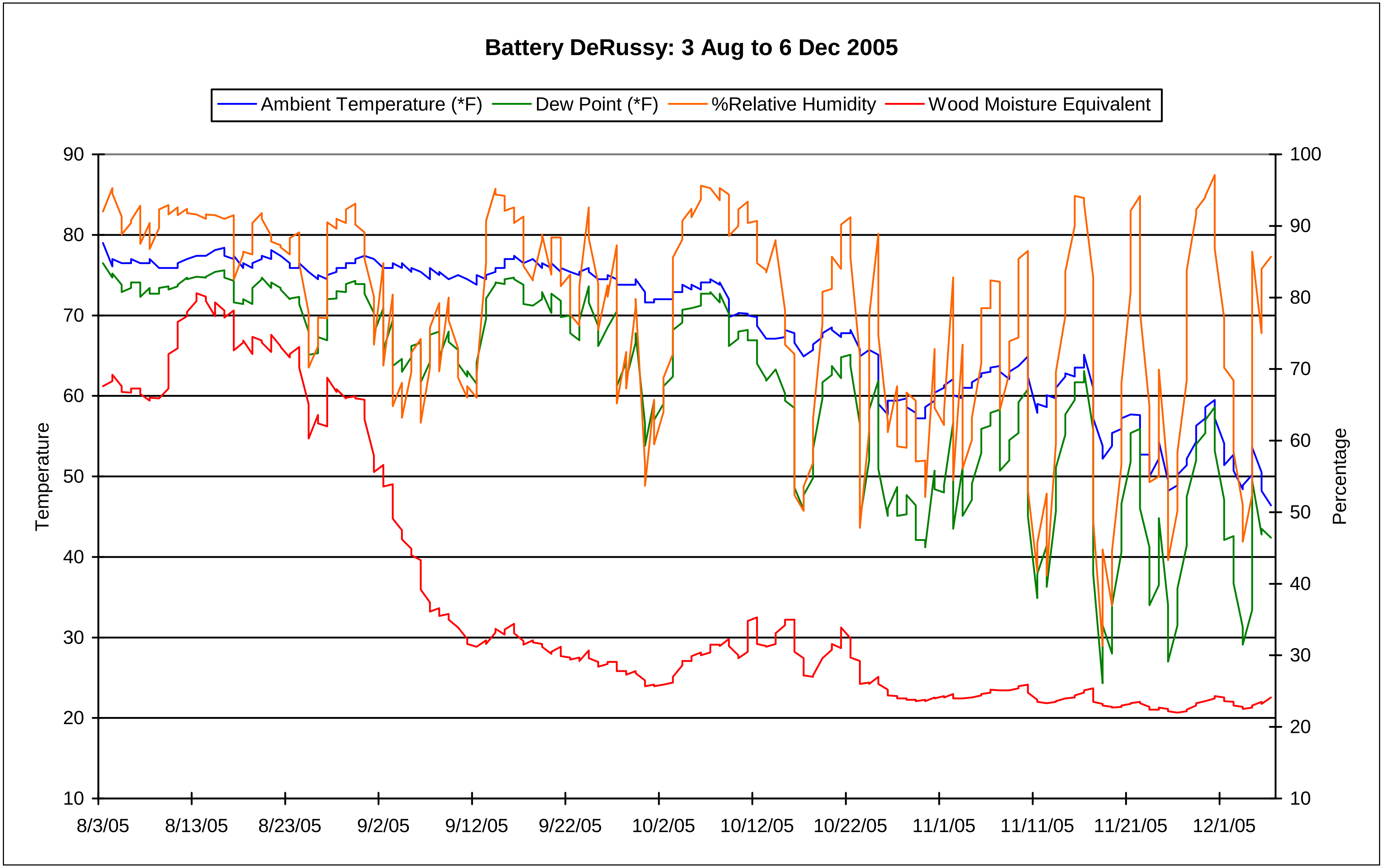


Figure 5: Ambient Temperature, Dew Point, Relative Humidity and WME data gathered for Battery DeRussy.

