CAPE HATTERAS NATIONAL SEASHORE

BODIE ISLAND
LIGHTHOUSE & OIL HOUSE

HISTORIC STRUCTURE REPORT

Cultural Resources Division
Southeast Regional Office
National Park Service
December 2004

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

Cultural Resources Division
Southeast Regional Office
National Park Service
100 Alabama Street, SW
Atlanta, GA 30303
404.562.3117

Bodie Island Lighthouse & Oil House
Cape Hatteras National Seashore
Manteo, NC 27954

http://www.nps.gov/caha

About the cover: Bodie Island Light Station, HABS # NC-395-5, photographed by Jon Buono; LCS#: 00114.

Cape Hatteras National Seashore

Bodie Island Lighthouse and Oil House

Historic Structure Report

Recommended by: Kirk A. Cordell 7/11/02

Chief, Cultural Resources Stewardship, Southeast Regional Office — Date

Approved by: Lawrence A. Belli 9/30/02

Superintendent, Cape Hatteras National Seashore — Date

Concurred by: Patricia A. Hooks 10/8/02

Acting Regional Director, Southeast Region — Date

Contents

PART 2 TREATMENT & USE

CONDITION ASSESSMENT

REFERENCE

List of Figures

Project Team

Project Manager	**Danny Scheidt,** Historical Architect National Park Service Southeast Regional Office Atlanta, GA
Contract Technical Representative	**Tommy Jones,** Architectural Historian National Park Service Southeast Regional Office Atlanta, GA
Building Reporters	**Deborah Harvey,** Historical Writer Hartrampf Inc. Atlanta, GA **Jack Pyburn,** Historical Architect, AIA OJP, Inc. Atlanta, GA
Specialized Building Investigation	**Robert A. Bass,** P.E., Structural Engineer **Ashraf Demian,** P.E., Electrical Engineer Hartrampf Inc. Atlanta, GA **Courtney Swann,** Historical Architect OJP, Inc. Atlanta, GA
Document Layout/ *Internet Access*	**Jon Buono,** Historical Architect **Jay Womack,** Historian National Park Service Southeast Regional Office Atlanta, GA
Program Reviews	**Bob Blythe,** History **Allen Bohnert,** Museum Services **Danny Scheidt,** Historic Architecture National Park Service Southeast Regional Office Atlanta, GA

Foreword

We are pleased to make available this historic structure report, part of our ongoing effort to provide comprehensive documentation for the historic structures and landscapes of National Park Service units in the Southeast Region. Many individuals and institutions contributed to the successful completion of this work. We would particularly like to thank the staff at Cape Hatteras National Seashore for their assistance throughout the process. We hope that this study will prove valuable to park management in their continuing preservation of the building and to everyone in understanding and interpreting the Bodie Island Lighthouse and Oil House.

Dan Scheidt
Chief, Cultural Resources Division
Southeast Regional Office
National Park Service
December 2004

Executive Summary

The area on which the Bodie Island Light Station now stands was originally spelled Body's Island. This spelling appears on many early documents. It is not known how the island got its name or when or why it was changed, though research is currently underway to determine the answer to those questions. The current spelling, Bodie Island, is used throughout this document for the sake of clarity unless directly referencing an original document using the original spelling. The Bodie Island Lighthouse is significant in the understanding of the history of maritime navigational aids used by the United States during the nineteenth and twentieth centuries. It was constructed during a period of building of several such aids along the shores of this country and stands largely unchanged except for the means of powering the light. The surroundings of the Bodie Island Lighthouse, unencumbered by visible signs of contemporary society, with the exception of the access road, are also significant to the understanding of under what conditions the Lightkeepers lived and worked in the last part of the nineteenth century and first half of the twentieth.

In March of 2002, at the request of the National Park Service, personnel from Hartrampf, Inc., engineers, and the Office of Jack Pyburn, Architect, Inc. traveled to the Bodie Island Light Station at Oregon Inlet near Nags Head, North Carolina to undertake a physical inspection of the Tower and attached Oil House, called, collectively, the Bodie Island Lighthouse. The purpose of the inspection was to provide information relative to the existing condition of the structure involved in the course of compiling this Historic Structure Report. Personnel inspecting the site included Mr. Robert A., Bass, P.E., structural engineer, Mr. Ashraf Demian, P.E., electrical engineer, and Ms. Deborah Harvey, historical writer, of Hartrampf, Inc. as well as Mr. Jack Pyburn, AIA, Historic Architect and Mr. Courtney Swann, Historic Architect, of the Office of Jack Pyburn, Architect, Inc., with the assistance of Mr. Steve Harrison, National Park Service Chief of Resource Management at the Cape Hatteras National Seashore, North Carolina.

Photographs, measurements, and notes were taken regarding the subject structure, in addition to a video record of the investigation. In accordance with the scope of work for this report, no historic fabric was removed or altered for this inspection, and no scaffolding or other inspection structures were constructed. No intrusive methods were used to inspect the structures. Therefore, only observations of the exterior surfaces of the Lighthouse normally accessible were possible. On- site personnel were interviewed about ongoing maintenance and restoration efforts currently underway at the site. A visit to the Cape Hatteras National Seashore headquarters archives and offices in Manteo, North Carolina was made by the representatives of Hartrampf, Inc., and, with the assistance of Mr. Steve Harrison, documents, drawings, and photographs regarding the Bodie Island Lighthouse were reviewed and pertinent documents copied. A trip by Ms. Deborah Harvey to the headquarters of the 5th United States Coast Guard District in Portsmouth, Virginia and, later, to the Civil Engineering Unit of the Shore Maintenance Detachment of the United States Coast Guard in Cleveland, Ohio, yielded further documentation, including drawings, notes, sketches, and reports, regarding the use and maintenance activities of the Government at the Bodie Island Light Station from its construction in 1872 to the present. Documents provided by the National Park Service, including a copy of *A History of the Bodie Island Light Station,* prepared in 1967 by Francis R. Holland, Jr. and published by the National Park Service, several recent structural evaluations of the Tower and Oil House, and an historic paint survey, completed by John H. Scott of the National Park Service in 2002, were also reviewed. An interested researcher, Jack McCombs, provided information regarding the steel fabricating company, and the book, *Lighthouse Families*, by Cheryl Shelton- Roberts, gave insight into the lives of Lightkeepers and their families. Ms. Harvey also conducted correspondence with Jack McCombs, Cheryl Shelton- Roberts, and John Gaskill, son of the last Lightkeeper, which produced further pertinent information about the history of the Lighthouse.

The Bodie Island Lighthouse is within the environs of the Cape Hatteras National Seashore.

There is a General Management Plan extant for the Cape Hatteras National Seashore. However, it was formulated prior to the acquisition of the Bodie Island Lighthouse in 2000 and, thus, contains no directives regarding use or preservation requirements for this structure. There is no Period of Significance established in the General Management Plan for the Bodie Island Lighthouse. In the absence of such direction, this report proposes that the Bodie Island Lighthouse be preserved to interpret its ongoing use as a maritime navigational aid.

Since changes to the building have been minimal, all eras of the history of the building can be interpreted, requiring only minor alterations to its present condition to allow for safe visitor access to the building. The United States Coast Guard expects to continue operation of the light for another eight or ten years. When that use ceases, the National Park Service may want to re- evaluate the significance of the Bodie Island Light Station within the context of an overall interpretive plan for all the surviving lighthouses on the Outer Banks. While there is no compelling rationale for restoring it to an earlier period at the present time, the National Park Service may decide later that the Bodie Island Light Station has special significance and that to properly interpret that significance, restoration to some earlier period is required.

Findings of the physical investigation and review of historic documents indicate that the Bodie Island Lighthouse, while essentially sound, has been the victim of 131 years of wind, weather, and insensitive maintenance activity. This is not to say that the Lighthouse Board and the United States Coast Guard did not engage in maintenance activities during their tenures as keepers of the structure. The main focus of both government entities was to maintain the light as a navigational aid, and their efforts did not focus on the preservation of the historic features of the building or on relating improvements to the structure's history or historical context. Consequently, when replacing surface finishes, repairing damage, or re- installing weathered features, the focus was not on keeping the historic fabric intact, but on keeping the facility functioning as a lighthouse.

A major concern regarding this building is whether or not it is structurally sound and can be opened for visitation by the public. In general, the structure is sound and could be opened, with some restrictions, for visitation by the public after modifications suggested herein have been made. The foundations and loadbearing walls, while experiencing some deterioration of mortar that might be expected in a 131- year old structure in a coastal setting, are stable and require only minor repairs. Deterioration of metal parts has occurred and must be remedied. The structural evaluation indicates that the stair treads and landings can support the loads mandated by current building codes; however, the stair stringers would require bracing before any wholesale visitation by the public could occur. The conclusion regarding the gallery on the outside of the Tower is that it should be repaired as necessary for maintenance of the exterior and to replace lost features. To open the gallery to the public, it will be necessary to strengthen the support structure and replace the handrail with one that complies with current codes.

Visitor management will be an issue at the Bodie Island Lighthouse. Fall protection at landing and stair handrails and at window openings must be provided. The physical size of the upper landings, especially the Watch Room and Lantern level, will restrict the number of people that can be accommodated to possibly no more than four or five on these levels at any one time. Therefore, a management strategy must be devised to coordinate public access with the capacity of the stairs and landings. To allow access to the top level, the Lantern level, a handrail must be installed along the stairs leading from the Watch Room to the Lantern level. These stairs are exceptionally steep and narrow, with no handholds of any kind. However, it seems imperative that, if the National Park Service allows visitors to the top of the Tower, they must be allowed to the Lantern level, as there is no other means of physically viewing and appreciating the light, the lens, the lamp, and the landscape.

Access for the physically disabled is an issue at the Bodie Island Lighthouse. The Lighthouse has never been an accessible structure. The building type, in general, is one designed for a unique use, and the configuration of the structure reflects that use. Applying the standards for physical modification to achieve accessibility in accordance with the Americans with Disability Act, UUDAG, and UFAS is not possible without producing a significant negative effect on the historic character of the structure. Therefore, the application of "minimum alternative access" as provided for in the consultation procedures of ADAAG 4.1.7(2) (56 Federal Register 35429, July 26, 1991) should be applied to this structure. The type of responses appropriate under the "minimum alternative access" provisions could include such elements as accessible observation points on the ground to view building features, videos interpreting the experience of ascending the tower and viewing from the watch balcony, or scale cutaway models of the interior of the structure for viewing at the Visitor Center.

The following represents a summary of the treatment recommended to preserve the Bodie Island Lighthouse and provide a safe and enjoyable visitor experience.

Paint Removal

- Perform lead paint abatement on all painted surfaces of the exterior and interior of the Oil House and Tower where necessary. Where lead paint is not indicated, remove paint to expose surfaces for inspection.

Masonry

- Inspect the granite, brick, and mortar forming the foundation and walls of the Oil House, Hall Connection, and Tower and document conditions.
- Repair cracks in foundations and walls using an appropriate method.

- Perform tests on the mortar to determine its composition and repoint the foundations and walls using appropriate methods and mortars.

Metal

- Inspect metal surfaces and features, document conditions, and repair or replace in kind as necessary.
- Install structural strengthening members as necessary to bring the gallery up to code to allow visitor access.

Wood

- Repair or replace in kind as necessary damaged existing wood features in the Oil House and Hall Connection.

Glass

- Reglaze the exterior panes of the lamp, replacing clouded or crazed panes.
- Reglaze windows as necessary in Oil House and Tower.

Roofing

- Remove existing Oil House roof, inspect the roof framing over the Oil House and Hall Connection, and document conditions.
- Replace any rotted members discovered during the inspection of the roof framing.
- Inspect the east chimney to verify that the chimney is not experiencing distress below the roof line.
- Install a new roof deck, new roof flashings, and new roofing on the Oil House and Hall Connection.
- Inspect the roof of the Tower and the ventilator ball at the top for damage, document conditions, and repair or replace if inspection indicates that this is necessary.

Flooring

- Refinish and seal the wood floor in the Work Room.
- Clean the marble floors in the Oil House and Tower and replace any cracked or missing tiles.
- Securely install replacement prisms in the Lantern level grating floor.

Safety

- Install a new, code- compliant railing around the existing exterior gallery.
- Modify the stair and landing level railings to provide fall protection.
- Install bracing on each side of stairs, mid-flight, to bring the stair stringers up to code.
- Install fall protection at the openings to the windows on the 2nd, 5th, and 8th level landings.
- Fabricate and install a railing conforming to current code requirements at the stair from the Watch Room level to the Lamp level.
- Remove the chain link enclosure at the base of the Tower stairs and repair the walls and floor of the ground level of the Tower as necessary.

- After reconstruction of the exterior metal gallery, remove the exterior wood fence around the Tower.

Electrical

- Verify the presence of asbestos insulation in wiring prior to making any repairs.
- Repair and replace electrical wiring and fixtures as necessary.
- Add lightning protection at the highest point of the Tower with two down conductors. Verify the connection of the existing lightning protection ground conductors. If the connection cannot be verified, install a new ground ring with ground rods.

Painting

- After repair, replacement, and modification of Lighthouse features have been completed, paint the Oil House and Tower using an historically- appropriate paint scheme.

Maintenance

- Implement a systematic program to open the windows regularly to provide ventilation and reduce moisture condensation on the interior of the Tower.
- Implement a systematic program to inspect the underside of the stair treads for future stress cracks.

The conclusion is that the Bodie Island Lighthouse is essentially in sound structural condition. Original physical features are substantially intact. Additionally, it is feasible to open it to the public, with some limitations. With coordinated, historically- appropriate physical improvements and a creative interpretive plan, the Lighthouse can be managed to achieve a safe and satisfying visitor experience while protecting the significant historic qualities and features of the structure and maintaining it as an active maritime aid to navigation.

Administrative Data

Location Data

Building Name:	Bodie Island Lighthouse
Building Address:	Bodie Island Lighthouse, Nags Head, North Carolina
LCS #	00114

Related Studies

Holland, Francis R., Jr. *A History of the Bodie Island Light Station,* National Park Service History Department, 1967.

National Park Service, *Historic Paint Finishes Study, Bodie Island Lighthouse and Oil House,* National Park Service Northeast Cultural Resources Center Building Conservation Branch, 2002.

Cultural Resource Data

National Register of Historic Places: The Bodie Island Light Station is eligible for listing in the National Register of Historic Places. A register nomination is being prepared by the National Park Service for this structure.

Period of Significance: The Period of Significance for the Bodie Island Lighthouse begins in 1872, when construction was completed and the light was first displayed as a navigational aid. The end of the Period of Significance has not yet been determined. Several options are available: 1872, the original condition; 1932, after the conversion of the Light Station from oil to electricity; 1940, the year the last Lightkeeper left Bodie Island; 1945, the year the Bodie Island Light Station site reached its present size; 1953, when the Light Station was converted to commercial electricity; or 2000, when the Lighthouse was transferred from the United States Coast Guard to the National Park Service. Each of these periods (1872 – 1932, for example) present unique characteristics, though they are, except for the last, mainly related to the production of light in the Tower. The adoption of most of these would probably necessitate the removal of some later features and the re- installation of missing components known to have existed and for which there is documentary evidence regarding the appearance of the missing feature. In the absence of direction in the General Management Plan of the Cape Hatteras National Seashore for the Bodie Island Lighthouse, the authors of this report, with the concurrence of the National Park Service, recommend that the Period of Significance be defined as the period in which the Lighthouse was used as an active navigational aid. Thus, the Period of Significance represents the collective history of the structure, a history that is not yet completed since the Lighthouse is still in use as an aid to navigation. At such time as the Bodie Island Lighthouse ceases to be used as an aid to navigation, the National Park Service may decide to modify this approach and determine a less inclusive Period of Significance. If so, the Park Service should open dialogues with representatives of families and groups in surrounding communities with historic ties to the Lighthouse, such as those who had ancestors who worked at the Lighthouse, who would qualify as "traditionally associated peoples," as defined in National Park Service management policies for ethnographic resources.

Proposed Treatment and Use: The Light Station remains in use as an aid to navigation, but it is also an attraction to visitors to the area. The treatment is to preserve the Tower and the Oil House, known collectively as the Lighthouse as it has evolved into the 21st century. While some modifications are necessary to address safety issues, the Lighthouse would essentially be only repaired to preserve the existing structure with no modifications made to the structure except to accommodate limited visitor access. Restoration of features removed in the course of the use of the Lighthouse as a navigational aid are not recommended. However, recent modifications that are not related to the use of the Lighthouse as an aid to navigation, such as the fences installed to prevent injury to visitors, could be removed. The General Management Plan for the Cape Hatteras National Seashore should be revised to include a plan for this structure that addresses continued maintenance and visitor access.

Historical Background & Context

The historical background of the Bodie Island Lighthouse has been ably documented by Francis R. Holland, Jr. in his report, *History of the Bodie Island Light Station*, written in 1967 and printed by the U.S. Department of the Interior, National Park Service. A copy of his report is included as an appendix to this report. Therefore, this section does not undertake to repeat Holland's work, but includes a summary based on that work, with some additional information not included in Holland's. Footnoting will not be provided for information in this section that is derived from Holland's *History*, but only for information from other sources that applies to the period from 1848 to 1954. The history of the Bodie Island Lighthouse is resumed in this report beginning at 1954, the last year documented in Holland's book.

The existing Lighthouse at Bodie Island is the third built in this vicinity, but it is not on the foundations of either of the first two. The foundations of the first two Bodie Island Lighthouses are now under water in the Oregon Inlet. The first Lighthouse was completed in 1848, but, only ten years later, it was necessary to replace it due to defects in the foundation. The foundation had not been designed to accommodate the soils on which the structure was placed, causing it to settle unevenly, leaning nearly a foot out of plumb by 1851. In addition, the decision was made to upgrade the light apparatus of this Lighthouse. Accordingly, a new Tower was built at a nearby site in 1859, at a cost of nearly eight times what the original had been. Whereas the first Tower had taken nearly 20 years from conception to completion, the second Tower was completed within a year, and the old Tower was subsequently razed.

Despite efforts to make the second Lighthouse more durable by improving the foundation on which it rested, it did not last as long as the first. In 1861, North Carolina seceded from the Union, and the state sent forces to the Outer Banks to build and occupy forts along the coast to protect against Federal incursions via the inlets. The forts were quickly built, but Federal forces launched amphibious attacks on the Confederates at Hatteras Inlet. Within three days, both Fort Hatteras and Fort Clark had fallen. With these two forts gone, the forts on either side of them, at Ocracoke Inlet and Oregon Inlet, were no longer tenable, and the Confederates abandoned them in November of 1861. Before leaving Oregon Inlet, however, the Confederate forces blew up the Lighthouse Tower – though they salvaged the light – apparently to prevent the Federals from using it as a lookout. The second Bodie Island Lighthouse was left in ruins by the Federal government for the duration of the Civil War because it was felt that the Cape Hatteras light, which had been restored after the Confederates abandoned the fort, was adequate for the coast at the time.

After the end of the Civil War, normal shipping resumed along the North Carolina coast. By 1867, the number of shipwrecks in the area caused the District Engineer of the Lighthouse Board to urge the reconstruction of the Bodie Island Light Station. Initial plans to place the third Light Station on the same plot of ground occupied by the first two were thwarted by the fact that the Oregon Inlet was advancing steadily on the site of the earlier lighthouses and had come within 400 yards of it. Consequently, the District Engineer proposed to select a site on the north side of the inlet on a plot of land owned by John B. Etheridge, who had been a keeper of the first Bodie Island Lighthouse. The 15 acres of land that John Etheridge and his wife agreed to sell to the Lighthouse Board were conveyed on June 13, 1871, for $150.00.

Shortly after the sale, site preparation began for the construction of the Lighthouse with the building of storage buildings, workers' quarters, a wharf, and a tramway connecting the wharf to the site. The pit for the foundation was dug, and the foundation was laid. In September and October of 1871, the foundry shipped beams to Baltimore to be loaded on ships bound for Bodie Island.[1] By November, the bricks for the Tower were being shipped to the site. On July 21, 1872, the Tower was nearly ready to receive its light, and the District Engineer requested that the lens ordered for Bodie Island be shipped immediately to Norfolk, Virginia. The lens was installed in September, and the light was first exhibited on October 1, 1872.

1. Phoenix Iron Company, Philada section of Business Ledgers, Phoenixville, Pennsylvania. Currently held at the Hagley Museum and Library, University of Delaware, Wilmington, Delaware, 1871, pp. 292, 331.

Figure 1 Bodie Island Light, 1893.

The total cost for the Light Station was $140,000.00.

The arrangement for maintenance of the Light Station involved, in 1872, the employment of a Principal Keeper, a 1^{st} Assistant Keeper, a 2^{nd} Assistant Keeper, and, for the first two years, a 3^{rd} Assistant Keeper. Between 1872 and 1940, four Principal Keepers served the Bodie Island Light Station.[2] The first Principal Keeper at Bodie Island Light Station was William F. Hatsel, of North Carolina, who was employed until 1878 at a salary of $820 per year. Peter Johnston was assigned as the 1^{st} Assistant Keeper on October 15, 1872 at a salary of $400 per year, and W. E. Etheridge was the 2^{nd} Assistant Keeper, assigned October 11, 1872 at a salary of $350 per year. By 1874, the office of 3^{rd} Assistant Keeper, held by Rebecca Hatsel, wife of the Keeper, had been abolished. Over the next five years, a succession of 1^{st} and 2^{nd} Assistant Keepers rotated in and out of the service of the Bodie Island Light Station.

Keeper William F. Hatsel was transferred from Bodie Island in July of 1878 and replaced by Peter G. Gallop of Maryland, who seems to have remained in that position until 1906. The frequent reassignment of Assistant Keepers continued. In 1887, the first pay raise for Assistant Keepers was approved: John Shannon, 2^{nd} Assistant Keeper, was given a raise from $425 to $450 per year, putting his salary on par with that of the 1^{st} Assistant Keeper. A year later, George Blivens, 1^{st} Assistant Keeper, received a raise of $50 per year, his salary rising from $450 to a whopping $500 per year!

In 1906, Keeper Peter G. Gallop was replaced by Ephraim Meekins, Jr. Meekins accepted the position with a decrease in the base pay for Keepers from $820 per year to $720 per year. The Assistant Keepers' pay rates apparently remained the same. By 1911, the 2^{nd} Assistant Keeper was making $456 per year. Still, Assistant Keepers were mostly transient; several were appointed nearly every year. In late 1919, Keeper Meekins relinquished his position to the fourth and final Principal Keeper at Bodie Island, Lloyd Vernon Gaskill.[3] In the 1920s, the position of 2^{nd} Assistant Keeper was abolished

2. McComb, Jack, to Deborah E. Harvey, e-mail dated 23 April 2002.

thanks to the installation of a "mechanical keeper," a thermostat positioned over the kerosene lamp flame and attached to a warning bell located in the Keepers' Quarters and to a recording device to notify the Keeper if the light went out and to record the event.[4]

The apparently high turnover may have been the result of long hours and an isolated condition for the Lightkeepers. A report in 1909 indicates that the only means of reaching the Light Station was by a small sailboat to a landing and then on foot down a sandy road almost ½- mile long.[5] Later, the Lighthouse had a powerboat that transported people and supplies to the island.[6] This situation was not rectified until the late 1920s, when a bridge to the island was built.[7] In 1909, the distance to the nearest post office was six miles, and to the nearest steamboat landing and town, 12 miles.[8] Because there were no schools or churches on Bodie Island, Keeper Gaskill, as well as his assistant keepers, housed his family on Roanoke Island at Wanchese for the majority of the year, moving them to Bodie Island only in the summer.[9]

3. Gaskill, John, to Deborah E. Harvey, e-mail dated 22 April 2002.
4. Shelton-Roberts, Cheryl, and Bruce Roberts, *Lighthouse Families,* Cranehill Publishers, Birmingham, 1997, p. 159.
5. ----, "Description of Lighthouse Tower, Buildings, and Premises". Report for the U.S. Department of Commerce and Labor, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 6 Mar 1909, pp. 3-4.
6. Shelton-Roberts, p. 163.
7. Gaskill, John, to Deborah E. Harvey, e-mail dated 26 April 2002.
8. ----, "Description of Lighthouse Tower, Buildings, and Premises," pp. 3-4.
9. Gaskill, John, to Deborah E. Harvey dated 26 April 2002.

The duties of the Keepers were incessant. When there were three keepers, two of the three men were on duty at all times.[10] Until the "mechanical keeper," the thermostat, was installed, a Keeper had to be in the Watch Room whenever the lamp was lit.[11] A small coal stove helped to dispel the cold for the Keeper on duty.[12] Keeper Gaskill kept the first watch, and one of his assistants relieved him about midnight.[13] After the installation of the thermostat and the elimination of one of the Assistant Keeper positions, the two remaining Keepers alternated nights on watch.[14] John Gaskill described his father's routine for Cheryl Shelton-Roberts in *Lighthouse Families*:

> "Daddy would come out here about thirty minutes before sundown. He would go to the storage house that was outside the tower on the south side, fill a three- gallon brass can with oil, and get a bucket of coal. Next he would climb the stairs to the watch room, fill the oil reservoir, and watching the gauges carefully, pump the oil to pressurize it and send it upward into the mantle in the center of the Fresnel lens in the lantern room. Then Daddy would climb the stairs to the lantern room, go in, take the alcohol torch from its holder, light the torch, and use it to warm the

10. Shelton-Roberts, pp. 158-159.
11. Ibid, p. 171.
12. Ibid.
13. Ibid.
14. Gaskill, Lloyd Vernon, "Personnel Classification Board Form No. 14 – Field Questionnaire" completed for the Lighthouse Board, certified as accurate and complete 21 Sept 1928 by H. D. King, Superintendent of Lighthouses, from Lloyd V. Gaskill papers at Cape Hatteras National Seashore headquarters, Manteo, North Carolina. Original documents in the possession of John Gaskill, his son.

> kerosene to vaporize it. The kerosene vapor burned in the mantle, producing a brilliant light."[15]

However, keeping the light lit was not the only task assigned to the Keepers. In 1928, Lloyd Vernon Gaskill described his work:

> "(1) As keeper in charge of this station, I am responsible for the for the [sic] proper execution of the duties whether performed by my self [sic] or Asst. I light lamp in tower every othe [sic] evening and raise curtains so the light will be visible to passing ships. Asst. Keeper performs the same duty the following evening. I watch the light intervals untill [sic] sunrise when I extinguish light and refill tanks with kerosene so it will be ready for lighting in the evening. Also I clean lens and watch room before coming [sic] down to dwelling. I am on duty about twelve hours in this instance. (2) I have one Asst. and I superintend and assist in painting, cleaning paint on outhouses and dwelling, clean iron work by chipping ruse [sic] from same when needed. Also keep grass cut on lawn, make minor repairs to sta. such as replaceing [sic] lantern glass when broken, repairing doors, replaceing [sic] hinges when broken, painting motor boat and skiff, keep engine repaired so it can be used at any time for getting supplies and mail from nearest store and Post Office seven miles across the sound. I put in about five hours per day at this work. (3) In addition to above duties I must make a weekly inspection of Sta. Including assistants quarters and record made of condition of Sta. log. Make monthly report of condition of Sta. to district Supt. at Baltimore. Take annual inventory and list all articles worn out have them surveyed and condemed [sic] when Supt. visits sta. on inspection. Also I superintend and assist in the painting of tower outside, steps inside, and whitewash once every five years. I attend to all correspondence from sta. with Supt. relative to general repairs to station. I average about two hours per day at this work."[16]

In addition to the long hours, the quarters were somewhat cramped, making it difficult for Keepers and their Assistants to have their families with them. One building at the Bodie Island Light Station, designed as a duplex known as a Double Keepers Quarters (DKQ), was expected to serve both the Keeper and his family and any Assistant Keepers assigned to the station. By the end of the 1800s, the Lighthouse Board had decided that a second Keeper's Quarters at Bodie Island would be desirable. It was determined that the Assistant Keepers could share the existing Double Keepers Quarters and that a new, larger residence should be built for the Principal Keeper. Several plans for these changes were drawn.[17] However, they were unable to convince Congress to appropriate the approximately $7,500 it would cost for construction of the second dwelling and associated cistern and outhouse until 1907. By that time, the cost of the second dwelling had risen, and the Lighthouse Board was unable to design a structure that would be within the limits of

15. Shelton-Roberts, p. 171.

16. Gaskill, "Personnel Classification Board Form No. 14 – Field Questionnaire," n.p.

17. Assorted plat plans and building designs in papers of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, various dates.

the authorized amount. The matter was dropped.

In 1910, the Lighthouse Board was abolished and the Bureau of Lighthouses created. The Bureau apparently consisted of one person, the Commissioner of Lighthouses. The lighthouse service was transferred from the Treasury Department to the Department of Commerce.

Between 1919 and 1937, the families of Keeper Gaskill and his Assistant Keeper lived in Wanchese on Roanoke Island during the winter months so that their children could attend school regularly.[18] However, by 1937, Gaskill had reached an agreement with the local school board to transport the children daily to and from the main highway, where they could board a school bus. The school board agreed to furnish the gasoline used to transport the children to the highway. For this reason, Gaskill's wife, Bertha, and youngest daughter, Erline, were able to live on Bodie Island year- round, the older children having already left home.[19] Gaskill enquired of the Commissioner of Lighthouses regarding reimbursement for car repairs and tires incidental to the transportation of the children, but was rejected. However, the following year, the school board agreed to pay for only 75 percent of the cost of gasoline (60 of the 80 gallons used). Gaskill asked the Commissioner of Lighthouses to provide the remainder, only 14 gallons since the owner of the Bodie Island Hunt Club, near the Light Station, was paying for six gallons so that his children could ride to the school bus with the children of the Keeper. The Commissioner acceded to his request on the condition that he provide information on the cost of gasoline and whether it would be taken from official stock or purchased privately. According to Holland, because the cost of a gallon of gasoline was, at that time, about seven and three- quarters cents, the expenditure of $1.08 by the Commissioner of Lighthouses required about $20 in paperwork.

In 1937, the Cape Hatteras National Seashore was authorized, and, in 1938, the Department of the Interior expressed an interest in the Bodie Island Light Station, which was rumored to be on the verge of being declared surplus. This, and the reorganization of the Bureau of Lighthouses in 1939, when the Bureau was consolidated with the United States Coast Guard, caused some consternation among the Lighthouse Keepers and prompted letters of inquiry from Gaskill to the Commissioner of Lighthouses as well as to his State Representative, Lindsay Warren, regarding his status.[20] He was assured by both the Commissioner of Lighthouses and President of the local Federal Employees Union that neither his position nor his salary was in jeopardy. He also received a soothing letter from Representative Warren, who informed him that an increase at Bodie Island was being considered. Additionally, his salary was raised to $1,740 per year.[21] However, the transfer of the lighthouses to the care of the Coast Guard did have an impact on Lloyd Ver-

18. Gaskill, John, to Deborah E. Harvey, 24 April 2002.
19. Shelton-Roberts, pp. 166-167, 170.
20. Lloyd V. Gaskill papers.
21. Short, Oliver C., Director of Personnel, Department of Commerce, in letter to Lloyd V. Gaskill, dated 16 Jun 1930, in Lloyd V. Gaskill papers.

non Gaskill's life. In May of 1940, he was transferred from Bodie Island to Coinjock to replace a retiring Keeper, and was then assigned to a buoy tender depot, a position of enormous responsibility.[22] The letter informing him of the transfer stated, "This detail is temporary, but it is anticipated you will not return to Bodie Island, and that your present temporary detail will become permanent."[23] At the same time, the Commander of the Norfolk District (5th District) of the Coast Guard, sent a letter to the Officer- in- Charge at the Nags Head Coast Guard Station stating that, as a result of the transfer of Lloyd V. Gaskill to the Coinjock Light Station and the transfer of Assistant Keeper, J. H. Austin, to the Sharps Island Light Station, the Bodie Island Light Station would be unmanned, making it necessary for the Officer- in- Charge to undertake the operation of the Light Station.[24] Lloyd V. Gaskill's records show that the Bodie Island Light Station became an unmanned station at 6:30 a.m. on May 22, 1940.[25]

In 1945, the size of the Bodie Island Light Station site increased by slightly over 40 acres. However, in 1953, the property was declared surplus, and the General Services Administration at last listed the 56.37 acres of the Bodie Island Light Station for disposal. The National

Figure 2 1964 NPS photograph showing sign to nature trail.

Park Service requested that the land be added to the Cape Hatteras National Seashore. This was established by Secretarial Order on January 12, 1953. On October 15, 1953, the Coast Guard relinquished all of the land of the Bodie Island Light Station except a small, square plot of ground, 100 feet on each side, on which the Lighthouse stands, to the National Park Service. The Coast Guard continued to operate the Lighthouse, though automation eliminated the need for a resident Keeper of the light.

The National Park Service and the Coast Guard cooperated on the maintenance and operation of the Bodie Island Light Station property. The Coast Guard signed agreements with the National Park Service to allow a nature trail and an observation deck to be built on the Lighthouse grounds. A parking lot to the northwest of the Double Keeper's Quarters was also constructed. Photographs from 1964 and 1969

22. Shelton-Roberts, p. 167.
23. Crapster, T. G., in letter to L.V. Gaskill, Keeper, Bodie Island Light Station, dated 20 May 1940, from Lloyd V. Gaskill papers.
24. Crapster, T. G., in letter to Officer-In-Charge, Nags Head Coast Guard Station, Manteo, North Carolina, dated 20 May 1940, from Lloyd V. Gaskill papers.
25. Gaskill, Lloyd V., trip report dated 22 May 1940 in Lloyd V. Gaskill papers,

show the location of the parking as well as the observation deck located to the south of the Lighthouse.[26] In 1972, permission was granted to Offshore Navigation, Inc. to temporarily install a 3- pound radar beacon on the Lighthouse in connection with their seismographic operation, provided this installation did not conflict with the environmental program involving the osprey in which the Coast Guard was participating.[27] Also in 1972, the Coast Guard and the National Park Service discussed an agreement to allow public access to portions of the Lighthouse, provided that it did not interfere with the operation of the light. The Coast Guard asked the National Park Service to agree to assume responsibility for maintaining those portions of the Lighthouse that were open to the public, which included all portions of the structures except the Generator Room (Oil Room) in the Oil House and the Lamp in the Tower. In addition, the National Park Service was to agree not to allow nighttime visitors to the Lighthouse without the installation of a Coast Guard- approved lighting system, to reimburse the Coast Guard for any damages to the Lighthouse caused by the National Park Service or its visitors, to make some required safety improvements to the Lighthouse, and to hold the Coast Guard harmless from liability for injuries sustained by Park Service staff or visitors to the Lighthouse, in addition to maintaining the grounds around the structures. The agreement was signed in June of 1973.[28] However, the National Park Service apparently still did not have access to the interior of the Oil House and the Tower in 1976, when the Coast Guard was reported to be making some improvements on the Oil House.[29]

In November of 1977, the Heritage Conservation and Recreation Service submitted a nomination for the Bodie Island Light Station to be added to the National Register of Historic Places. The Coast Guard was concerned that this was done without their concurrence.[30] Their concern was that a National Register listing would impede any maintenance activities they might want to undertake at the Lighthouse. However, the nomination was never forwarded to the National Register, and the matter lapsed.

The Coast Guard allowed the firm of Brown and Caldwell, consulting engineers to install a

26. Photographs from Bodie Island Lighthouse papers at Cape Hatteras National Seashore headquarters, Manteo, North Carolina.
27. Bullard, Ross P., Rear Admiral, U. S. Coast Guard, Commander, 5th Coast Guard District in letters to Offshore Navigation, Inc. from papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 5 May 1972 and 11 May 1972.
28. "Use Agreement, Bodie Island Light," signed by T. N. Miller, Property Officer for the U. S. Coast Guard, 5th Coast Guard District, and Robert D. Barbee, Superintendent, of Cape Hatteras National Seashore, National Park Service, Department of the Interior, from papers at the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated June 19/23, 1973.
29. Garner, John C., Jr., Historic Architect, Planning and Compliance Division, Southeast Region, National Park Service "Memorandum" to the Regional Director, Southeast Region, National Park Service, in the papers at the Cape Hatteras National Seashore headquarters at Manteo, North Carolina, dated 4 November, 1976.
30. ----, Commandant, United States Coast Guard, in letter to the Commander of the 5th United States Coast Guard District, from papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated August, 1978.

temporary transponder on the gallery of the light tower during the month of July 1981.[31] This was part of an oceanographic study being conducted by the firm for the preliminary design and siting of a wastewater ocean outfall offshore of Kill Devil Hills, North Carolina.[32] The transponder was mounted on a surveyor's tripod, so no intrusion into the fabric of the lighthouse was necessary.

In May of 1983, the National Park Service obtained permission from the Coast Guard to present historical programs inside the Oil House and the lowest level of the Tower.[33] The National Park Service proposed to provide a movable barrier to block access to the upper portions of the Tower and to perform routine interior maintenance.[34] National Park Service personnel would be stationed within the Lighthouse four hours a day, five days a week, to answer questions, The Coast Guard indicated that they would install a door to the Generator Room (Oil Room), which was to be off limits to the public.[35] By November, the Coast Guard had decided to install a more permanent barrier to block public access to the Tower than that provided by the National Park Service. An 8' high chain link fence with a locking access door was installed at the foot of the spiral stairs to the Tower.[36] Visitors were then allowed to enter the lowest level of the Lighthouse and peer up the shaft toward the Watch Room level. However, on August 7, 1988, the National Park Service and the United States Coast Guard jointly commemorated the bicentennial of the Lighthouse Service by escorting visitors to the top of the Tower. One Coast Guard escort climbed the first half of the Tower stairs with the visitors, and another escorted them the rest of the way.[37] A year later, Captain BMC Grady reported that 930 people had climbed to the top of the Bodie Island Tower during the period from Friday through Sunday.[38]

The United States Coast Guard and the National Park Service, despite their efforts at cooperation, appear to have had some differences regarding responsibility for the maintenance of the Bodie Island Light Station, in particular, the Oil House and the Tower. In

31. Koloski, M. E., "Special Use Permit" in the papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 24 July 1981.
32. Pitman, R. W., Project Manager, Brown and Caldwell, letter to H. J. Styron, U. S. Coast Guard Facility, Cape Hatteras, North Carolina, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 6 July 1981.
33. Pritchard, H. S., Commander, U.S. Coast Guard Group Cape Hatteras, letter to Commander, 5th United States Coast Guard District, in papers of 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 27 May 1983.
34. Hartman, Thomas L., Superintendent, Cape Hatteras National Seashore, National Park Service, letter to Lieutenant Herman Pritchard, Commander, U. S. Coast Guard Group Cape Hatteras in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 6 May 1983.
35. "Bodie Island Light" sketch showing which locations would be accessible to the National Park Service, in the papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 14 July 1983.
36. Dunn, Thomas M., in memo in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, n.d.
37. Hohmann, Jack, "Bodie Island Lighthouse," article in The Coastland Times newspaper, August 14, 1988, p. 1B.
38. ----, Telephone conversation note in the papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 8 August 1989.

Figure 3 Bodie Island Light Station, looking south, 2002.

August of 1990, J. A. Chop, CWO2 of the U.S. Coast Guard, made a trip to the Cape Hatteras Coast Guard Group for the purpose of inspecting the light stations in their keeping. He reported that "a significant problem … is the confusion in maintenance responsibility. The Park Service allegedly holds the responsibility for all maintenance on the LT though this cannot be confirmed until the individual lease agreements are reviewed. Presently, some work is not being accomplished because one party (Park Service) thinks the other (Coast Guard) is responsible to do it. In addition, the procedure for one agency to submit work requests or report problems to another is not clear. Work is not done until major complications arise."[39]

By 1994, negotiations were underway to transfer the Bodie Island Lighthouse to the care of the National Park Service.[40] According to the Biennial Lighthouse Inspection Report, the Lighthouse was already on the National Register of Historic Places[41] and currently leased to the National Park Service, who had responsibility for performing all maintenance and repairs on the Lighthouse except in the Lantern Room.[42] The Coast Guard was to retain access rights and the optics in the Tower. It was expected that these negotiations would be finalized by June of 1994,[43] but this was an optimistic projection. By 1996, the Coast Guard was still in possession of the Lighthouse and was negotiating with the Outer Banks Lighthouse Society to assume some of the maintenance responsibilities.[44] The Outer Banks Lighthouse

39. Chop, J. A., CWO2, USCG, in Trip Report in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 24 October 1990.
40. "Biennial Lighthouse Inspection Report," in papers of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, dated 25 January 1994.
41. The Light Tower and Oil House were not then on the National Register of Historic Places. A National Register Nomination is currently being prepared (2002).
42. It is not clear that the Park Service was aware of these expectations of the Coast Guard regarding their maintenance responsibilities.
43. "Biennial Lighthouse Inspection Report," 1994.
44. Westfall, Edward A., Lieutenant, Fifth Coast Guard District Lighthouse Program Manager in fax to Cheryl Shelton-Roberts, president of Outer Banks Lighthouse Society, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 25 July 1996.

Society is a non- profit organization incorporated in 1994 to "aid in the preservation of the lighthouses in the area and work with the National Park Service and other agencies and non- profit groups to achieve the safekeeping of the buildings, artifacts, and records."[45] The Society organized a volunteer program to open the lower portion of the Lighthouse to the public[46] and independently authorized an engineering evaluation of the structure.[47] On December 4, 1996, the Superintendent of the Cape Hatteras National Seashore wrote to the Commander of the Coast Guard, Atlantic Area, to request the transfer of "the remaining USCG property," i.e. the Lighthouse and the surrounding land retained by the Coast Guard.[48] Though negotiations between the Coast Guard and the National Park Service continued, by October of 1997, the Outer Banks Lighthouse Society had a limited license in place with the Coast Guard to provide cleaning and ventilating of the interior of the Tower in conjunction with their volunteer efforts.[49]

On 13 July 2000, the Bodie Island Lighthouse (Tract No. 02- 102) was finally officially transferred to the National Park Service and became part of the Cape Hatteras National Seashore. The original first order Fresnel lens at the top of the Tower was retained by the United States Coast Guard as personal property, to be maintained as part of their museum program.[50]

45. "Outer Banks Lighthouse Society Mission Statement," at www.outer-banks.com, 2002.
46. Shelton-Roberts, Cheryl, to Deborah E. Harvey, e-mail dated 25 April 2002.
47. Alden and Associates, "Bodie Island Lighthouse, Dare County, N.C., Report of Structural Conditions – July 20, 1996" in papers of Cape Hatteras National Seashore headquarters, Manteo, North Carolina, dated 20 July 1996, n.p.
48. Harrison, Steve, National Park Service, in reference note to preparers of this report, 31 May 2002.
49. "Biennial Lighthouse Inspection Report, Fifth District, Bodie Island Light, LLNR 590," noted "Information current as of 10/1/97 in papers of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, 1997 and Cheryl Shelton-Roberts in e-mail to Deborah E. Harvey dated 25 April, 2002.
50. Harrison, 2002.

Chronology of Development & Use

The description of the construction and early maintenance of the Bodie Island Light Station is excerpted from Francis Ross Holland's *History of the Bodie Island Light Station*. A copy of that report may be found in the Appendix to this report. Information regarding construction and maintenance of the Light Station between 1871 and 1954 that was not part of Holland's book but was discovered in other sources is included in this report. Descriptions of later maintenance to the Lighthouse are from documents held at the National Park Service Cape Hatteras National Seashore headquarters at Manteo, North Carolina, the 5th District of the United States Coast Guard Headquarters in Portsmouth, Virginia, and the Shore Maintenance Detachment, Civil Engineering Unit, of the United States Coast Guard in Cleveland, Ohio.