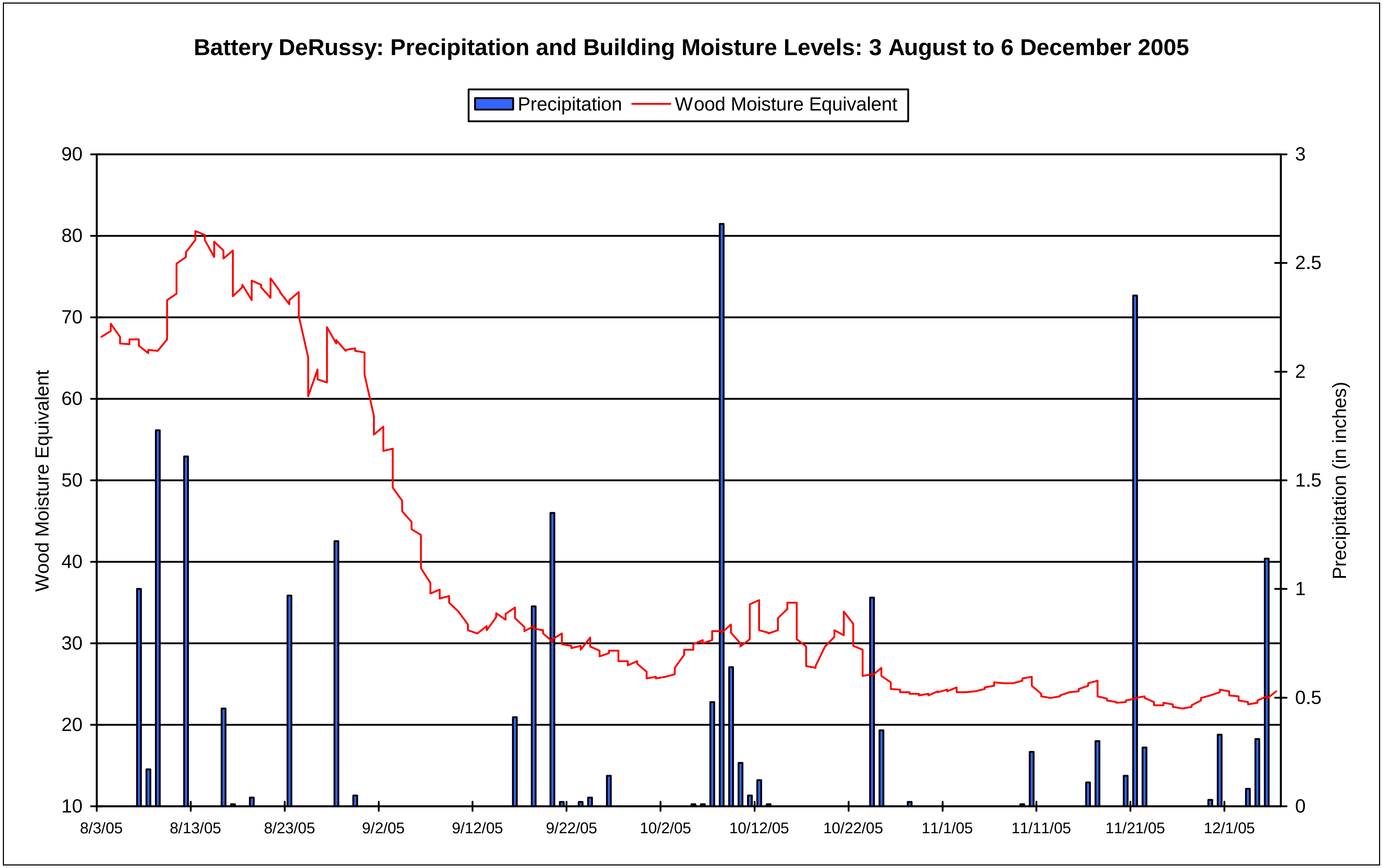


Figure 6: Precipitation and WME levels for Battery DeRussy.

Appendix H
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