The construction of the third Bodie Island Light Station was begun mid- 1871. Determined to build a foundation for this Lighthouse that would preclude any of the foundation and structural problems such as those that plagued the first one, the Lighthouse Board contracted for a construction crew to dig a pit 7 feet deep, which was kept pumped free of water. At the bottom of this pit was laid a grid of 6” x 12” timbers, in two courses at right angles, topped by 18” thick granite blocks. Water was then allowed to cover the foundation construction, preserving the wood.

Atop this base, courses of rubble block weighing up to five tons were laid, each grouted with hydraulic Portland cement, to raise the foundation an additional five feet. On this was the base of the tower set: "cut granite on the outside and rubble set cement on the inside."[51]

The foundry began to ship beams to Baltimore in September of 1871. Holland refers to the beam supplier as Paulding, Kemble, & Co. of West Point Foundry, New York.[52] However, examination of the beams reveal that they are stamped with the legend "Phoenix Iron Company Philada." In addition, several of the original plates specifically call for Phoenix shapes. Researcher Jack McCombs located the business records for the Phoenix Iron Company of Phoenixville, Pennsylvania among the papers housed at the Hagley Museum and Library, associated with the University of Delaware, in Wilmington, Delaware. These records show 17 beams shipped to Baltimore for the Lighthouse Board on September 15, 1871 and 16 beams shipped on October 27, 1871. Six more beams were shipped to the Lighthouse Engineer on February 13, 1872.

Which of these beams, if not all, were used at Bodie Island Lighthouse is not recorded, but the evidence clearly points to the Phoenix Iron Company as the supplier of beams for the con-

Figure 4 Landing support beams in Tower. Beams were actually installed with manufacturer's stamp upside down. Photo courtesy of Jack McCombs.

struction of the Bodie Island Lighthouse. Payment in cash for the shipments is recorded in the ledger. The 39 beams shipped to Baltimore for the Lighthouse Board cost the Lighthouse Board $1,072.65.[53]

By November of 1871, the bricks had begun to arrive for the construction of the main body of the Tower. About March of 1872, the Lighthouse Board decided to change the bonding of the brick to resemble that at Cape Hatteras rather than as shown on the drawings. By the first of July, the Tower was nearly ready for the installation of the light, and the District Engineer requested that the lens be shipped immediately. Toward the end of September, the light was in place. It was first exhibited on October 1, 1872.[54] This Lighthouse and the associated structures, such as the Keepers' Dwelling, had cost $140,000 to construct,[55]

51. Holland, Francis R., Jr., *A History of the Bodie Island Light Station*, National Park Service, U. S. Department of the Interior, 1967, p. 39.
52. Ibid.
53. Phoenix Iron Company business ledger, pp. 292, 331, 441, and 731.
54. Holland, pp. 41-42.

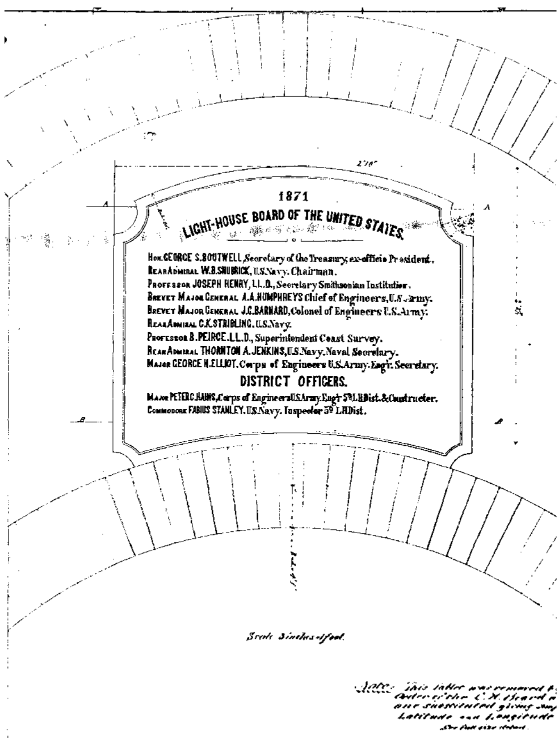


Figure 5 Drawing of original Bodie Island plaque.

more than 46 times the cost of the original Lighthouse and more than five times the cost of the second. A carved marble plaque was erected commemorating the 1871 Lighthouse Board responsible for the construction of this Lighthouse. The plaque listed the names of all members of the Lighthouse Board and the District Officers. This was later removed by order of the Lighthouse Board and replaced with one that gave simply the longitude and latitude of the Lighthouse and the date construction was completed.[56]

The Tower rose 156 feet from the water elevation to the focal point of the light. To the ventilator ball, it was 162 feet. It was painted in alternating bands of black and white, about 22 feet wide. The first order Fresnel lens installed at the top exhibited a fixed white light that could be seen for over 18 nautical miles.[57]

On October 29, 1872, less than 30 days after the lighting of the new Station, a flock of wild geese flew into the lamp, shattering three panes of the 3/8th- inch thick glass and greatly damaging the lens. To prevent a recurrence, the District Engineer ordered the installation of a protective screen around the glass enclosure of the light.[58] A screen remained around the light until after the installation of electrical power and the conversion from a fixed to a flashing light in 1932. The flashing light apparently solved the problem of birds colliding with the Lighthouse at night.[59]

Lightning was also found to be a problem with the Lighthouse. In December of 1877, the District Engineer discovered vertical cracks on all landings of the tower from the second landing to the seventh.[60] He attributed these cracks to lightning rather than to settlement.[61] The Lighthouse was equipped with lightning protection, which consisted of a connection between the metal spiral stairway of the Tower to the metal work of the lantern at the top and to a copper rod driven into the ground at the

55. Ibid, p. 42.
56. Drawing of original Bodie Island Lighthouse plaque in documents of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, n.d. The history of this plaque is noted on the drawing.
57. ----, "Description of Lighthouse Tower, Buildings, and Premises," 1909, p. 4.
58. Holland, pp. 42-43.
59. Shelton-Roberts, p. 171.
60. Holland, p. 44.
61. Ibid.

center of the Tower at the bottom.[62] During storms, the stairway could become heavily charged with electricity, as an early Keeper discovered when he was temporarily paralyzed as the result of being on the stairs when lightning struck.[63] The District Engineer surmised that the stress of these electrical strikes gave rise to the cracks he discovered. The Engineer made a proposal for additional lightning protection, which was not installed until 1884, when lightning again struck the Tower. Though not following the recommendation of the District Engineer to the letter, the installation did follow the spirit of his recommendation. A cable was run from the lantern through the center of the spiral staircase to a cast iron plate buried in the ground. The cable was connected to each of the landings in the Tower.[64] The cable that is currently fastened to the newel of the first flight of stairs in the Tower and runs along the north side of the Tower ground level floor, along the wall of the connecting hall, out through the window in the hall, down the outside wall of the connecting hall and into the ground may be the remains of this lightning protection system. The installation of the cable apparently resolved the problems of the Tower with lightning, for no other lightning damage is reported until after the installation of commercial power in 1953, with the exception of a rogue lightning bolt which struck the Tower in 1939 and traveled through the telephone wires to the Keepers' Dwelling, breaking glass windows, exploding the telephone, and frightening the inhabitants.[65]

62. Holland, p. 45.
63. Shelton-Roberts, p.166.
64. Holland, pp. 45-46.

Over the years, the third Bodie Island Lighthouse performed well, requiring only routine maintenance, though changes were made to the Lighthouse and its environs, as well as to the light itself. In 1883, the Lighthouse Board substituted mineral oil (kerosene) for the original lard oil as the fuel, and the following year installed regular kerosene lamps.[66] The light consisted of five wick- burning lamps inside the lens which had to be kept lit all night and during fog events.[67] Due to the smoke produced by both lard oil and kerosene, keeping the lens and the glass of the light clean would have been a continuous task. Even after the conversion to kerosene lamps, the Keepers may have occasionally used lard oil. John Gaskill relates that the third Bodie Island Keeper, Ephraim Meekins, Jr., told his father, Lloyd Vernon Gaskill, that he had used lard oil.[68] Meekins assumed responsibility for the Bodie Island light in 1906,[69] much later than the date Holland gives for the conversion to kerosene. The low flashpoint of the kerosene eventually resulted in the construction of an oil storage facility separate from the Lighthouse. An 1890 plat in the possession of the Coast Guard shows an oil tank drawn to the east of the Oil House.[70] Whether this tank was ever installed at that location is not clear. A supplementary sheet iron Oil House was erected in 1896.[71] A

65. Shelton-Roberts, p. 166.
66. Holland, p. 46.
67. Shelton-Roberts, p. 171.
68. McCombs, Jack, e-mail to Deborah E. Harvey dated 23 April 2002.
69. Holland, p. 55.

Figure 6 Bodie Island Lighthouse, 1920s. Photograph courtesy of Cheryl Shelton-Roberts. Original in possession of John Gaskill.

rectangle labeled "Oil House, 10x16 iron, brick found." is sketched on the 1896 plat map in a location that is now part of the parking lot of the Bodie Island Visitor Center.[72] No record has been found that it was ever built in that location, and a sheet iron Oil House is referred to in 1909 as being 50' S.E. of the tower, which may be the actual original location of the 1896 supplementary Oil House.[73] A photograph taken between 1920 and 1930[74] shows a structure in that general location that matches a photograph taken in 1945 by the Coast Guard and labeled "Oil House".[75] The oil tank sketched on the 1890 plat map appears to be installed next to the flat- roofed oil house shown in these pictures. In 1898, the Bodie Island Lighthouse received telephone service as a result of a national defense initiative.[76] In 1912, the light was upgraded to an incandescent oil vapor lamp.[77] The brightly- burning, incandescent lamp was a great improvement over the old wick lamps.[78] During the 1920s, a "mechanical keeper" was installed to monitor the light, thus eliminating the need for one of the Assistant Keeper positions. The device consisted of a thermostat installed above the lamp and connected to an alarm installed in the Keepers' Quarters and to a recording device. If the lamp was extinguished, the alarm sounded in the Keepers' Quarters and a record was made of the event. Though this device eliminated the need for a Keeper to constantly watch the light while it was lit, the Keepers still had to strain the oil through a cloth to remove impurities to produce a clean, bright flame and make sure the lamp was properly lit. The re-

70. "Plat of Site of Body's Island L. Sta.," drawing, microfiche in the possession of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio.
71. Holland, p. 46.
72. "Plat of Site of Body's Island L. Sta.," drawing, microfiche in the possession of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio.
73. ----, "Description of Lighthouse Tower, Buildings, and Premises," 1909, p. 9.
74. Shelton-Roberts, p. 158.
75. Photographs in the records of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia. A photograph of a small, flat-roofed building approximately 10' square with a concrete stoop and what appears to be a fuel storage tank to one side is labeled "Oil House." Photograph of what was originally and is now called the Oil House is labeled "Engine House."
76. Holland, p. 46.
77. Ibid, p. 49.
78. Shelton-Roberts, p. 171.

cording device monitored whether the light was burning erratically, which occurrence could result in a negative report on the Keepers when the Lighthouse inspector made a visit.[79] On September 19, 1932, the lighting apparatus was converted to electricity.[80]

The upgrade to electrically- generated light significantly changed the operation of the Lighthouse. No longer was the Keeper required to mount the 214 steps to the top of the Lighthouse in the evening and again in the morning to light and to extinguish the light, not to mention the reduced effort involved in hauling fuel and supplies up the stairs to maintain the light and the lens. With the installation of the incandescent electric light, the candlepower rose to 160,000, and power was supplied by two oil-burning, 2 KW, 110V Kohler generators to four 250- watt rotating lamps on an Astronomic timing switch.[81] This change in operation also allowed the light to be converted from a fixed to a flashing light.[82]

The Tower was repainted in 1934. Keeper Gaskill persuaded the Commissioner of Lighthouses to allow him to hire local labor to perform this task. Consequently, Earl Mann, son of the manager of the Bodie Island Hunt Club, Fritz Hayman, and John Gaskill, the Keeper's son, were hired to do the job. John Gaskill described the arrangements for this task to Cheryl Shelton- Roberts for her book, *Lighthouse Families*. According to John, a box large enough for the painters to stand in was suspended by ropes on hooks attached to the stanchions of the gallery railing. "Every morning the three painters hoisted the box up the outside of the tower and then climbed over the railing and down … into the box. Armed with scrapers, paintbrushes, and the black and white paint they had mixed with zinc, lead, linseed oil, and turpentine – and as much courage as they could muster, the three men scraped and painted."[83] They started at the top of the tower and worked their way down, scraping, painting, and then lowering the box to the next work level. They could not paint if it looked like rain. "To paint the area under the [gallery], John put the ends of a board into the holes of the massive iron braces to make a scaffolding."[84] They made $3 a day.[85]

The United States Coast Guard assumed responsibility for the operation of the Lighthouse in 1940 and transferred all personnel away from Bodie Island. The Nags Head Lifeboat Station was given the oversight of the light,[86] which was lit by a bulb powered by an electrical generator operated by a timer. In 1941, the candlepower was reduced from 160,000 to 13,000,[87] possibly in response to national security concerns. A plot plan of the Lighthouse

79. Shelton-Roberts, p. 159.
80. Holland, p. 50.
81. Ibid, and "Gas Buoy Record Card, Bodie Island Light Station, N.C.", in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, n.d.
82. Holland, p. 50.
83. Shelton-Roberts, p. 162.
84. Ibid.
85. Ibid.
86. Crapster, T. G., in letter to Officer-in-Charge, Nag's Head Coast Guard Station, Manteo, North Carolina, dated 20 May 1940, from Lloyd V. Gaskill papers.
87. Holland, p. 50.

site, drawn in 1944, shows that the grounds and buildings around the Lighthouse remained much as they had been when a Keeper occupied the Double Keepers' Quarters.[88] Though the additional oil house erected in 1896 is not documented on the plot plan, photographs indicate one existed in 1945 that matched one in photographs taken in the 1920s. According to the plot plan, a fence enclosed both the original 15 acres and the perimeter of the walk between the Double Keepers' Quarters and the Lighthouse. The separate cisterns, storage buildings, and privies erected for the Keeper (on one side of the Double Keepers' Quarters) and the Assistant Keepers (on the other side of the Double Keepers' Quarters) remained intact, with walkways leading from the dwelling northwest and southeast to the perimeter of the site, the location of the privies. Although the National Park Service currently has the front entrance of the Visitor Center in the former Double Keepers' Quarters on the road side of the site, the dwelling was built to face the Lighthouse, [89] possibly because the site was originally accessed by boat before the construction, in the late 1920s, of a bridge and road to Bodie Island.

In 1945, the Coast Guard acquired an additional 40 acres around the Light Station, ostensibly for expansion purposes.[90] A power cable survey was performed in March of 1945, but it was another seven years before the Light Station was supplied with commercial electrical power.[91] The Watch Room and the first through seventh level landings were scraped and painted in July of 1945.[92]

During the Coast Guard's operation of the Bodie Island Lighthouse, weekly, monthly, and biennial inspections and reports were made regarding the condition of the Lighthouse, and repairs and maintenance efforts were undertaken. The Coast Guard personnel struggled with a faulty Astronomic clock for two years, from 1946 through 1948, before replacing it.[93] Then, the Kohler generators began to require frequent repairs.[94] The Lighthouse was finally converted from 110 V.O.C. to 3- wire, 120/240V commercial power on October 9, 1953.[95] The two original Kohler generators were removed. One of the generators was then replaced with a 1½ KVA, 110V A.C., single- phase, 60- cycle, automatic start, emergency standby Kohler generator, installed on the existing foundation.[96] A new, heavy- duty lamp changer was

88. "Bodie Island N.C. Light Plot Plan," in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 10 May 1944.
89. Holland, p. 41.
90. Ibid, p. 50 and "Preliminary Survey Description, Map of Proposed Area to be Acquired for Future Expansion, Bodie Island Lighthouse Station," in papers of the 5th United States Coast Guard District headquarters, Plymouth, Virginia, dated 22 Nov 1944.
91. "Power Cable Survey, Bodie Island Station and Lighthouse," in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 13 Mar 1945. It shows the area acquired by the Coast Guard in 1945.
92. "Gas Buoy Record Card, Bodie Island Light," in papers of the 5thUnited States Coast Guard district headquarters, Portsmouth, Virginia, n.d.
93. Ibid.
94. Ibid.
95. Ibid.
96. ----, "Memo" to Commanding Officer, Unmanned Aids Ashore in papers of 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 12 Jun 1953.

Figure 7 Bodie Island, 1969. Observation platform to the right of Tower.

installed.[97] The Tower was cleaned and painted.[98]

Thereafter, power difficulties occurred mainly as a result of interruption of commercial electrical power. Most of the maintenance activity involved recharging the generator batteries or replacing minor worn parts. The Coast Guard continued to inspect the Lighthouse and to make repairs and paint. The Tower and Oil House were scraped and painted in 1959 and again in 1963. The cost for painting the Lighthouse in 1963 was $3,375.00. The work was completed by U. S. Building Services of Virginia from Norfolk, Virginia. Also in 1963, the light was reworked, with a new lampchanger, a new generator, and flashers installed, and the candlepower was increased to 80,000. In February of 1964, the gallery railings around the lamp on the outside of the Tower were replaced and painted at a cost of $856.50.[99]

By 1964, the National Park Service had constructed an observation platform on the grounds at the location of the former detached Oil House. A nature trail was laid out, and signs were posted directing visitors to the attractions that were being developed on the property.

An electrical storm caused a power outage and damage to the Lighthouse and equipment in June of 1964. This necessitated the replacement of the electrical switch box, the main switch, the service entrance switch, two three- way switches for the Tower lights, one outlet box, and 14 broken windowpanes in the Tower.[100] The timing clock that operated the light at Bodie Island, which had been causing some trouble, was replaced with a photo- electric cell, 120V A.C., in May of 1969. The Coast Guard continued to inspect the Lighthouse regularly and to repair and refurbish as was necessary to maintain the light.[101]

In 1972, permission was granted to Offshore Navigation, Inc. to temporarily install a 3-pound radar beacon on the Lighthouse in con-

97. Ibid.
98. Purchase Order No. 05-13171-53, Painting of Bodie Island Lighthouse Tower, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 20 May 1953.
99. Maintenance Records in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, various dates.
100. Ibid.
101. Ibid.

nection with their seismographic operation.[102] Later that year, the Coast Guard began negotiations with the National Park Service to allow public access to a portion of the inside of the Bodie Island Lighthouse, provided such access did not interfere with the operation of the light.[103] The result of this arrangement, signed in June of 1973, was that the National Park Service agreed to make some required safety modifications to the Tower, including rebuilding and modifying the gallery structure by installing additional railing on the inward side, closer to the Tower, and repairing, replacing, and restoring the existing railing. In addition, the Park Service was required to paint the interior of the Tower and the portions of the Oil House that would be open to the public, to repair, replace, or restore, as necessary, the front entrance door, including the hardware, and to make any other necessary improvements that the Coast Guard required for the protection and safety of visitors to the Tower.[104]

102. Bullard, Ross P., Rear Admiral, U. S. Coast Guard, Commander, 5th Coast Guard District in letters to Offshore Navigation, Inc. from papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 5 May 1972 and 11 May 1972.
103. Masse, S. J. T., Chief, Civil Engineering Branch, U. S. Coast Guard, "Public Access to Bodie Light," in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 17 November 1972.
104. "Use Agreement, Bodie Island Light," signed by T. N. Miller, Property Officer for the U. S. Coast Guard, 5th United States Coast Guard District, and Robert D. Barbee, Superintendent, of Cape Hatteras National Seashore, National Park Service, Department of the Interior, in papers at the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 19 and 23 June 1973.

It appears that, by the end of 1974, the Bodie Island Lighthouse was still not open for public access, apparently because the National Park Service had not performed the repairs and maintenance required by the Coast Guard. On 12 November 1974, Lieutenant Junior Grade T. H. Donek met with personnel from the Cape Hatteras National Seashore to discuss the maintenance of the Lighthouse as required by the 1973 agreement. A walk- through of the facility was performed and deficiencies noted. LtJG Donek reported that the exterior paint of the Tower was in extremely poor condition, badly blistered and flaking, though the interior appeared to be in good condition except near the top of the Tower, where some moisture damage was evident. The spiral stairs exhibited surface rust and some cracked treads near the top of the Tower but were in generally good condition. Donek noted that the spiral stairs were unsupported except at the top and the bottom and could use some intermediate bracing. The Watch Room door needed replacing, and several of the wall plates on the east side of the gallery were badly cracked and rusted, with many of the thinner members wasted away. The entrance door and jamb of the Oil House were in need of replacement, as well as the floor, windows, and windowsills, which were reported as being termite- infested. The Oil House needed painting.[105]

It is unclear how the National Park Service and the Coast Guard resolved their differences re-

105. Donek, T. H., "Memo – Cape Hatteras Light and Bodie Island Light," in papers at the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 25 November 1974.

garding responsibility for the maintenance of the Bodie Island Lighthouse. By October of 1976, the National Park Service apparently had a use permit for visitation in place, though it seems to have been only for approach onto the grounds around the Lighthouse that were controlled by the Coast Guard, not inside the structure. At this time, the Coast Guard was reported to be replacing the wooden floor on one side of the Oil House.[106] A later paint analysis indicates that this was in the Work Room.[107] The National Park Service representative, John C. Garner, Jr., who observed this activity, expressed concern over whether or not the Coast Guard was complying with Section 106 procedures.[108] The paint analysis indicates that the Coast Guard re- layed at least some of the original wood floor boards, in compliance with Section 106 requirements.[109] Garner also iterated that the spiral stairs in the Tower were not supported between landings and were subject to "considerable movement when traversed."[110] Garner's trip to Bodie Island may have included a meeting with representatives from Industrial Non- Destructive Testing Co., Inc., of Charleston, South Carolina, the Department of Materials Engineering of North Carolina State University at Raleigh, North Carolina, and personnel from the National Park Service. A report issued by that group, which met on October 19 and 20, indicated that the structural integrity of the staircase at the Bodie Island Lighthouse was a complex problem that would require "complete testing of all components and extensive structural modification" before the public could safely be allowed access. They concluded that "[t]he present structure is unsafe for public use because of both the present extent of deteriorating due to apparent corrosion and the original design."[111]

By November of 1977, the roof of the Oil House had been replaced with asphalt shingles, and the main entrance door had also been replaced.[112] When these changes were made and by which government entity is unclear. No record of this work exists among either the records of the Cape Hatteras National Seashore at Manteo, North Carolina or the records of the 5th Coast Guard District Headquarters in Portsmouth, Virginia. John Gaskill relates that the original wooden shingles were first replaced with asbestos shingles, though he did not know the date.[113] Since he did not recall the Oil House ever having wooden shingles, it is likely that they were replaced around or before 1920. The 1893 photograph shows a rough- surfaced roof, which was likely the original wood

106. Garner, 1976.
107. National Park Service, *Historic Paint Finishes Study, Bodie Island Lighthouse and Oil House*, 2002, p. 32.
108. Garner, 1976.
109. National Park Service, *Historic Paint Finishes Study, Bodie Island Lighthouse and Oil House*, 2002, p. 32.
110. Garner, 1976.
111. ----, "Visual Inspection of Cape Hatteras and Bodie Island Lighthouses," from papers of the Cape Hatteras National Seashore headquarters at Manteo, North Carolina, (undated, but referencing the Oct 1976 meeting dates).
112. ----, "National Register of Historic Places Inventory Nomination Form, Bodie Island Visitor Center and Lighthouse," in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 9 November 1977.
113. Gaskill, John, to Deborah E. Harvey, e-mail dated 2 May 2002.

roof. The asbestos shingles that replaced it were unsatisfactory because, being brittle, they broke in high winds, so they were replaced with asphalt shingles, according to John Gaskill, sometime in the late 1920s.[114] Photographs from the 1920s and 1930s belonging to Gaskill shows a roof that appears to be of a lighter color than that in the 1893 photograph, but the composition is not discernable.[115] Photographs in the possession of the National Park Service and the Coast Guard appear to show a darker, rough shingle applied to the roof of the Oil House in 1948 through 1964. By 1969, however, photographs indicate a lighter roof again. It appears that roofs were routinely replaced without making mention of them in reports.

In 1977, some ice damage was reported at the Bodie Island Light Station. The starter motor to the emergency generator was replaced as a result of this damage, but the generator was beginning to reach the end of its useful life and require more frequent servicing.[116] The Coast Guard inspector recommended overhauling the one removed from Cape Hatteras and installing it at Bodie Island.[117] The inspector also reported that six panes of glass were cracked on one side of the Tower.[118] Both the Tower and the Oil House were painted in 1978.[119] The paint manufacturer expressed some concern at the time that the Coast Guard might be applying too much paint over the old paint if the sealer coat required in the specifications was used, but he was instructed to follow the specifications.[120]

The work request to overhaul the Onan Generator removed from Cape Hatteras and install it at the Bodie Island Light Station was signed on 2 February 1979. However, this plan was found not to be feasible because the Cape Hatteras generator was determined to be obsolete, with replacement parts not available. The order was cancelled. In April of 1980, authorization was signed to replace the existing emergency generator, citing it as obsolete and unreliable, with parts not available for maintenance and support.[121] Still, it was not until February of the following year that the procurement request was signed, authorizing the purchase of a new, diesel Onan generator and an Onan automatic transfer switch from the Paxton Company of Norfolk, Virginia, at a total cost of $9,906.00 after a 35 percent government discount.[122] An inspection in March of that year revealed that the existing generator would not start on loss of commercial power due to a dead battery.[123]

114. Ibid.
115. Shelton-Roberts, pp. 158 and 165.
116. Maintenance Records, Portsmouth, Virginia, various dates.
117. Baines, Charles A., Inspector, "Ocean Engineering Aids to Navigation Inspection, Bodie Island Light (LL-163)" in records of 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 18 October 1978
118. Ibid.
119. Ibid.
120. ----, Telephone Conversation Record of a conversation between a representative of the U.S. Coast Guard and Mr. Kalis, of Baltimore, Md. regarding Mr. Kalis' concerns over the painting of the Bodie Island Light Station, in the records of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 19 August 1977.
121. Maintenance Records, Portsmouth, Virginia, various dates.
122. "Procurement Request No. 10518" in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 20 February 1981.

A later report based on the inspection noted that the generator, the control panel, and the battery charger were due to be replaced in the fourth quarter of Fiscal Year 1981. It was recommended that the Coast Guard maintain the existing generator operational until replacement.[124] The March 1981 inspection also noted that the six cracked panes of glass remained and that the steel window casings were badly cracked at the Watch Room level. More rust was noted than previously, and several stair treads were noted as cracked. A new item on the inspection report was the notation of cracks in the wall below the Service Room, extending five levels, 180 degrees apart.[125]

In August of 1981, the work order to replace the existing obsolete Onan engine generator with a 6KW Onan Engine generator was finally signed for both the Bodie Island and the Currituck Beach Lighthouses. In September, a request for additional funds ($150) was made to cover the cost of purchasing three transformers. By the 23rd of the month, the original work order was reported as being complete at a cost of $1,456.00 (for both lighthouses), stating that additional work of renewing the service entrance cable, main disconnect, and watt hour meter was required at Bodie Island.[126]

The biennial inspection report of 1983 continued the trend begun in 1981 of reporting an increasing number of maintenance items and structural concerns, though the superstructure of the Lighthouse continued to be reported as safe. Metal parts were increasingly described as rusty, and condensation was reported on the inside of the window frames. The biggest concern that year, though, was that the lightning protection grounding conductor on the east side was frayed and a potential safety hazard.[127] By March of the next year, the lightning protection grounding conductor was reported to have been repaired.[128]

In November of 1983, the United States Coast Guard inspected the Lighthouse, along with the National Park Service, which wanted to present historical programs within the Lighthouse, and Thomas Dunn of the 5th District Coast Guard issued a memo regarding what should be done to the Lighthouse to make it safe for the general public to tour. It was determined that, since the generator was subject to

123. May, D. R., Lieutenant, Junior Grade, "Ocean Engineering Aids to Navigation Inspection, Bodie Island Light (Ll-163)" in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 12 March 1981.
124. ----, Commander, 5th United States Coast Guard District in memo to Commander, U.S. Coast Guard Group Cape Hatteras, in papers of 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 6 April 1981.
125. May, 1981.
126. Work Orders in papers of 5th United States Coast Guard District headquarters, Portsmouth, Virginia, various dates.
127. Slade, H.B. and C. A. Baines, "Ocean Engineering Aids to Navigation Inspection, Bodie Island Light (LL-163), in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 12 October 1983, and Memo from Thomas M. Dunn, at the direction of the Commander, Fifth Coast Guard District, to the Commanding Officer, Coast Guard Group Cape Hatteras in the papers of the 5th United States Coast Guard District Headquarters, Portsmouth, Virginia, dated 15 November 1983.
128. DeLong, John P., Commander, Coast Guard Group, Cape Hatteras in memo to Commander, Fifth Coast Guard District in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 22 Mar 1984.

start at any time during a loss of power, the room in which the generator was set must remain off limits. One window in the lower level required replacement, and a security fence was to be installed at the bottom of the spiral stairs. It was suggested that the National Park Service provide funding for these improvements.[129] By May of 1984, a work request for the installation of the security fence at a total cost of $650 had been issued and signed.[130] In addition to the installation of the security fence, the Oil Room was painted.[131]

Another work order for the Bodie Island Lighthouse was signed in November of 1984. This one provided for the conversion of the light to solid state at a cost of $790.00.[132] The work was apparently completed in June of 1985.[133] At the same time, it was reported that the fuel tank was leaking due to deterioration and should be replaced.[134] At the end of the year, M. Roman and Chief Midgett also recommended in their biennial report on the Lighthouse that the 30- gallon diesel tank be replaced. The list of needed repairs was growing longer. They also reported that the window frames and ceilings of the Oil House were infested with termites to an unknown extent and that the upper windows should be replaced, that the steel and iron at the top of the Tower was in extremely poor condition and should be repaired, and that the cracks, previously noted on earlier inspections, should be repaired as soon as possible. They recommended fabricating a new bug screen for the main gallery and re- pointing and painting the exterior brick. The recommendation was to make the repairs in 1986 and paint the structures in 1987.[135] A hand- written list attached to the biennial report contained suggested repairs not included in the official report: replace the roof on the Oil House, especially over the Oil Room, replace the main door frame in the Oil Room, repair the tongue- and- groove ceiling in the Work Room, and replace a total of four window frames. All these suggested repairs were a result of noted termite damage.

In September of 1986, repairs were begun on the termite damage to the door and window frames and the ceiling in the Oil House, in addition to treating it for termites.[136] There is no mention of roof replacement. The specifications for repainting the Lighthouse were issued in January of 1987.[137] The estimated cost was

129. Dunn, Thomas M., Memo to unknown party, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 16 November 1983.
130. "Work Request No. 36-84" in the papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 22 May 1984.
131. Maintenance Records of the Bodie Island Light Station in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 13 July 1984.
132. "Order for Supplies or Services, No. DTCG27-85-P-50428" in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 21 November 1984.
133. "Work Order Number J319-85" in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 7 June 1985.
134. Maintenance Records of the Bodie Island Light Station in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 25 June 1985.
135. Roman and Midgett, "Ocean Engineering Aids to Navigation Inspection, Bodie Island Light, (LL-163)" in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 17 December 1985.

$14,682.30.[138] The procurement request asserted that the painting of the Lighthouse would be beyond the capabilities of the Cape Hatteras Group Coast Guard unit.[139]

The report of the semi- annual group inspection of lighthouses of 1988 made only a few minor recommendations for improvements to the Bodie Island Lighthouse, including replacing the six cracked window panes that were first reported in 1977, repairing a light switch at the door to the outside along the gallery, repairing the lightning ground cable, and repairing the fallout shelter sign.[140] In March, the fuel pump to the emergency generator had to be replaced.[141] In April, the Coast Guard erected a VHF- FM Hi- Level Site Communication Antenna on the watch gallery railing of the Bodie Island Lighthouse,[142] much to the consternation of the North Carolina Department of Cultural Resources, who received the news after the fact.[143] The Department was not so concerned with the attachment of the antenna to the railing as it was with the impact of the installation of power cables to the visual presentation of the historic site.[144]

In July of 1989, an inspection and structural evaluation was performed and a report prepared by the U.S. Army Corps of Engineers on the Bodie Island Lighthouse on behalf of the United States Coast Guard Shore Maintenance Detachment.[145] It was the first of several more thorough investigations into the condition of the Lighthouse. The report was based only on a visual inspection; no materials testing or other evaluation requiring instruments was involved. Some exterior components of the Tower were not closely inspected because that activity would have required construction of exterior scaffolding. A copy of the report of the Corps of Engineers is included as an appendix to this report. It is summarized as follows.

136. ----, Tele-com, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 8 July 1986. Shows schedule is to inspect on 30 July, demolish 20 September, treat for termites 25 September, order materials, and rebuild in October and November.
137. "Specifications for the Exterior Painting of Bodie Island Light Tower Located on Bodie Island Near Oregon Inlet, North Carolina, Specification No. 7688," in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated January, 1987.
138. Procurement Request to "provide services and materials to paint Bodie Island Lighthouse LL-245," in papers of the 5th United States Coast Guard District headquarters, dated 23 January 1987.
139. Ibid.
140. Phillips, M. L., "Report of Semi-Annual Group Inspection of Lighthouses," in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 6 October 1988.
141. Maintenance Records, Bodie Island Light Station in papers of the 5th United States Coast Guard District, Portsmouth, Virginia, dated 28 March 1989.
142. Malmrose, J. C., Commander, U. S. Coast Guard, Supervisor, Shore Maintenance Detachment in letter to William S. Price, Jr., State Historic Preservation Officer, North Carolina Department of Cultural Resources, in papers of the United States Coast Guard Shore Maintenance Detachment, Cleveland, Ohio, dated 7 April 1989.
143. Brook, David, Deputy State Historic Preservation Officer, North Carolina Department of Cultural Resources, in letter to J. C. Malmrose, Commander, U.S. Coast Guard, Supervisor, Shore Maintenance Detachment, in papers of the United States Coast Guard Shore Maintenance Detachment, Cleveland, Ohio, dated 25 April 1989.
144. Ibid.
145. Wilmington District, U.S. Army Corps of Engineers, Wilmington, North Carolina, "Bodie Island Lighthouse, Dare County, North Carolina Inspection Report," in papers of the United States Coast Guard Shore Maintenance Detachment, Civil Engineering Department, Cleveland, Ohio, dated July 1989, cover, n.p.

Figure 8 1989 USCOE photo showing cracked masonry in Oil Room interior chimney.

In the Oil House, the ceiling boards and wood molding next to the south chimney wall exhibited signs of water damage, likely caused by deteriorated chimney flashing or bricks. There were cracks and displaced bricks on the inside chimney walls that were probably caused by thermal expansion. The Corps recommended that the wood framing around the chimneys be checked for deterioration and replaced if warranted and that the chimneys be checked for soundness. They suggested that flashing around both chimneys be replaced, and, though the roof did not appear to be leaking, that roof replacement would likely become necessary within the next several years.

The report noted that the exterior masonry of the Tower appeared "in good condition,"[146] including the stone foundation, and had been painted within the past three years (the stone foundation had not been painted). The Corps noted the vertical cracks on the interior masonry beginning at level five and ending just below level nine on the north and south sides of the Tower, the same cracks noted in previous reports. The cracks began or ended at intersections of the stair landing support beams and the wall. Corps engineers concluded that the cracks were caused by "a combination of the corrosion of the support beams and thermal expansion of the wall."[147] Additionally, several vertical cracks were noted near the windows on level nine, probably caused by the same factors. These cracks were not considered to compromise the integrity of the walls or stair landings.

The Corps reported that, in addition to some deterioration of the window frames, the windows in the Tower did not close properly and, therefore, water penetrated to the interior from the outside. The frames at level nine, which are part of the ornamental bracket and panel system below the gallery platform and serve as an anchoring system for the gallery platform brackets, were cracked and had "separated significantly at three of the four windows,"[148] allowing water to leak down and behind the frames, corroding the frames, and deteriorating the masonry behind them. The cause of the cracked frames appeared to be differential thermal movement between the cast iron brackets and the masonry of the supporting wall.

The stairs and landings were found to be in generally good structural condition, though some corrosion on all units was noted as well

146. Wilmington District, U.S. Army Corps of Engineers, 1989, p. 2.

147. Ibid.

148. Ibid.

Figure 9 1989 USCOE photo showing deterioration of exterior edge of lantern gallery.

Figure 10 1989 USCOE photo showing missing lantern deck prisms.

as corrosion on "the ends of the landing support beams embedded in the masonry wall and at the edge of each stair landing where the landing abuts the tower wall."[149] This corrosion was felt to be the result of "moisture entering through openings above the gallery level"[150] and through "the poorly fitted tower windows"[151] and condensate forming on the stairs and landings as a result of high humidity levels on the interior due to a lack of ventilation. The extent of the corrosion was not considered severe in 1989.

Beneath the gallery, the Corps noted that a complete inspection of the cast iron support system was not possible due to limited access to the underside of the gallery deck. An inspection of this portion of the Tower would require the construction of a scaffolding system. The Corps suggested that this be done in the near future in order to identify portions of the system that had deteriorated and to repair those portions that might fall, endangering visitors below. From visual observations of the support system from within the Tower, through the windows below the support system, it was noted that there were "cracks in the gallery belt course under the support brackets, missing sections of the support brackets, and corrosion damage to the brackets and gallery deck."[152] Additionally, the cast iron handrail and posts around the gallery had deteriorated from corrosion as much as 40 percent in some places. However, this was not felt to be a structural problem. The Corps reported that the gallery deck plates did not exhibit any cracks, displacement, or settlement, indicating that the support system below the plates was probably also sound, though they did not investigate it due to lack of access. The gallery wall plates, however, did show "significant" cracking, with some cracks running "the entire width of the plate section."[153] The Corps speculated that the cause of these cracks was

149. Ibid, p. 3.
150. Ibid.
151. Ibid.
152. Ibid.
153. Wilminton District U.S. Army Corps of Engineers, 1989, p. 3.

Figure 11 1989 USCOE photo showing detached hinge on door to gallery.

probably corrosion on the back side of the plates and thermal expansion.

According to the report, the "ornamental iron work surrounding the exterior edge of the lantern gallery [showed] significant deterioration," with "sections of the iron work … missing or separated from the deck."[154] One result of the missing iron work was that birds were building nests in the vent accesses. The report noted that bars under the eave of the lantern roof, used to support a moveable ladder, were heavily corroded and one had become completely detached. However, the lantern balcony and interior deck were reported to be "in good structural condition, [with] no visible cracks or significant corrosion of the support system below the deck."[155] Leaking of the surrounding exterior lantern windows, caused by cracked glass and poor caulking, had caused slight corrosion of the top surface of the inner portion of the deck. Though not mentioned in the report, photographs accompanying it also show that some of the deck prisms, designed to allow light to penetrate below the lantern gallery level to the watch level, were missing. The roof of the lamp, though not inspected, was judged to be in good condition based on a lack of evidence to the contrary from the underside of it.

154. Ibid, p. 4.
155. Ibid.

The Watch Room doors leading from the Watch Room beneath the lantern gallery to the exterior gallery deck were considered to be in good condition, although the bottom hinge on the right side door had separated from the jamb.

Overall, the Bodie Island Tower and Oil House were found to be in generally good condition, with one area of concern being the cast iron support system of the gallery, which could not be inspected. The Corps estimated that the cost for the repairs suggested for the stabilization of the structure and prevention of further deterioration would be $18,600.[156]

Later in 1989, the Coast Guard performed its own inspection of the Bodie Island Lighthouse as part of its annual inspection program. The inspector's report was much less detailed than that submitted by the U.S. Army Corps of Engineers earlier in the year. The main recommendation of his report was that the electrical wiring needed to be inspected and replaced as necessary.[157] In August of 1990, J. A.

156. Wilmington District, U.S. Army Corps of Engineers, 1989, p. 5.
157. Reed, M.L. (by direction), "Memo from Commander, Coast Guard Group Cape Hatteras to Commander, Shore Maintenance Detachment, Cleveland, in papers of the United States Coast Guard Shore Maintenance Detachment, Civil Engineering Unit, Cleveland, Ohio, dated 17 Jan 1990.

Chop, CWO2 of the United States Coast Guard, also made a trip to the Cape Hatteras Group for the purpose of inspecting the light stations under their care. He reported that the Bodie Island Lighthouse was equipped with non- standard emergency generator and transfer unit equipment and that the Oil Room, which housed an electric heater, lead acid batteries, diesel fuel, and the generator set, was not equipped with an automatic fire suppression system.[158]

The electrical work suggested in the 1989 inspection report was apparently completed in 1992, as evidenced by a statement written and signed by one of the workmen, Edward J. Thacker, regarding the cause of damage to several of the stairs of the Tower.

> "On 5 May 1992, I, Edward J. Thacker, was working on Bodie Island Lighthouse removing one inch conduit that was running from the top floor of the Light to the Emergency Generator Room located on the ground floor. I was on the 6th staircase landing removing the conduit with a pipe wrench and a hacksaw when a section of conduit about 15 ft. long slipped away from me as I was unthreading it. This section of conduit had a 2" x 4" junction box on it that must have caught on to part of the staircase below me which directed it to the center of the staircase steps. The conduit then passed through one step on the staircase between the 2nd and 3rd landing. It then passed through two steps on the next staircase between the 1st and 2nd landing. Then it passed through one more step on the next staircase between the 1st landing and the ground floor. [signed] Edward J. Thacker [typed] Edward J. Thacker.[159]"

Regardless of the upgrades to the electrical service, it appears that, by 1992, wind, weather, and a certain amount of deferred maintenance had taken their toll of the Bodie Island Lighthouse. After the 1992 inspection, the inspector reported, "This light is in the worst shape out of any that I inspected on this trip."[160] The inspector expounded on his comment as follows:

> "This brick lighthouse is in poor condition. The exterior needs to be tuckpointed and painted. Shifting in the foundation has caused major cracks that run from the fourth level to the top. Damaged and missing stairs and the poor condition of the flooring are liability concerns which should be addressed. The majority of the windows and doors have rotted and need to be replaced. The lantern and gallery levels are in extremely bad condition; work involves poor exterior servicing ladder, missing and deteriorated handrail sections, and the fascia band around the decking which has worked its way loose and has deteriorated.
>
> Bodie Island is a brick lighthouse with a concrete and stone foundation. The granite around the base is chipped and spalled and is in overall good shape [sic]. The brick on the exterior is in good

158. Chop, J. A., CWO2, USCG, in Trip Report in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 24 October 1990.

159. "Biennial Lighthouse Inspection Report," 1994.

160. "Bodie Island Light (LLNR 505) Report for Group Cape Hatteras, aNT, Kennebec," in papers of Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, 1992.

> shape (visually) and only needs to be tuckpointed and a paint job. The interior view of the bricks shows major cracks that run along the interior from the 4th level up. This crack appears to be caused by some shifting of the foundation. The interior stairs are cracked at the same place in six locations. Recently, the Coast Guard had an accident and a piece of conduit fell and damaged about five steps including one which is totally missing. The marble flooring located in the entry level is in extremely poor condition and needs replacing/repair. All of the windows/doors have wooden casings which are rotted and need replacing. The interior of the light has paint spalling and the brick needs repointing and painting. The top portion of the tower is cast iron and is cracked in several places. It is in poor structural condition and needs major work. The ladder on the exterior of the gallery level to the exterior of the lens level is showing signs of member deterioration and it is scary to climb up it due to its location. The fascia band around the lens level decking has worked its way loose and is rusting badly. It needs to be replaced. The stanchions and handrails are all corroded and need replacement."[161]

The inspector was sufficiently alarmed that he recommended immediate action regarding repairs to the Lighthouse, estimating that it would cost about $55,000.[162]

The deterioration of the Lighthouse appears to have been, in part, the result of misunderstanding between the United States Coast Guard and the National Park Service regarding responsibility for the maintenance of the structures. J.A. Chop, CWO2 of the United States Coast Guard, after his trip to the Cape Hatteras Group, reported that

> "a significant problem ... is the confusion in maintenance responsibility. The Park Service allegedly holds the responsibility for all maintenance on the LT though this cannot be confirmed until the individual lease agreements are reviewed. Presently, some work is not being accomplished because one party (Park Service) thinks the other (Coast Guard) is responsible to do it. In addition, the procedure for one agency to submit work requests or report problems to another is not clear. Work is not done until major complications arise."[163]

The Coast Guard must have taken at least some of the concerns of the inspector to heart. On 22 October 1993, a request was made for a structural evaluation of the Bodie Island Lighthouse, stating that temporary repairs had been made to broken stair steps in order to continue servicing the light and referencing a VHS tape showing the interior deterioration.[164] The request was also to make necessary repairs based on the structural evaluation. Unfortunately, the tape seems to have disappeared and was not available for viewing at the headquarters of the 5th District United States Coast Guard at Portsmouth, Virginia, the Shore Maintenance

161. Ibid.
162. Ibid.

163. Chop, J. A., CWO2, USCG, 1990.
164. Ransone, S.B., "Shore Maintenance Record, GB02-94 for Discrict 05, USCG Group Cape Hatteras" in papers of the Shore Maintenance Detachment, Civil Engineering Unit, United States Coast Guard, Cleveland, Ohio.

Figure 12 USCG close-up photograph of damage to stair treads, 1992.

Figure 13 USCG photograph of damage to stair treads, 1992.

Detachment, Civil Engineering Unit in Cleveland, Ohio, or the Cape Hatteras National Seashore headquarters at Manteo, North Carolina.

On 25 January 1994, Mr. Ward of the Civil Engineering Unit, Cleveland, and BM3 Barry of the Cape Hatteras Group, both of the United States Coast Guard, made another biennial inspection of the Bodie Island Lighthouse. The 1994 report described a less grim picture of the structural condition of the Lighthouse, though it continued to need cosmetic attention and other repairs. The inspector reported that the structure was in good overall condition with no major structural deficiencies, including the granite block foundation, though some lime leaching of the mortar was observed. Except for the foundation, the exterior masonry exhibited minor cracking throughout, and larger cracks were observed through the upper four sections of the Tower, running in a longitudinal direction. The inspector recorded that the interior masonry near the top of the Tower showed signs of moisture intrusion, evidenced by deteriorated brick and joints and by severe corrosion on the adjacent metal surfaces. He noted that the stairs exhibited pitting and rust and that approximately eight stair treads had been damaged, though two, broken during the 1992 electrical demolition, had been replaced with steel plates. The stairs also tended to be unstable during climbing due to a lack of lateral support. All metal surfaces throughout the structure exhibited rust as well as pitting and material loss in some places. Cracking of the exterior cast iron trim work around the perimeter of the lantern gallery reduced the allowable safe working load on the deck, and some of the exterior handrails had lost material due to the corrosive action of the weather. The coating system on the exterior iron surface at the Lantern and Watch Room levels was also beginning to exhibit signs of pitting and deterioration. Four of the lantern glass panes had cracked, and interior window channels showed signs of standing water. The plexi- glass glazing in six of the 48 window frames, probably those installed in 1988, had clouded significantly. The wood frames of the windows throughout the Tower and the main entrance doorframe had experienced considerable wood rot. Some of the asphalt roofing material on the Oil House had deteriorated. The interior plaster walls and ceiling in this building were cracked and broken in several locations, the cupola roof was badly corroded, and the fascia was cracked and pitted.[165] The inspector also noted, perhaps in contrast, that the grounds surrounding the Lighthouse and the associated outbuildings were well maintained by the National Park Service.[166]

The inspector recommended that the Coast Guard repair the damage done by personnel performing the electrical work in 1992 and add lateral bracing to the stairs to stabilize them. In addition to this work, the inspector recommended replacing the broken, cracked, and clouded lantern glazing with Lexan, sealing all glazing to prevent water intrusion, and cleaning and painting all iron surfaces, both interior and exterior, in the Lantern Room. The inspector recommended notifying the National Park Service that cleaning and painting of the main access stairs and interior masonry repairs at the Watch Room level were required, as well as repair of the masonry cracks and spalling and exterior iron work at the Lantern Room gallery and cupola. Despite any repairs to the exterior iron work, the inspector recommended that personnel accessing the exterior Lantern Room gallery be limited to two.[167]

Probably in response to these recent reports of maintenance requirements at the Bodie Island Lighthouse, R. A. Koehler, Commander of the U. S. Coast Guard Civil Engineering Unit of the Shore Maintenance Detachment in Cleveland, Ohio, wrote to Dr. William S. Price, Director of the Division of Archives and History of the North Carolina Department of Cultural Resources, in August of 1995 regarding proposed refurbishment work at the Bodie Island Light Station. The Coast Guard proposed to repair the damaged interior cast- iron stair steps in place and in kind, paint all interior metal surfaces including stairs and handrails, paint all exterior metal surfaces, repair damaged window glazing and frames, and tuckpoint any cracked masonry.[168] The Deputy State Historic Preservation Officer responded that the North Carolina Department of Cultural Resources concurred with the proposal of the United States Coast Guard regarding the refurbishment of the Bodie Island Lighthouse.[169]

165. "Biennial Lighthouse Inspection Report, 1994."
166. Ibid.
167. Ibid.
168. Koehler, R. A., Commander, U. S. Coast Guard in letter to William S. Price, Jr., Director of the Division of Archives and History, North Carolina Department of Cultural Resources, in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 15 August 1995.

However, no repairs were undertaken until two years later.

On 11 September 1995, another Coast Guard inspection of the Bodie Island Lighthouse was made, and it was determined that "the current condition of the lighthouse is virtually unchanged since the 1994 inspection."[170] The inspector in this case also reported that the exterior paint was reaching the end of its useful life, having been applied eight years previously.[171] The 1995 inspection report recommended that the painting of the Lighthouse be scheduled within the next three years, and noted that a project scheduled for FY96 included minor tuckpointing, repair of the spiral staircase, window frames, and gallery metalwork but was part of a backlog of scheduled projects.[172] The inspector suggested that the replacement of the cracked and clouded panes with Lexan, the resealing of the glazing and the cleaning and painting of the Lantern Room could be accomplished at the unit level, apparently without a submittal to the Civil Engineering Department.[173] By October, the endorsement for the work cited for unit level accomplishment had been signed, with a notation to ensure that all damaged Lantern Room windows be replaced with safety glass. However, the proposed painting of the Lighthouse was not submitted while research was underway to determine when it should be accomplished.[174]

Writing in May of 1996 to the Commander of the Fifth Coast Guard District, the Commander of the Coast Guard Group Cape Hatteras stated

> "Since the biennial inspections conducted [2 Oct 1995 and 8 Jan 1996], conditions at ... Bodie Island Lighthouse (LLNR 590) continue to deteriorate at an increasing rate. The paint coatings in the lantern galler[y] ... have failed allowing corrosion to advance on the gallery framing. ... Additionally, structural deterioration at Bodie Island Light is making the light unsafe for personnel to maintain the light gallery and optics. Cracks in the brickwork beneath the light gallery have lengthened, weakening the I beam anchor points for the landing.
>
> P/N C3278 RPR/PAINT BODIE ISLAND LIGHT ... refer[s] to the structural repairs ... and require immediate attention to preserve the light structures and to allow personnel safe access to the light galleries to accomplish required maintenance. ... I strongly recommend that the repair projects process be hastened to minimize further structural damage ... as well as to prevent possi-

169. Brook, David, Deputy State Historic Preservation Officer, North Carolina Department of Cultural Resources in letter to R. A. Koehler, Commander, U. S. Coast Guard, Civil Engineering Unit in papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated 12 September 1995.
170. "Biennial Lighthouse Inspection Report, Fifth District, Bodie Island Light, LLNR 590," in the papers of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, dated 1995.
171. Ibid.
172. Ibid.
173. Ibid.
174. Walters, J. R. (by direction), in "First Endorsement" from Commander, Fifth Coast Guard District to Commander, Coast Guard Group, Cape Hatteras in papers of the 5th Coast Guard District headquarters, Portsmouth, Virginia, dated 2 October 1995.

> ble personnel injury to maintenance personnel."[175]

In July of 1996, a structural evaluation of the Bodie Island Lighthouse was conducted by Alden and Associates of Reading, Pennsylvania at the request of Cheryl Shelton-Roberts, President of the Outer Banks Lighthouse Society.[176] The Outer Banks Lighthouse Society was formed in 1994 as a non-profit, citizen effort to aid in the preservation of the buildings and artifacts of the lighthouses in the area. A copy of the report may be found in the Appendix to this report. It is summarized as follows.

> Alden and Associates, like the Corps of Engineers before them, made a visual inspection of the Oil House and Tower and reported on their findings. They did not engage in any removal of materials for testing, build scaffolding or employ any other means of exploring the condition of the Lighthouse that could not be accomplished without such aids. The inspection of the exterior of the Tower revealed stains and possible masonry deterioration on the south side in the uppermost and middle white bands and on the east side above and adjacent to the windows in the uppermost and middle white bands and in the upper black band. Additionally, at least one of the cast iron supports for the gallery was missing, though the cause was not determined. This is the first recorded instance of this condition.

> On the interior of the Tower, the circular cast-iron stairs, landings, platforms, structural supporting members, and railings were found to be severely rusted and corroded. The report speculated that the paint on the metal work appeared to be lead-based and had, in some places, been hand-sanded. The "[c]ondition of the stairs is deplorable and in some instances, dangerous."[177]

Of the brick walls of the Tower, the report noted cracks from below the fourth landing through the seventh landing. These cracks are the same as those that were reported beginning in 1981. The report noted that "the further up you go, the more the brick walls [are] cracked and deteriorated. Water penetration has obviously been severe. Some repointing has been unsuccessfully done."[178] Alden and Associates postulated that the cracking was probably due to "severe windloading"[179] and suggested that the structural integrity of the Tower could be in doubt. The report stated that "the greatest proliferation of cracks is in the vicinity of the Seventh Landing thus indicating that the greatest amount of lateral movement in the tower takes place around the Seventh Landing,"[180] and also noted "some evidence of misalignment of the stairs with the brick walls"[181] at the sixth landing.

The windows of the Tower were reported as being generally in need of maintenance, with gaps reported between some window sashes

175. Letter from Commander, Coast Guard Group Cape Hatteras to Commander, Fifth Coast Guard District (oan), in papers of the Shore Maintenance Detachment, Civil Engineering Unit, United States Coast Guard, Cleveland, Ohio, dated May 1996.
176. Alden and Associates, 1996, cover.
177. Ibid, p. 6.
178. Ibid.
179. Ibid, p. 7.
180. Ibid.
181. Ibid.

and sills, inoperative hardware, and rotted wood components.

The report on the Tower was organized by levels. By the eighth level, the investigator was clearly disturbed by the condition of the Tower. Of the eighth landing, he observed,

> "Extensive water penetration is very evident. Most of the paint has peeled off. Some bricks should be replaced. Some mortar is VERY bad. Some pointing has been done in this area some time in the past, but with minimal effort, it can be pulled out of the joints. This entire [area] should have deteriorated brick replaced, tuckpointing in depth should be done with an expanding type of specially blended and formulated tuckpointing mortar."[182]

The investigator's comment about the Watch Room and interior gallery was that the "entire area is in deplorable condition."[183] The description of this area indicated severe rust and corrosion on all ferrous metal parts, including the lens and lantern gallery supports as well as the stairs and railings. The attachment of some of the electrical conduits to plywood mounted on steel framing, in violation of the National Electrical Code, was noted, as was a missing cover from a condulet box that left wiring exposed. The investigator also noted the missing glass prisms from the overhead walkway.

In reviewing the condition of the lantern level, the report noted that the tube through the mantel at the top of the lens, which was originally used to vent smoke and gasses from burning oil, was stuffed with paper towels and rags and that the metal was rusting. This condition of rusting was evident on all metal parts of the lantern room and interior and exterior galleries. In addition, it was noted that some of the metal hardware for operating the vent windows was missing, and some of the glass panes of the windows were broken.

The report explored the ventilation of masonry construction lighthouses in the United States, noting that the ventilation originally provided to the Bodie Island Lighthouse had, over the intervening years, been closed, a fact that was a cause of the high humidity levels inside the tower, which, in turn contributed to the deterioration of the components and the surface treatments.

In reference to the Oil House, the report noted "some type of cementitious coating applied over the brick walls"[184] which appeared to be in need of repair. Additionally, the investigators speculated that lead paint covered the wood surfaces. "Rusted anchors were noted at several roof structure support members" of the roof, and "the structural integrity of these anchors is questionable."[185] It was inferred from water stains that the roof sheathing of the Oil House had rotted in some places. At the transition between the wood ceilings and the underside of the brick arch to the light tower, staining indicates evidence of a "water leak probably occurring at the roof flashing where

182. Alden and Associates, 1996, p. 2.
183. Ibid, p. 8.
184. Ibid.
185. Ibid, p. 4.

the [Oil House] roof meets the Tower wall."[186] It is evident from the report of Alden and Associates that the Coast Guard had done very little to rectify the problems outlined in the 1989 report. It seems that there was still a lack of agreement between the Coast Guard and the National Park Service regarding which entity was responsible for the maintenance of the Lighthouse.

In a 1996 fax to Cheryl Shelton- Roberts of the Outer Banks Lighthouse Society, Lieutenant Edward Westfall, Fifth Coast Guard District Lighthouse Program Manager, indicated that a "more detailed architectural/engineering study" was needed for the Bodie Island Light and that such a study would be contracted before October 1, 1996.[187] Whether he was aware at the time of the study done by Alden and Associates is unclear. The fax includes, at the bottom, handwritten notations regarding responsibility for repairs and timetables, and a note within the body of the fax stating that Lieutenant Westfall was "confident that OBLS and the CG can negotiate a license or outlease that allows the OBLS to do some things at the site…. [T]he CG position is that we want to develop creative flexible agreements that work with any organization willing to shoulder some of the responsibility for these lights."[188]

However, the Coast Guard may have been made aware of the possibility of lead paint in the structure. Later in the year, Frederic R. Harris conducted a visual inspection of the Bodie Island Lighthouse while collecting paint samples for lead paint analysis. Laboratory analysis of the paint samples indicated that the coatings of Bodie Island "substantially exceed regulatory levels" for lead.[189] A copy of the Bodie Island portions of that report (it was combined with a report on the Reedy Island Lighthouse) is included in the Appendix of this report.

Specifications were issued for the painting of the Bodie Island Lighthouse in March of 1997,[190] and it was subsequently repaired and repainted at a cost of $148,623.[191] Additional items in the specifications were for the replacement of five of the wooden windows in the Tower and four at the Watch Room level, repointing of the interior brickwork at the Watch Room and gallery levels, replacement of 15 of the 48 Lantern Room windows and resealing all 48 Lantern Room windows, fabrication and installation of four steel covers for the damaged stair treads on the spiral staircase, repair of the cast iron cracks on the exterior of the gallery level wall, gallery level catwalk, and lantern level catwalk, and sealing of approximately 150

186. Alden and Associates, 1996, p. 5.
187. Westfall, 1996.
188. Ibid.
189. White, B. S., Memo from Commanding Officer, Coast Guard Civil Engineering Unit Cleveland to Commander, Fifth Coast Guard District (oan), in papers of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, dated 10 Oct 1996.
190. "Specifications to Repair/Paint Bodie Island Light, Outer Banks, North Carolina," in the papers of the 5th United States Coast Guard District headquarters, Portsmouth, Virginia, dated March 1997.
191. "Biennial Lighthouse Inspection Report, Fifth District, Bodie Island Light, LLNR 590," noted "Information current as of 10/1/97 in papers of the Civil Engineering Unit, Shore Maintenance Detachment, United States Coast Guard, Cleveland, Ohio, 1997.

Figure 14 Existing repairs to stair treads.

linear feet of masonry cracks in the lighthouse.[192] Additive bid items in the specifications called for surface preparation and painting of the spiral staircase and landings up to, but not including, the Watch Room level. The 2002 inspection of the Lighthouse by personnel from Hartrampf, Inc. and the Office of Jack Pyburn, Incorporated noted a fairly recent painting of the staircase and landings, as well as metal plates installed in place of the damaged stair treads. It should be noted that these metal plates do not meet the criteria for "repairing in kind" suggested in the 1995 letter of R. A. Kohler to Dr. William Price.[193] Additionally, the paint scheme appears to have been changed from that in the specifications, which called for following the existing paint scheme. The stairs, painted gray or brown at the time, according to the 2002 paint analysis,[194] were painted black.

192. "Specifications to Repair/Paint Bodie Island Light, Outer Banks, North Carolina," 1997.
193. Kohler, 1995.

In mid 1997, the biennial inspection of the Bodie Island Lighthouse was conducted, and a one- page report issued on the status of the Lighthouse stated that a survey (that done by Frederic R. Harris) showed that there was lead- based paint on both the interior and exterior of the Tower. The report noted that an asbestos survey had not been completed, but that it was unlikely that any asbestos- containing material (ACM) was present. (However, see Electrical Evaluation of this report for further information regarding ACM in the buildings.) The report also stated that the original first-order Fresnel lens was still in service. According to the report, the Lighthouse was likely to continue to be needed by the Coast Guard until 2010, though it was in the process of being transferred to the National Park Service. In addition, the Outer Banks Lighthouse Society had received a limited license for cleaning and ventilating the interior of the Lighthouse. [195]

Another report on the condition of the Bodie Island Lighthouse was generated in 1997. It was based on an inspection by Cullen Chambers, of the Tybee Island Historical Society, sponsored by the Outer Banks Lighthouse Society. Though prefaced by a disclaimer that all observations should be verified by a registered Structural Engineer, the report is thorough in its scope and detailed in its recommendations.

194. National Park Service "Historic Paint Finishes Study, Bodie Island Lighthouse and Oil House," 2002, pp. 23, 26.
195. Ibid.

A copy of the report can be found in the Appendix of this report.

In general, Chambers concurred with the findings of Alden and Associates, expanding on the details. Of greatest concern was the deterioration of the metal parts, particularly those of the deck supporting the lantern and the surrounding galleries and ornamental ironwork. The report was replete with warnings regarding the possibility of falling metal parts. At the canopy above the lantern, the report warns that rust has "caused the soffits to expand away from [the] canopy. Loss of fabric and structural integrity has resulted in sections of pipe rail separating from rail brackets and hanging [loose]."[196] This condition was first noted in 1989 by the Corps of Engineers. Of the lantern gallery deck, it said, "Two deck sections nearest ladder has [sic] structural cracks which could result in sections of deck falling from lantern."[197] The bolts of the 16 sections of the cornice that were bolted to the deck had lost integrity, and there were "wide gaps between [the] cornice and [the] gallery deck. Several sections have large pieces…cracked or missing,"[198] and stress and expansion fractures were widespread. The bracket and belt plate cornice was experiencing many stress and expansion fractures and some loss of structural integrity; indeed, "[s]everal large pieces have already fallen."[199] The lantern deck cornice and vent system produced even more startling findings of deterioration:

> [The] "entire system located just below the lantern room gallery has widespread stress and expansion fractures and massive loss of historic fabric with resultant falling debris. …Cornice could fall in [sic] mass in one or more six pound sections. Condition also allows excessive moisture behind Cast Iron plate watch roof walls along Gallery walk. Six panels have extensive stress and expansion cracks [sic] any further radical movement could produce large sections of falling debris."[200]

An interesting feature of this report is the detailed assembly information given for the support system of the gallery deck. This information is not found in any previous assessment of the Lighthouse structure. In describing the condition of the support system, Chambers states:

> "The sixteen huge support brackets were built into the brick wall and connected to internal cast iron framing. They were designed to carry the load of the gallery walk deck but to be part of the safety rail system on the gallery walk as well. …[T]he safety rail post fed through the gallery deck plates, into the support bracket box and was screwed into the huge decorative nut which forms the end point of the bracket. Over the course of time moisture has dissolved the rod which is within the box, especially at the connecting nut. Not only is the rail system dependent on the threaded post but the 50 pound decorative nut is

196. Chambers, Cullen, in letter to the Outer Banks Lighthouse Society summarizing his findings in his report, in papers of the Cape Hatteras National Seashore headquarters, Manteo, North Carolina, dated 17 March 1997, n.p.
197. Ibid.
198. Ibid.
199. Ibid.
200. Ibid.

> also dependent on the threaded post. One nut on the north west side of the tower has already failed and fell [sic] to the ground. Large sections of the hollow decorative box walls have also cracked and fallen from the bracket....
>
> Between each support bracket there are cast iron spanning plates weighing approx [sic] 80 Lbs. These plates are connected by six bolts to the inner edges of the support brackets along the masonry wall. Moisture trapped between the wall and spanning plates has caused the bolts to fail and numerous and widespread cracks to occur throughout many of the plates. The end result could be large sections of cast iron weighing several pounds to fall from the plates."[201]

These alarming predictions caused the National Park Service, heeding the recommendations of Mr. Chambers, to cordon off the area around the Lighthouse to protect the viewing public from falling debris. Later, a sturdy wooden fence was built around this area.

In addition to his safety concerns, Chambers made an extensive report on the condition of the other components of the Tower and Oil House and detailed recommendations for their preservation, repair, or replacement. His inspection and recommendations regarding architectural features went far beyond the structural engineering inspection performed by Alden and Associates. Mr. Chambers estimated that the repairs he recommended would be at a cost of about $635,000, but noted that his estimate was based on the cost of repairs performed at the St. Augustine Lighthouse and that the metal work at Bodie Island "represents some of the worst [conditions] that I have found in either the Key West; St. Augustine; or Currituck Lights and will require extensive and expensive repair and / or replacement,"[202] and that "[t]he conditions at Bodie represent a far greater level of deterioration to the metal work and a greater logistics problem due to the location."[203]

Three years after Chambers' report was generated, no significant remediation having taken place at the Bodie Island Lighthouse, the Outer Banks Lighthouse Society contracted with another firm, the International Chimney Corporation of Buffalo, New York, for another structural review of the Tower. This corporation was then working on restoration of the Currituck Beach and St. Augustine Lighthouses, and had previous experience in the restoration of the Tybee Island and Cape Hatteras Lighthouses.[204] A copy of that report is included in the Appendix of this report and summarized as follows.

201. Chambers, Cullen, in letter to the Outer Banks Lighthouse Society summarizing his findings in his report, in papers of the Cape Hatteras National Seashore headquarters, Manteo, North Carolina, dated 17 March 1997, n.p.

202. Chambers, Cullen, "Bodie Island Lighthouse, Bodie Island North Carolina – Selected Existent Conditions and Recommendations," in papers of the Cape Hatteras National Seashore headquarters, Manteo, North Carolina, n.d., Section II, p. 32.

203. Chambers, n.d. Section II, p. 33.

204. International Chimney Corporation report on Bodie Island Lighthouse, no title, in papers of the Cape Hatteras National Seashore headquarters, Manteo, North Carolina, dated 30 March 2000, cover page.

The shortest of the reports contracted by the Outer Banks Lighthouse Society, it focuses on concerns regarding the safety of the public if allowed to ascend to the top of the Tower. Noting that replacement of any of the damaged stair treads will be difficult as they are "structurally integrated such that no one (1) step can be removed for replacement without endangering the remainder of the system,"[205] the report also iterated previous warnings that, because the staircase was designed only to support one or two people at a time, the load of 20 or 30 people gathered on one section of the stairway might "translate to sway and eventual failure"[206] of the stair system. Additionally, though not couched in the extreme language used by Cullen Chambers, the report confirmed the loss of structural integrity that his report noted on the metal support system of the lantern and gallery levels. This report also contains an enlightening discussion of the assembly of the lantern curtain wall and the roof above and the reasons for deterioration in these areas. In addition to the structural concerns, the report made some observations and recommendations for repair of other portions of the Tower and Oil House, all of which had been made previously in other reports. The report also suggested that the Fresnel lens was showing signs of age, specifically in the cracking of the white lead putty holding the sections of the prisms together, but that the United States Coast Guard, with specialists in this type of work, should be contacted for repairs to this feature. The International Chimney Corporation estimated that stabilization measures to allow the interior of the facility to be safely open to the public would cost about $900,000 with an additional cost of $400,000 to $500,000 for total restoration.

Four months after this report was returned to the Outer Banks Lighthouse Society, on the 13th of July, 2000, the Bodie Island Lighthouse was officially transferred from the United States Coast Guard into the care of the National Park Service.

205. International Chimney Corporation report on Bodie Island Lighthouse, no title, in papers of the Cape Hatteras National Seashore headquarters, Manteo, North Carolina, dated 30 March 2000, n.p.
206. International Chimney Corporation report on Bodie Island Lighthouse, no title, in papers of the Cape Hatteras National Seashore headquarters, Manteo, North Carolina, dated 30 March 2000, n.p.

Bodie Island Light Station Timeline

1848	Completion of the first Bodie Island Lighthouse.
1859	Completion of the second Bodie Island Lighthouse. First Lighthouse subsequently razed.
April, 1861	Start of the Civil War. Confederates occupy Bodie Island Lighthouse.
November, 1861	Confederates abandon Bodie Island Lighthouse to the Federals but blow it up, after removing the light, to prevent the Federals from using it.

Bodie Island Light Station Timeline

June 13, 1871	Government purchases land from John B. Etheridge and his wife for the location of a new Bodie Island Lighthouse.
October 1, 1872	Light of third Bodie Island Lighthouse first exhibited. Original oil source was lard oil
October, 1872	William F. Hatsel employed as first Keeper of the Bodie Island Light.
October 29, 1872	Flock of geese collides with, and damages, the light, causing a protective screen around the glass enclosure to be installed.
July, 1878	Keeper Hatsel transferred; Peter G. Gallop becomes Keeper of the Bodie Island Light.
1883	The Lighthouse Board substitutes mineral oil (kerosene) as the fuel source for the light.
1884	Regular mineral oil lamps installed in the light. New lightning protection installed.
1898	Telephone service installed.
1906	Ephraim Meekins, Jr. replaces Peter G. Gallop as Keeper of the Bodie Island Light.
1912	Light upgraded to vapor oil lamp.
1919	Lloyd Vernon Gaskill replaces Ephraim Meekins, Jr. as Keeper of the Bodie Island Light.
September 19, 1932	Lighting apparatus converted to electricity. Generator installed in former Oil Room of the Oil House. Light converted from a fixed to a flashing light. Candlepower jumps to 160,000.
1934	Tower scraped and painted.
1937	Cape Hatteras National Seashore established.
1939	United States Coast Guard assumes control of lighthouses.
May 1940	L. V. Gaskill, last Lightkeeper at Bodie Island Light Station, transferred to Coinjock Buoy Tending Depot. Bodie Island Light Station becomes an unmanned light.
1941	Candlepower reduced from 160,000 to 13,000.
1945	Size of Bodie Island Light Station site increased from 15 acres to a little over 56 acres.
1953	Tower cleaned and painted.
October 9, 1953	Electrical source converted from generator to commercial power. Existing generator used for emergency power only.

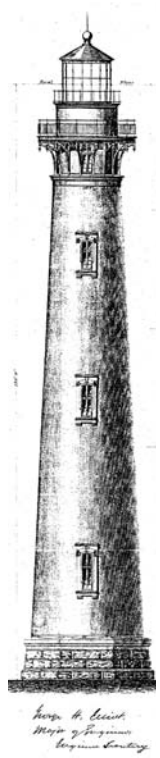
Bodie Island Light Station Timeline

October 15, 1953	Bodie Island Light Station property (56.37 acres) declared surplus and transferred to the care of the National Park Service, except for the small, square plot of land, 100' on a side, on which the Lighthouse stands.
1959	Tower and Oil House painted.
1963	Candlepower increased to 80,000. Tower and Oil House painted.
February 1964	Gallery railings replaced and painted.
May 1969	Timing device controlling the light replaced with a photo- electric cell.
October 1976	Coast Guard replaces termite- ridden flooring on the Work Room side of the Oil House.
1978	Tower and Oil House painted.
September 1981	Obsolete emergency generator replaced.
May 1983	National Park Service begins to present historical programs inside the Oil House and to permit visitors to enter the lowest level of the Tower to peer upward toward the light deck.
May 1984	8' high chain link security fence preventing access to the Tower by the general public installed by the U.S. Coast Guard.
June 1985	Light converted to solid state.
July 1986	Oil House treated for termites, and termite damage repaired in ceilings, door frames, and window frames.
1987	– Lighthouse painted.
August 7, 1988	The National Park Service and the United States Coast Guard jointly commemorate the establishment of the Lighthouse Service by escorting visitors to the top of the Lighthouse.
July 1989	Structural evaluation of the Lighthouse prepared by the U.S. Army Corps of Engineers.
1992	Upgrade of electrical service completed. Spiral staircase treads damaged by workman pulling cable.
1994	Outer Banks Lighthouse Society established.
July 1996	Structural evaluation of the Lighthouse prepared by Alden and Associ- ates; paint analysis and visual inspection prepared by Frederic R. Harris, Inc.

Bodie Island Light Station Timeline

1997	Tower and Oil House repaired and repainted by the United States Coast Guard at a cost of $148,623.00. Inspection report issued by Cullen Chambers of the Tybee Island Lighthouse Society at the request of the Outer Banks Lighthouse Society.
March 2000	International Chimney Corporation issued a report on the condition of the Tower and Oil House and recommendations for the repair and preservation of the structures, as well as upgrades to make the Lighthouse safe for visitors to climb to the top.
July 13, 2000	Bodie Island Lighthouse officially transferred to the care of the National Park Service.

Physical Description



Summary of Historic Character

Overall, the Bodie Island Lighthouse is substantially intact as originally built and is in generally sound condition, with some exceptions, from an architectural standpoint.

There are three primary elements of the historic structure: the Oil House, consisting of three rooms (including a hall), the connecting hall between the Oil House and the Tower, and the Tower. All sections of the structure were constructed at the same time. The project was conceived in 1869, with construction beginning in 1871. The light was presented October 1, 1872. The date carved into the head of the front door is 1871 (per the 1871 construction drawings). While the structure has seen a number of modifications over time, the vast majority of the original structure is extant. Both the Tower and Oil House have load- bearing, masonry wall systems. The Oil House has a wood floor system in the north area and stone on fill in the hall and, likely, in the south room, the Oil Room. The roof structure of the Oil House is wood frame. The stairs, landings, and upper rooms of the Tower are cast iron. Because they are interior features, they have been protected from the elements and, overall, are in good condition. Only the stairs show signs of notable deterioration. The exterior finish of the Tower and Oil House is

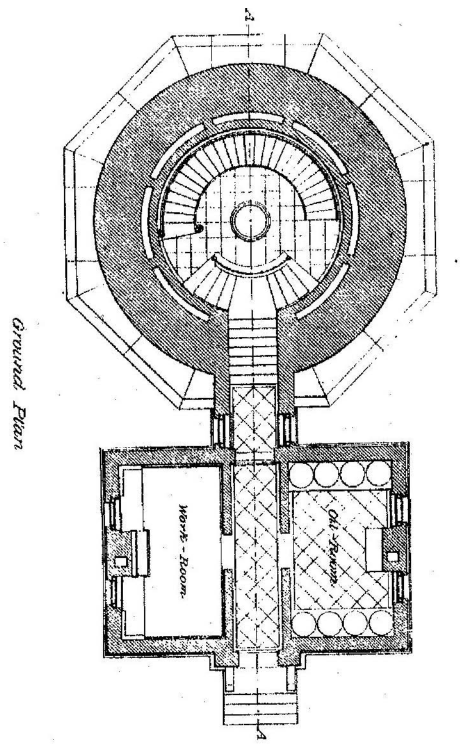


Figure 15 Historic plan of ground floor.

painted brick. The upper exterior of the Tower is cast iron. The exterior cast iron on the Tower is exhibiting considerable deterioration. The Oil House is painted white, and the Tower is painted alternating black and white stripes consistent with the original exterior markings. The interior walls of both the Tower and Oil House are painted white, though some of the finishes are not original. The interior cast iron is painted black, not the original colors, which varied throughout the Tower. There is evidence in the 2000 Historic Paint Finish Study, prepared by the Building Conservation Branch of the Northeast Cultural Resources Center of the National Park Service, that graining was used on some of the interior woodwork of the Oil House. In particular, the interior door to the north room of the Oil House (OH/D2) was identified to have graining. The paint analysis indicates that the presence of graining dates to the 1872 period of the buildng.

Associated Site Features

- *Fence:* The four- railed fence is of recent vintage, constructed by the National Park Service for safety. The fence is not a contributing feature of the site or structure. It appears in sound condition.
- *Walk:* The walk between the Double Keepers' Quarters (DKQ) and the Oil House may be a contributing site feature based on information provided by the site staff. It was stated that the brick walk that connects the Double Keepers' Quarters to the Oil House was laid with brick left over from the original Tower construction. This understanding should be confirmed by testing as the existing brick appears to be in very good condition, in fact, much better condition than the brick on the Oil House and Tower, suggesting the existing brick in the walk might be of more recent vintage. Additionally, according to Holland, the "vast quantity of bricks" left over from the building of the Bodie Island Light Station were proposed by the Engineer to be used to build the Keepers' Quarters at Cape Lookout.[207] However, early plat drawings (1890) appear to corroborate the information provided by site personnel by noting the walk between the Double Keepers'

207. Holland, p. 42.

Quarters and the Oil House to be brick. There is an absence of any maintenance information from the Coast Guard or the National Park Service indicating that the brick walk was ever replaced, and information from John Gaskill, son of the last Keeper at Bodie Island (1919- 1940), indicated that the walk had never been replaced as far as he could recall.

- *Double Keepers' Quarters (DKQ):* The Double Keepers' Quarters was rehabilitated by the National Park Service in 1992 and has been converted to a Visitor Center with interpretation, exhibits, and a bookstore on the first floor and staff office and work space on the second floor. This structure is contributing to the site and appears, overall, in sound condition based on cursory observations only.
- *Brick Cisterns adjacent to the Double Keeper's Quarters:* North and south of and adjacent to the Double Keepers' Quarters are early brick cisterns of historical significance, two on either side. These features are presently covered with concrete slabs.
- *Support Buildings:* There are several support buildings on the site: a restroom building (built by the National Park Service) and an historic storage building.

Exterior Materials Finishes and Characteristics

A paint analysis was performed by the National Park Service in 2002. It is this analysis that is referenced in discussing the following.

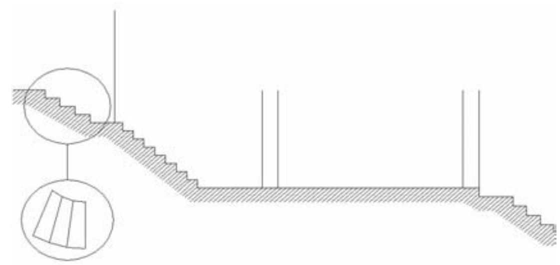


Figure 16 Stair configuration.

Oil House

Structural System: The Oil House structure consists of the following components:

- *Foundation:* The foundation of the Oil House was not accessible. However, based on the 1871 construction drawings and given the substantial consistency between the drawings and the majority of the structure, it is reasonable to expect that the foundation is substantially consistent with the drawings. The foundation appears in the drawings to extend to a depth equal to the widest part of the Tower footing. Several cracks were observed in the masonry walls on the north and south side of the building. All cracks were patched at some unknown date and appear dormant. The wall cracks were generally at typical stress points originating in upper corners of windows. While there could be some relationship to structural movement, the cracks are likely a result of early differential settling that is no longer active. It appears that the structure is stable at this time, including the foundation of the Oil House.

- *Walls:* The walls are load- bearing masonry. As noted in the foundation observations, the walls appear to be sound and stable. While there is evidence of cracks in the masonry walls on the north and south elevations of the Oil House, the cracks appear dormant and have all been patched. The primary concern with the walls is the underlying condition of the brick. Though apparently structurally sound, the existing bricks, covered with numerous layers of paint, appear to exhibit a significant amount of spalling. Given the frequent exposure to moisture and the potential for moisture to be trapped behind the paint in the brick due to rising damp, it is logical that the brick could have experienced some damage over time. See the Ultimate Treatment and Use portion of this report for treatment recommendations.
- *Floor Structure:* The floor framing in the Oil House is not accessible. No access to the crawl space was provided in the original design, and none has been created since. Therefore, the comments made in this section are based on field observations of secondary conditions and correlating those observations with the original plans for the structure. There is a curiosity about the floor framing in the hallway (OH/100) and Oil Room (OH/102) of the Oil House. The original plans indicate the Oil House floor framing to be 3"x 12" beams spanning north/south in all three rooms. The plans indicate the placement of a crawl space vent on the south wall of the building, under Room OH/102. Further, the plans indicate the floor framing in the hall (OH/100) and Oil Room (OH/102) were 3" below the framing in the Work Room (OH/101), where the flooring is wood. This original depressed- floor framing layout appears appropriate to accommodate marble tile in the hall (OH/100) and the Oil Room (OH/102) over wood framing. Given a 1" thick marble tile as was observed in the lower level of the Tower, 3" remain for a mortar bed in the Hall (OH/100) and Oil Room (OH/102). A 1" dimension between the top of the floor joist and the desired finished floor was provided in the Work Room (OH/101) to accommodate wood flooring. This seems logical. The three observations that raise questions about the actual floor framing in rooms OH/100 and OH/102 are:
- There are no crawl space vents in the south elevation or south half of the east elevation, but there are two vents in the north elevation and one in the north side of the east elevation. There are no vents in the west elevation. The absence of crawl space vents on the south side of the building raises a question whether the decision was made during construction to put all marble flooring on fill.
- The original drawings indicate that the marble tile flooring in the hallway connection between the Oil House and the Tower and the marble flooring on the first level of the Tower are set on fill. This establishes a precedent on site for this approach.
- When the power source for the beacon was changed from oil to electricity, a generator was installed in the Oil Room (OH/102). At

that time, what appear to be two slabs of a cementitious material, presumably concrete, were installed in the room as mounts for power generating equipment. It seems unusual, but not out of the question, that the support for a motor mount would be concrete or grout on wood framing. It would be more appropriate for fill or a pier to support the generator. According to several reports, the flooring in the Work Room (OH/101) was partly replaced in 1976 due to termite damage. Termite damage was never reported in the Oil Room floor. The condition of the flooring and framing in the entire Oil House appears to be quite sound. The marble tiles do not appear to have been cracked or offset due to sagging or settling. The floor structure under the hall (OH/100) and the Oil Room (OH/102) could be further explored by removing a piece of the floor tile and grout in one or both of these rooms to determine the support. However, physical evidence indicates that it is probably fill rather than wood framing.

Another concern, particularly given the lack of access to the crawl space under the Oil House, is the fact that the site has flooded numerous times over the 130 years the Oil House has been in place. It is likely that the framing has been exposed to high humidity, if not water, creating the conditions for mildew, mold, and rot. However, the floor does not appear to be failing. If it becomes necessary in the future to replace the flooring of the Oil House, the wood floor framing beneath should be inspected, fully documented, and rotted members replaced.

- *Roof Framing:* No access was provided to the attic area of the Oil House in the original design, and no access has been created since. Unlike the floor framing, the roof framing is much less likely to have been subjected to direct water from below; however, water infiltration from above is a factor in the condition of the roof framing. The wood tongue- and- groove ceiling in the northwest corner of the Oil Room (OH/102) is rotted, indicating a significant leak in recent history. Overall, however, the wood ceilings in the Oil House are in good condition, suggesting that the roof framing is in reasonable condition as well.

West Elevation: The west elevation of the Oil House is the front elevation. It has a Stick styled, cantilevered, gabled roof supported by three brackets over the front stoop. The front stoop is four risers above grade. From the stoop landing, there is one additional riser to the threshold of the front door. See sketch of the lower level stair configuration. Flanking the front door is a pavilion- like projection of brick about 10” off the prevailing plane of the front wall. On the same elevation as the floor is a water table of cut stone. This band is presently painted white; however, the paint analysis indicates this feature of the Oil House was not painted until recent times, but was probably first painted in the last 20 years, certainly before the last painting in 1997. Below the water table course of stone is an inset plane of brick producing the appearance of a building base.

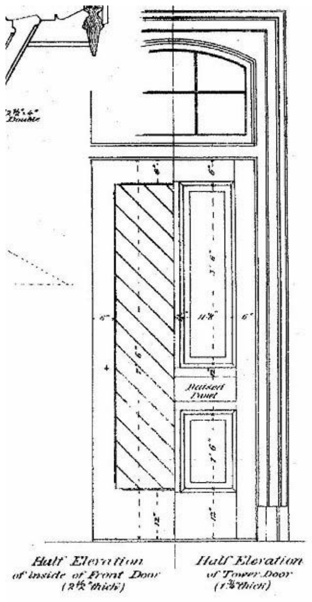


Figure 17 Original drawing of front door details.

This area, too, is painted white. The paint analysis indicated that this portion of the west elevation was historically painted white but with a clear glaze coating, presumably to give an added level of moisture protection to the brick. An 1893 photograph shows this paint scheme. A late 1920s photograph shows the band to be dark, probably black.

The brick wall above the water table, including the brick pilasters or pavilion- like detailing, is painted white to match the white banding on the Lighthouse behind and seen from the west. One earlier application of paint on the building is textured. According to Peggy Albee, of the National Park Service, the Coast Guard experimented with paints in attempts to find solutions that would provide better, more durable coverage in the harsh environments typical of most lighthouse locations. The textured materials in the paint on the Bodie Island Oil House are tiny, transparent sheets, thinner than mica, that, when they clump together in the paint, present the appearance of a sand painted finish.[208] It is unknown whether these materials are naturally occurring or synthetic. Based on the location of the layer, the paint containing this material was probably applied in the 1960s.

The front- cantilevered roof over the front stoop is wood construction and appears in sound condition with limited probing. As previously stated, this pedimented door hood is in a Stick style and is consistent with the original plans in detailing, materials, and dimensions. This feature is painted white as it was historically, according to the paint analysis.

The front steps are unpainted granite but the cheek walls on either side of the steps, including the low railing- like walls on either side of the upper stoop landing, are masonry and painted white. Paint analysis was not performed on this portion of the Oil House, so it is difficult to say when painting of these features began.

The existing front door is not original. The door originally was a single paneled door with diagonal infill within the stiles and rails (shown on the left of the adjacent graphic). A door such as this can be found on the front door of the Currituck Beach Lighthouse, the sister structure to the Bodie Island Lighthouse, built in

208. Albee, Peggy, Northeast Building Conservation Branch, National Park Service, to Jack Pyburn, e-mail dated 28 May 2002.

1875. Over the front door is a 3/3 transom light, intact. This window appears to be original by the profiles of its muntins and frame. The transom is in fair condition, certainly well within restorable condition. The head of the door opening is a cut stone arched head with the inscription 1871, per 1871 construction drawings. The stone head of the front door remains unpainted with its original finish. Some overpainting of white was observed on the stonework from the most recent painting application in 1997.

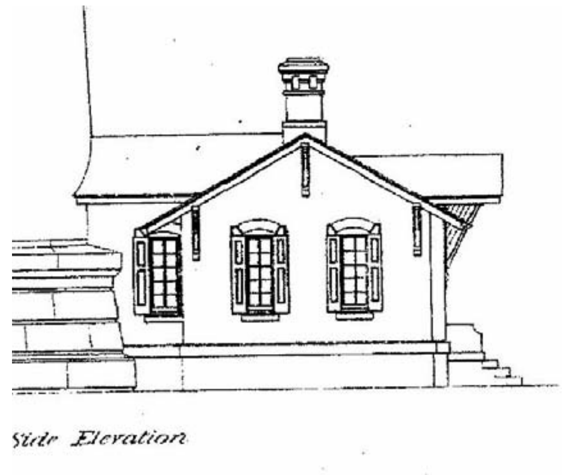


Figure 18 Drawing detail of north elevation.

North Elevation: The main wall of the north elevation is brick painted with the same paint characteristics as the west wall, white with a clear glaze coating. The north elevation contains two windows, two crawl space vents (3”x 9”, without a vermin or insect cover), a water table, and the inset brick base below the water table as described in the west elevation. Two 4/6 double hung windows are positioned at approximately quarter points in the wall and flanked by Stick- style brackets at the center and outside corners of the gabled elevation. The westernmost bracket shows substantial deterioration in the lower portion of the vertical member. A sheet metal cover evidences attempts at remedial improvement over the deteriorated area.

Overall, the north elevation is in sound condition. However, there are signs of past stress in the cracks over the west window in the elevation. This crack has been patched and painted, is sealed, and appears to be inactive.

A chimney is located on the center of the elevation and inset into the building so that the chimney is not expressed in the outside wall. The design of the chimney includes a granite cap and granite detail six bricks below the twin openings on the north and south sides and single openings on the east and west sides of the chimney. The chimney appears in good condition.

South Elevation: The south elevation is a mirror of the north elevation in composition. Like the north elevation, the south elevation exhibits a dormant and repaired crack from the west corner of the east window downward and to the east. In addition, there appear to be several patches in the elevation that have repaired brick damage, likely spalling. One patch is over the head of the east window, and one is at the east side and below the sill of the west window. Evidence of spalled brick can be seen on the lower east corner of the elevation below the water table.

Figure 19 Photo of south elevation by U.S. Coast Guard, 1948.

There are two patched holes in the center of the elevation below the water table and above the inset in the wall. Earlier photos suggest these patches mark the location of what appear to be drain outfalls from the Oil Room. Mid-20th century photos also indicate the location of a box mounted to the south wall below the water table. The brick shelf defining the inset brick panel below the water table was partly removed to accommodate the box sometime between 1930 and 1948. A portion of a bracket, likely part of the anchorage system for the box, remains attached to the wall. The windows on this elevation are 4/6 like those on the north elevation. However, the east window on the south elevation has a metal screen on a wood frame attached to the window frame. Also present are five brackets for shutters that no longer exist.

The chimney on the south elevation matches the chimney on the north elevation but is leaning noticeably to the west. A visual inspection of the chimney by the structural engineer of Hartrampf, Inc. suggests the lean is not due to deterioration but was more likely produced in the original construction, an interesting deviation in craftsmanship from the quality of the balance of the structure. At the time of the next roofing and flashing related rehabilitation in this area, the alignment and condition of the chimney masonry at and just below the roofline should be further evaluated. There is no evidence on the interior that this chimney is in any distress. The crack on the interior side of the chimney is likely due to early thermal expansion of the vent flue and does not appear to be active. This flue was originally designed to vent gasses from the building when oil stored in the room was burned as a light source. The vent is no longer used.

East Elevation: The east elevation is a continuation of the painted brick, water table, and inset band below the water table on the north and south elevations. The banding on the Oil House is terminated into the wall of the connecting Hall (H/100). The north side of the east elevation contains a single crawl space vent of the size and in a similar relationship to the water table as on the north elevation, just below the water table and centered in the wall.

Roof: The roof of the Oil House is a brown asphalt composition shingle of unknown age. The earliest reference to the material of the roof is in the 1977 National Register Nomination drafted by the North Carolina Heritage Conservation and Recreation Service, which refers to the roof as being asphalt shingle. No reference to a roof replacement since then has been located among the agencies charged with the maintenance oversight of the Lighthouse. While showing some age, the roofing appears to be functioning satisfactorily. There were originally no gutters or downspouts on the building, and there are none now. The fascia board on the Oil House appears to be in reasonably good condition. The likely culprit causing the damage to the ceilings below is the flashing.

The flashing on the building is a problem. The valleys are copper and appear to be functioning, but the southwest valley is in the approximate location of an apparent leak in the Oil Room (OH/102). The flashing at the chimneys appears to have had remedial repair with a black mastic- type material and could well be close to failing, if not already failing.

Summary Observations: The following summarize the observations and issues identified related to the exterior of the Oil House:

- Spalling of the brick was observed on the Oil House. This is a concern due to the potential for water to enter the building from flooding and rising damp, given the high water table in the area. See the Ultimate Treatment and Use portion of this report for recommendations.
- The condition of the roof framing, currently not accessible, should be examined and fully documented at the next roof replacement. Rotted members should be replaced.
- There did not appear to be any notable movement in the structure that merited concern. Stress cracks observed all appeared to be stable and not active.
- The flashing around the chimneys and in the valleys appears, from visual observation on the underside, to require replacement.

Hall Connection

The Hall Connection (H/100) is a short corridor between the Oil House and the Tower. This space is defined by the door separating the hall from the Oil House and the radial stairs leading to the first level of the Tower.

Foundation: The original drawings of the Hall Connection (H/100) indicate that the foundation, shown to be brick resting on a stone footing, extends down from 4' to 6' below grade. All observable conditions suggest that the foundation of the Hall Connection is sound.

Structural System: The structural system for this part of the structure is similar to the structure of the Oil House:

- A footing that extends some distance below grade
- Load- bearing masonry walls
- Wood roof framing
- The floor supported by fill, possibly stone fill, as suggested in the original drawings.

The structural systems appear in sound condition. However, the roof framing was not accessible and, therefore, its condition could not be verified. There are no sags or other irregularities in the roof ridge or decking, common clues of damage to the wood roof support system.

North Elevation: The north elevation of the hall (H/100) contains one double- hung 4/6 window approximately centered in the wall. A diagonal crack extending from the upper east corner of the window and extending to the east was patched and appeared dormant. A lightning protection cable penetrates the east jamb of the window frame approximately in line with the middle of the upper sash and extends vertically to the ground. A National Park Service staff member on site reported to have been told that this cable was the original lightning protection cable. However, examination of historic data does not support this speculation. The original lightning protection system was the stair, which was connected to the lightning rod atop the ventilator ball at the top and to a copper grounding rod driven into the ground near the center of the Tower at the bottom, according to Holland. When this method proved to be dangerous to personnel at the Lighthouse, it was changed, in 1884, to a cable running from the light, down the center of the Tower, and connected at the bottom to an iron plate buried in the ground. The location of the iron plate is not known. It may be that this cable is a remnant of the second lightning protection system, as it runs along the interior wall of the connecting hall at floor level with the Tower and then along the perimeter of the floor in the Tower, terminating at a connection to the bottom stair newel.

The brick walls of this elevation are similar to that described on the Oil House. Painted with numerous coats of paint, the brick condition is difficult to determine. However, the amount of irregularity in the wall surface suggests the face of the brick under the paint may be damaged.

The fascia board of the roof eave at this elevation was rotted and will require replacement. This elevation contains a notable amount of mildew on the painted brick surfaces, suggesting both exposure to a significant and ongoing amount of moisture and poor air circulation and sun exposure, which, if improved, could deter mildew growth.

South Elevation: The characteristics and conditions of the south elevation are similar to those on the north elevation except for the following:

- No rotted fascia board on the eave of the roof at this elevation was observed.
- A repaired crack in the masonry, patched prior to the last painting, extending from the upper east corner eastward, appears dormant.
- There is less mildew on this elevation than on the north elevation
- The window has been covered with plywood to protect it from further deterioration.

Roof: The roof of the Hall Connection (H/100) has a common ridgeline with the Oil House. The roofing material is, as on the Oil House, reddish brown asphalt composition shingles. The primary flashing related to this roof is two valleys where the roof ties into the roof of the Oil House and step flashing at the junction with the Tower. The flashing at the Tower appears marginal in condition and may be contributing to the infiltration of water into the Tower as exhibited by peeling paint in the brick arched ceiling area of the Tower at the connection with the Hall (H/100).

Summary of Observations: The following summarize issues and conditions of note in considering restoration of the Hall between the Oil House and Tower:

- Spalling of the brick was observed on the Hall Connection (H/100). This is a concern due to the potential for water to enter the building from flooding and rising damp, given the high water table in the area. See the Ultimate Treatment and Use portion of this report for recommendations.
- The condition of the roof framing, currently not accessible, should be examined and completely documented at the next roof replacement. Rotted members should be replaced.
- There did not appear to be any notable movement in the structure that merited concern. All previous stress cracks appear to be stable and not active.
- The flashing at the Lighthouse/Hall Connection joint appears, from observations on the interior, to be failing.

LIGHTHOUSE

Structural System: The Tower is load- bearing masonry on a stone foundation.

Foundation: The foundation of the Tower is described in *A History of the Bodie Island Light Station* by Francis R. Holland, Jr. (1967) in which he states that a pit 7' deep was dug and pumped during construction to keep it dry. In the pit, a timber grillage, two courses of 6"x 12" timbers, was placed. Large granite blocks, 18" thick were placed on the grillage. On top of the grillage blocks, courses of rubble blocking weighing one to five tons were placed to raise the foundation an additional 5'. Each course of stone was grouted with hydraulic Portland cement. Overall, the foundation of the Tower appears in very good condition.

Wall Structure - Base: The exterior course of the base is split- faced granite with a cut band around each piece except for the cap, which has a smooth finish. The interior of the base, behind the exterior cut stone, was rubble set in cement.

Wall Structure - Brick: The Tower's brick walls taper from 2 ½ bricks thick at the top to 6 bricks thick at the base as indicated on the original drawings.

The drawings further suggest that there is an interior course of veneer brick throughout the Tower. It is unclear if and how the interior course of brick is tied into the exterior, more massive, assembly by other than mortar and the characteristics of its cylindrical configuration. Windows are offset vertically to avoid two windows with overlapping vertical alignment. Overall, the masonry structure appears sound. No cracks in the exterior masonry were observed from the ground using a 10x monocular.

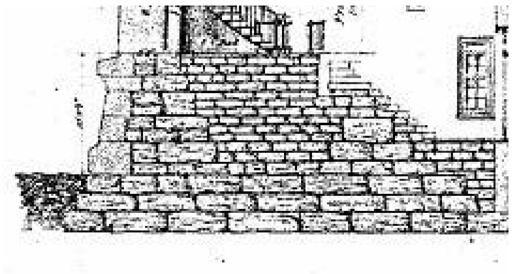


Figure 20 Drawing detail of Lighthouse base.

The Tower was last painted in 1997, which, along with the number of previous paint layers, may have masked conditions that cannot be observed from the ground.

West Elevation: Being a symmetrical, tapered cylinder, the basic characteristics of the Tower are similar on each elevation. The overall characteristics of the Tower exterior will be discussed here, and conditions and characteristics specific to the balance of the elevations will be discussed under the presentation for each of the other elevations.

According to the paint analysis, the strata of finish on the exterior of the Tower includes:

Masonry: Overall, the masonry appears in good condition. However, as was observed on the exterior of the Oil House, there are areas of irregularity in the masonry surface that suggest that, over time, moisture has penetrated behind the paint, primer, and sealer as a result of flooding or rising damp, and, possibly, produced spalling.

Parge Coating: This strata is not visible from the exterior but was documented in the paint analysis. The paint analysis refers to the Currituck Beach Lighthouse as also having a parge coating (but never painted) similar to the Bodie Island structure. A site visit was made to the Currituck Beach Lighthouse to observe the surface conditions. No parge or mortar- like wash coating remained on that structure, likely due to its erosion by the forces of local weather.

Resinous Oil- Based Sealer: This layer is not exposed. The stratum of finish was analyzed and addressed in the paint analysis. Its condition and effectiveness in retarding moisture infiltration is unknown.

Paint Primer: This layer, like the sealer, is not exposed and, like all the coating layers on the tower, is examined in the paint analysis of the structure. The condition and effectiveness of this layer is unknown but is presumed to be sound, given the age and condition of the current exterior paint coating.

Paint Finish Coats: The existing exterior paint coating was applied in 1997 by the United States Coast Guard. This coating is, overall, intact, with exceptions noted below.

The color scheme of the tower is of note. The existing color scheme includes:

- Unpainted cut ashlar granite base except for the top of the cut cap course, where the vertical surface is painted white.
- Five approximately- equal alternating bands of white and black starting with white (band 1) above the unpainted base. Bands are about 22' wide.

Specific observations on the west elevation

What appeared as a dark stain or moisture was observed in this area. It was difficult to view this condition, but the condition was sufficiently noticeable to merit recording.

Stain or dampness in band three vertically aligned with the north corner of the window in band 4 and extended to that point. It had rained earlier in the day that these visual observations were made; therefore, the "stain or dampness" may have been of little or no significance. However, given the other observations made on this and other elevations of the Tower, it is worth noting and monitoring.

What appears to be efflorescence on bands 1 and 2 to the north of the window in band 2.

A small spall area was observed at the area of the upper south corner of the window in black band 2. While not major, this observation suggests the likelihood of some moisture behind the brick in isolated areas.

- Black at the watch level and above with the exception of the white window muntins at the lantern level.

The placement of the five windows in the Tower is notable. They are alternating so as to not align, providing sufficient spacing between them to retain structural integrity of the Tower shaft. The windows are on the east and west elevations of the Tower. The windows on the west side are positioned in the black bands, 2 and 4. The windows are articulated by projecting brick surrounds further detailed by stone window hoods, lintel corner stones, and keystones, all rusticated in texture with a smooth cut band around their perimeter of about 1".

Until about 1944, the stone window details were not painted.

The upper three levels of the Tower are notably different from the zone of the elevation between the base and the belt course of masonry at approximately the floor elevation of the Watch Room. At and above the belt course, cast iron features are introduced to the elevation. At the Watch Room level, the first level above band 5, substantial cast iron brackets are mounted to the wall of the Tower. These brackets support the lower gallery above. There are four brackets per quadrant of the Tower's circumference. A window is centered in the Tower at quarter points on the north, south, east, and west. The four brackets in each quadrant are spaced equally from the jamb of one window to the jamb of the next adjacent window.

The exterior of the Watch Room level is currently painted black, including the windows. This may not have always been the case, based on observations documented in the paint analysis. It may be that this zone, below the lower gallery and above the black belt course at the bottom of the structural cast iron brackets, was a lighter shade. This is supported by the original rendering of the Tower showing a lighter shade than the darker bands that were rendered as black in the original drawings. However, it has been painted black since before 1932, according to the paint analysis.

A cast iron band the height of this level and surrounding the tower between the lower and upper gallery encases the level below the lantern. From observation inside the Tower and from the original drawings, the brick, it appears, may be two courses thick. It extends above the thickened brick belt course at the bottom of the watch level to the top of the level below the lantern. The exterior of the brick was not accessible. However, observations of the iron banding revealed a generally horizontal crack that extended from the south quadrant of the west elevation well into the south elevation of that level and material. There was no evidence of a corresponding condition in the brick; however, the full surface of the interior brick was not accessible.

The galleries are cast iron. Refer to the structural evaluation, based on visual observation, regarding the current structural condition and carrying capacities of the galleries contained later in this report. Clues of their condition include the following site observations:

- Some decorative components of the cast iron brackets supporting the lower gallery are missing parts. The on- site staff indicated that some parts have fallen from the Tower in recent times. The earliest record of this occurrence is in the Alden and Associates report of 1996. The loss of decorative parts can be a clue to the potential for deterioration in the balance of the brackets.
- Observations from the Watch Room level windows, located vertically in the middle of the gallery brackets, indicated a considerable amount of oxidation on and erosion of the cast iron fittings and features of the gallery brackets and underside of the flooring.
- Some of the stanchions on the lower gallery railing, as stated in the paint analysis, are showing considerable deterioration. As much as 30 percent of their cross section has been lost to corrosive erosion.

The window muntins at the lantern level appear in sound condition. Attached to them on the exterior are two sets of what appear to be brass handles, presumably as grips for use when it was necessary to be on the gallery to maintain, inspect, or operate the Lighthouse. The handles appear to be in very good condition. It is not known when they were installed.

North Elevation: Observed conditions specific to the north elevation include:

- An area of mold or algae growth appears to exist in the area of band 4 on this side of the Tower.
- A lightning protection ground cable is attached to the Tower on this elevation.
- At the base, generally in the middle coursing of the cut granite base, there appears to be leaching at the mortar joints. The characteristics of the mortar are not known. While the condition of the mortar appears generally sound all around the base, the leaching suggests some pressure from the inside of the Tower base outward. One possible cause is that, over time, the combination of high water table and flooding has pushed moisture up into the base, and that those conditions and events have resulted in leaching. The stone base, however, appears to be stable.
- The upper vertical surface of the base capstone is inappropriately painted and should be stripped.

South Elevation: Observed conditions specific to the south elevation include:

- There appears to be an efflorescence- type action on this elevation similar to the leaching identified above on the north elevation.
- The upper vertical surface of the base capstone is inappropriately painted and should be stripped.

East Elevation: The east elevation is similar to the other three elevations except that it contains three windows. The three windows are in the three white bands of the Tower, bands 1, 3, and 5, and are of the same design and detailing as the windows on the west side. Like the west windows, the stone detailing of the window hood and sill have been painted, though, in this case, white to match the banding of the Tower.

Observed conditions specific to the east elevation include:

- Staining at belt course of brick, generally at the floor level of the Watch Room. The source is likely the cast iron brackets and associated fittings in the vicinity of the belt course.
- Earlier photographs reveal that a lightning protection ground was installed at one time on this elevation of the Tower. On the south side of the three windows on this elevation are a series of small areas of deterioration generally extending from the base of the lowest window to the middle of the black band between the second and third windows from the base. These conditions deserve further evaluation from closer range.
- The upper vertical surface of the base capstone is inappropriately painted and should be stripped.

Roof: The roof of the Tower is presently inaccessible and is historically and architecturally significant. Most, if not all, of the original roof structure appears intact when comparing site observations with the original drawings. The roof material is shown on the 1871 drawings to be made of 3/32" copper sheeting. There are no records that it has ever been replaced. With the limited amount of rain on the day of the site visit for this report, there were no obvious leaks in the roof and no signs of wholesale roof leaks when viewed from the underside.

The crown piece with ventilator ball is a distinctive feature of the roof. As shown on the original drawings, it includes several components. Its spherical top, the ventilator ball, supports a bronze, platinum- pointed pinnacle of 3'- 10 ½ " in height, the original lightning protection. On the lower half of the copper ventilator ball is a series of holes designed to vent the lantern room when oil was the source of fuel. Within the ventilator ball is a cylindrical ventilator that works in tandem with the vent holes in the sphere.

Interior Materials Finishes and Characteristics

The original drawings for the Tower illustrate in considerable detail the original finish characteristics of the Tower. An examination of the drawings in relation to on- site observations of the interior of the structures indicates the interior is substantially intact. The observations documented herein are focused on modifications of details that have occurred to respond to the requirements for maintenance and the repair of deterioration. The three primary generators of change in the structures are moisture infiltration, insect infestation, and changing power sources and luminaries for the operation of the light. The following Schedule of Finishes catalogs the finishes and characteristics found in the structure in the preparation of this report.

Schedule of Existing Finish Characteristics - Floors & Walls

Ident. #	Location	Floor	Walls			
			North	*South*	*East*	*West*
Oil House						
OH/100	Hall	Marble	Brick/ Paint	Brick/Paint	Door	Door
OH/101	Work Room	Wood	Brick/Paint/ Wainscoting	Cement/ Paint	Brick/Paint/ Wainscoting	Brick/Paint/ Wainscoting
OH/102	Oil Room	Marble	Cement/Paint	Brick/Paint	Brick/ Paint	Brick/ Paint
Hall						
H/100	South Window	Marble/ Granite	Brick/ Paint	Brick/ Paint	-	Door
Lighthouse						
LH/100	First Level of Tower	Marble/ Granite	Brick/ Paint	Brick/ Paint	Brick/Paint	Brick/Paint

LH/101	First Cast Iron Landing	Cast Iron	Brick/ Paint	Brick/ Paint	Brick/Paint	Brick/Paint
LH/102	Second Cast Iron Landing	Cast Iron	Brick/ Paint	Brick/ Paint	Brick/Paint	Brick/Paint
LH/103	Third Cast Iron Landing	Cast Iron	Brick/ Paint	Brick/ Paint	Brick/Paint[3]	Brick/Paint
LH/104	Fourth Cast Iron Landing	Cast Iron	Brick/ Paint	Brick/ Paint	Brick/Paint	Brick/Paint[3]
LH/105	Fifth Cast Iron Landing	Cast Iron	Brick/Paint[1]	Brick/Paint[1]	Brick/Paint	Brick/Paint[3]
LH/106	Sixth Cast Iron Landing	Cast Iron	Brick/Paint[1]	Brick/Paint[2]	Brick/Paint[3]	Brick/Paint[1]
LH/107	Seventh Cast Iron Landing	Cast Iron	Brick/Paint[1]	Brick/Paint[3]	Brick/Paint[3]	Brick/Paint[3]
LH/108	Eighth Cast Iron Landing	Cast Iron	Brick/Paint[1]	Brick/ Paint	Brick/Paint	Brick/Paint
LH/109	Watch Room	Cast Iron	Cast Iron	Brick/Paint[2]	Brick/Paint	Cast Iron
LH/110	Lantern Room	Cast Iron	Granite / Cast Iron	Glass	Glass	Glass

LEGEND

Flooring

Wood 3 ¼” Tongue & Groove Wood Flooring running East/West

Marble 12”x12”x1” Marble, Black/ White Checkerboard

Cast Iron Cast Iron Checker Plate

Granite Granite Steps

Walls

Brick Brick

Paint/BK/GR Paint/ Black/Gray

Wainscoting Wainscoting/ See Detail

Door Door & Transom

Open Open

Cement Cementitious Finish on Brick

Glass Glass

Cast Iron Cast Iron

Notes

1 Vertical Wall Crack, Patched, Inactive

2 Paint & Brick Spalling

3 Peeling Paint and/or Moisture Stains

4 Prismed Floor Grate

Schedule of Existing Finish Characteristics - Ceilings, Moldings & Fixtures					
Ident. #	Location	Ceiling	Moldings		Fixture
		Material	*Base*	*Crown*	
Oil House					
OH/100	Hall	Wood 1	Paint/8"	-	1
OH/102	Oil Room	Wood 1	-	Wood	1
OH/101	Work Room	Wood 1	Wood	Wood	1
Hall					
H/100	South Window	Wood 2	Paint/7"	-	-
Lighthouse					
LH/100	First Level of Tower	Cast Iron/Open	Paint/GR/8"	Corbel	2N
LH/101	First Cast Iron Landing	Cast Iron/Open	Paint/BK/4"	Corbel	2S
LH/102	Second Cast Iron Landing	Cast Iron/Open	Paint/BK/4"	Corbel	-
LH/103	Third Cast Iron Landing	Cast Iron/Open	Paint/BK/4"	Corbel	2N
LH/104	Fourth Cast Iron Landing	Cast Iron/Open	Paint/BK/5"	Corbel	-
LH/105	Fifth Cast Iron Landing	Cast Iron/Open	Paint/BK/5"	Corbel	2N
LH/106	Sixth Cast Iron Landing	Cast Iron/Open	Paint/BK/4 ½"	Corbel	-
LH/107	Seventh Cast Iron Landing	Cast Iron/Open	Paint/BK/5"	-	2NE
LH/108	Eighth Cast Iron Landing	Cast Iron	Paint/BK/4"	-	2NE
LH/109	Watch Room	Cast Iron[4]	-	-	2N
LH/110	Lantern Room	-	-	-	-

LEGEND

Ceiling

Wood 1	3 ½" Beaded Board running East/ West
Wood 2	4" Beaded Board Running East/West
Corbel	4 brick Corbel, See Detail
Cast Iron	½ Cast Iron Landing
Open	½ Open to accommodate Stair

Base

P/ __"	Black Paint on Masonry/ Inches in ht.
Wood	Wood Assembly

Crown

Wood	Wood Crown Type 1/ See Detail

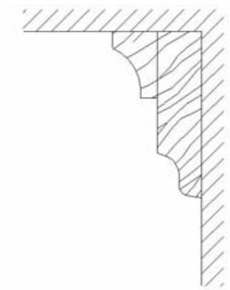
Fixtures *(Note: location is indicated by direction)*

1	Fixture 1/See Detail
2	Fixture 2/See Detail

Notes

1	Vertical Wall Crack, Patched, Inactive
2	Paint & Brick Spalling
3	Peeling Paint and/or Moisture Stains
4	Prismed Floor Grate

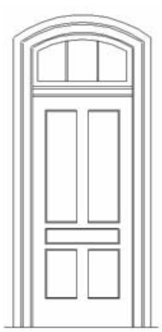
Molding & Light Fixtures

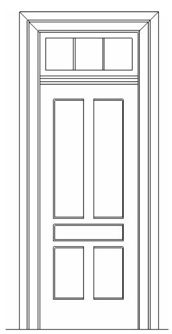

Ceiling Molding Type 1

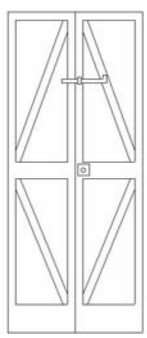

Fixture 1

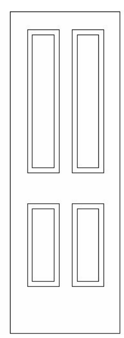

Fixture 2

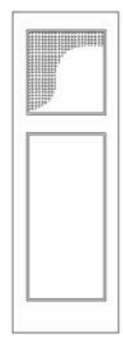
Door Elevations


Elevation 1


Elevation 2


Elevation 3


Elevation 4


Elevation 5

Door Schedule

Ident. #	Location	Width	Height	Profile	Transom	Material	Finish	Head	Jamb	Threshold	Hardware	Original
Oil House												
OH/D1	Front Door	3'- 3 1/4”	7'- 5 ½”	2	1	Wood	Painted	2	2	1	Not Original	No
OH/D2	OH/100 to OH/102	2'- 11 ½”	7'- 6”	2	1	Wood	Painted	1	1	2	Not Original	Yes
OH/D3	OH/100 to OH/101	2'- 11 ½”	7'- 6”	1	1	Wood	Painted	1	1	2	Mortise	Yes
OH/D4	OH/100 to H/100	3'- 3”	7'- 5 ¼”	1	1	Wood	Painted	3	3	3	Mortise	Yes
Hall												
No Doors												
Lighthouse												
LH/D1	Lower Gallery Exteror Door	2'- 10”	6'- 8 ½”	3	-	Iron	Painted	4[1]	4	4	1[2]	Yes
LH/D2	Lower Gallery Interior Door	2'- 3”	6'- 8 ¼”	4	-	Wood	Painted	4[1]	4	4	Mortise	Yes
LH/D3	Watch Room Door	2'- 2 ½”	6'- 8 ½”	5	-	Wood	Painted	-	-	5	Not Original	No

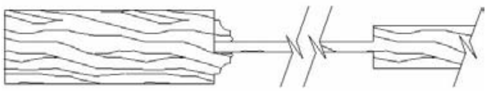
LEGEND

Notes

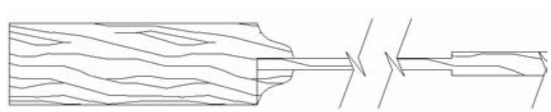
1 Head detail matches jamb detail

2 Iron slide bolt on face of door

Door Profiles

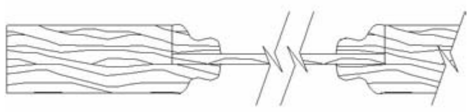


Profile 1

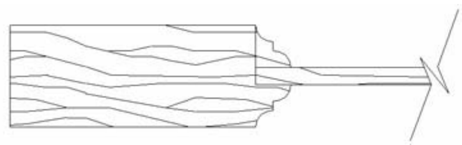


Profile 2

Profile 3

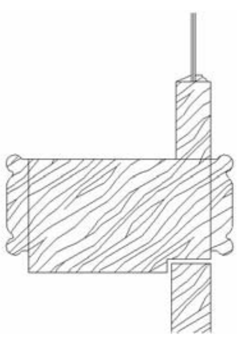


Profile 4

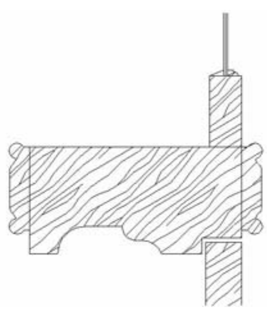


Profile 5

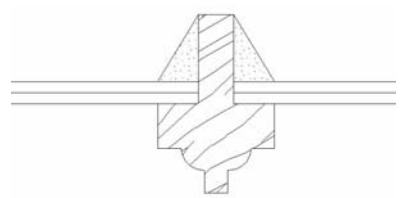
Door Head/Transom Details



Head 1 (Head 2 similar)

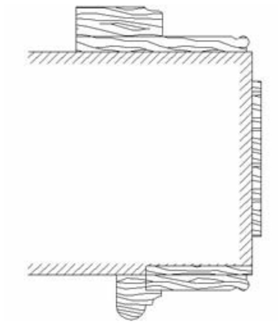


Head 3

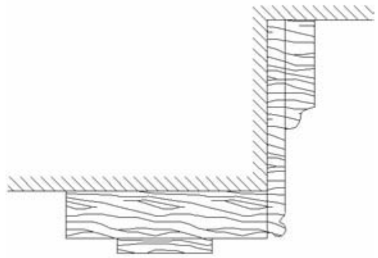


Transom Muntin

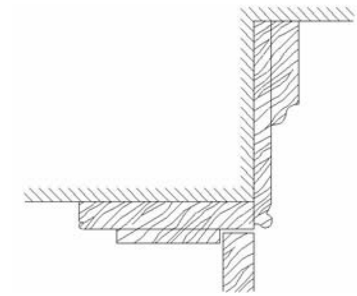
Door Jamb Details



Jamb 1



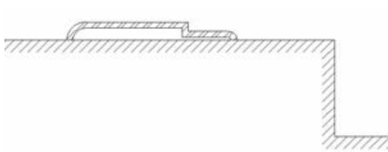
Jamb 2



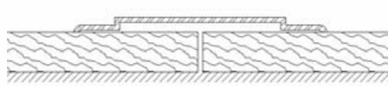
Jamb 3

Jamb 4 (Head 4 similar)

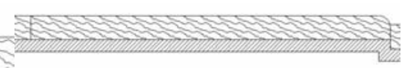
Door Threshold Details



Threshold 1

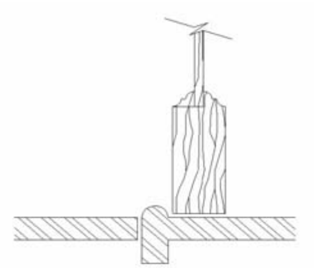


Threshold 2



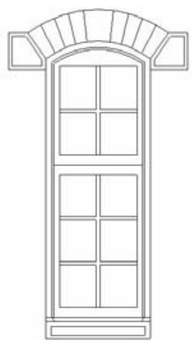
Threshold 3

Threshold 4

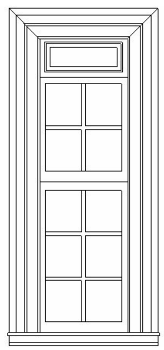


Threshold 5

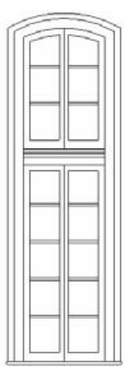
Window Elevations



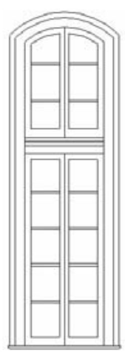
Oil House- Exterior
Window Elevation



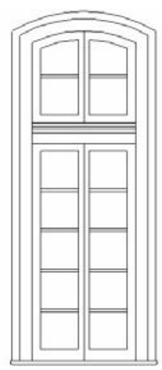
Oil House- Interior
Window Elevation



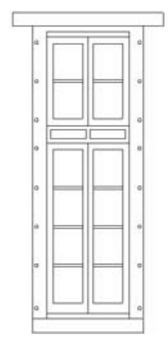
Tower - lh/w1 & w2



Tower- lh/w3 & w4



Tower- lh/w5



Tower - lh/w6, w7, w8, & w9

Window Schedule

Ident. #	Location	Width	Height	Type	No. Lights	Material	Finish	Head	Jamb	Sill
Oil House										
OH/W1	Southwest Window	2'- 31/2" 2'- 6 1/4"	5'- 10"[1] 6'- 6 1/2"	Fixed/ Double Hung	4/6 Lts.	Wood	Painted	1	1	2
OH/W2	Southeast Window	2'- 31/2" 2'- 6"	5' 10"[1] 6'- 6 3/4"	Fixed/ Double Hung	4/6 Lts.	Wood	Painted	1	1	2
OH/W3	Northwest Window	2'- 31/2" 2'- 4 3/4"	5'10"[1] 6'- 7 1/2"	Fixed/ Double Hung	4/6 Lts.	Wood	Painted	1	1	1
OH/W4	Northeast Window	2'- 31/2" 2'- 4 3/4"	5'10"[1] 6'- 7 1/2"	Fixed/ Double Hung	4/6 Lts.	Wood	Painted	1	1	1
Hall										
H/W1	South Window	27- 1/2"	5'- 10"	Fixed/ Double Hung	4/6 Lts.	Wood	Painted	1	2	3
H/W2	North Window	27- 1/2"	5'- 10"	Fixed/ Double Hung	4/6 Lts.	Wood	Painted	1	2	3
Lighthouse										
LH/W1	Level 2/3 East Window	3'- 2"	9'- 51/4" 9'- 11"[2]	Fixed/ Casement	4/10 Lts.	Wood	Painted	2	3	4
LH/W2	Level 4 West Window	3'- 2"	9- '6" 9'- 11"[2]	Fixed/ Casement	4/10 Lts.	Wood	Painted	2	3	4
LH/W3	Level 5/6 East Window	3'- 2"	8'- 91/4" 9'- 3"[2]	Fixed/ Casement	4/10 Lts.	Wood	Painted	2	3	4
LH/W4	Level 7 West Window	3'- 1 1/2"	8'- 10"[3] 9'- 3 1/4"	Fixed/ Casement	4/10 Lts.	Wood	Painted	2	3	4
LH/W5	Level 8/9 East Window	3'- 2"	7'- 4"[3]	Fixed/ Casement	4/10 Lts.	Wood	Painted	2	3	4

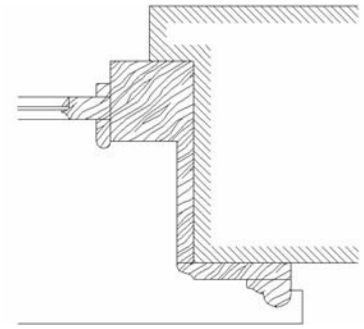
LH/W6	Level 10 East Window	2'- 2 1/4"	7'- 6 1/2"	Fixed	4/8 Lts.	Wood	Painted	3	4	5
LH/W7	Level 10 South Window	2'- 2 1/4"	7'- 6 1/2"	Fixed	4/8 Lts.	Wood	Painted	3	4	5
LH/W8	Level 10 West Window	2'- 2 1/4"	7'- 6 1/2"	Fixed	4/8 Lts.	Wood	Painted	3	4	5
LH/W9	Level 10 North Window	2'- 2 1/4"	7'- 6 1/2"	Fixed	4/8 Lts.	Wood	Painted	3	4	5

LEGEND

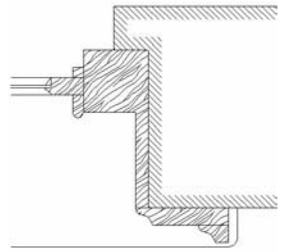
Notes

1	Exterior window dimension
2	Height of window at crown of arch
3	Height of window at spring of arch

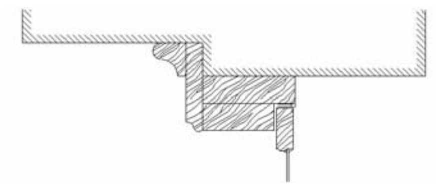
Window Jamb Details



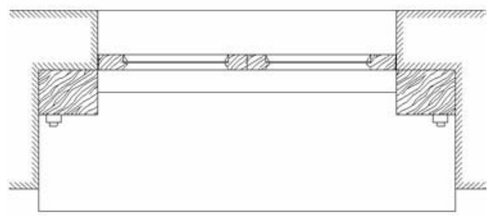
Jamb 1



Jamb 2

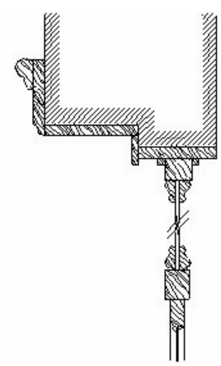


Jamb 3

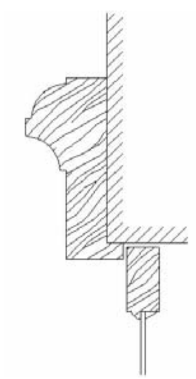


Jamb4

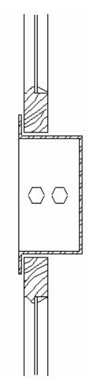
Window Head Details



Head 1

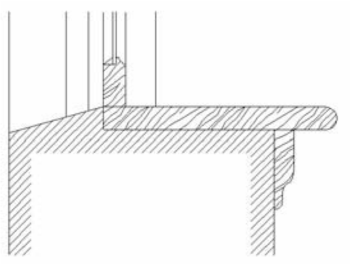


Head 2

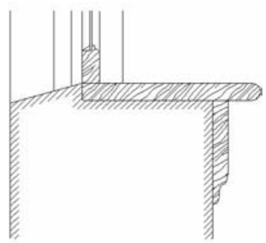


Head 3

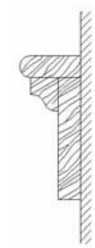
Window Sill Details



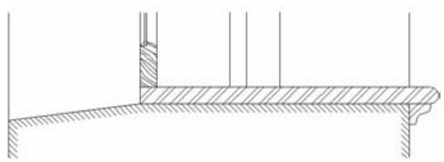
Sill 1



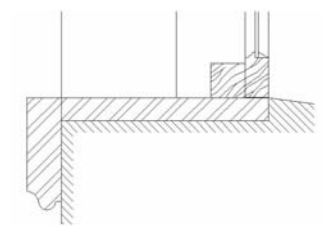
Sill 2



Sill 3

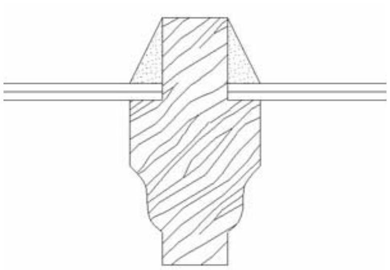


Sill 4

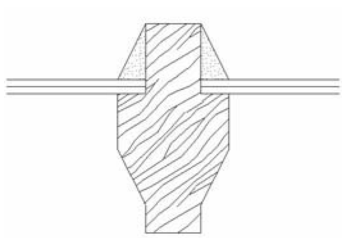


Sill 5

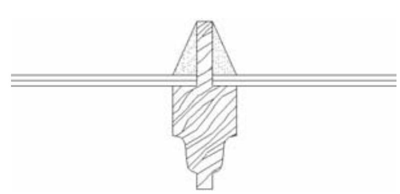
Muntin Details



Muntin 1



Muntin 2



Muntin 3

Summary Description of Interior Conditions

OIL HOUSE

Hall (OH/100)

Floor: The 12"x12" black and white marble tile is set to produce a diamond pattern in the space. The marble tile is typical of the Oil Room in the Oil House, the Connecting Hall and the first level of the Tower and is likely 1" thick as was observed in the Light Tower. A 5" white marble band surrounds the diamond pattern in the floor.

Walls: The plaster on masonry walls have a smooth finish and are painted. Generally, the plaster is in sound condition.

Ceiling: The ceiling is arched and finished with tongue- and- groove boards with one bead on the tongue side. There is one 4" wide board just south of center of the ceiling, while the prevailing board width is 3 ½". The ceiling is in good condition.

Base: The base is painted on the wall up to a height of 7" in black.

Crown: No crown molding exists in this room.

Fixture: Light fixture Type 1 is affixed to the ceiling of this room.

Other Features: None identified.

Figure 21 Oil House, Hall (OH/100)

Work Room (OH/101)

The Work Room finish merited a more refined treatment than the Oil Room. Given the industrial functions of the Oil Room, it would have been impractical to finish it with wainscot and wood floors. The Work Room, on the other hand, could provide more comfortable surroundings for the Keeper and his Assistants who used it.

Floor: The floor in this room is wood and is in sound condition. According to the paint analysis and Coast Guard maintenance reports, the floor and floor framing were partly replaced in 1976 due to termite damage.

Walls: The north wall of this room contains the fireplace and windows. The walls in the Work Room have different treatments. The south wall is brick with a cementitious finish. The other three walls are painted brick. All walls in this room have a wainscot with a chair rail cap at 3'- 8 ¾".

Ceiling: The ceiling in this room is tongue-and- groove, single bead board 3 ½" wide running east and west. The ceiling material appears in good condition overall. This ceiling may have been the one repaired by the Coast Guard in late 1986 due to termite damage.

Trim: The wainscot is illustrated in the detail attached to the finish schedule. An examination of the details of the existing wainscot indicates trim that is different from that suggested in the original drawings, raising some question that one of the following may be the case:

- the wainscot may not be original, or
- parts were altered in the past, or
- the original wainscot was not built as indicated on the drawings.

It may be that the wainscot was included in the repairs undertaken by the Coast Guard in late 1986 that were the result of termite damage.

Base: The base in this room is wood and, like the wainscot, does not match the profiles shown on the original drawings. It may also have been repaired due to termite damage in 1986.

Crown: The crown molding in this room is a two- piece assembly as illustrated in the finish schedule and appears in good condition.

Fixture: An industrial metal shaded fixture mounted to a junction box is on the ceiling of this room. Its date of installation is not known.

Fireplace: The fireplace in the north wall of this room is original, including the mantle and surround, and is in good condition. The original stone mantle cap is in place. According to the paint analysis, the mantle surrounds and cap have always been painted. Missing paint at the bottom of the surrounds should not be mistaken for the shadow of a past base as one was never installed according to the paint analysis.

Shadow of Past Shelving: There is evidence of bracketed shelving or cabinets on the east and west walls of this room. The 1871 drawings define the characteristics of this shelving.

Oil Room (OH/102)

The Oil Room has seen the most change of any of the spaces in the structure. This is due to the fact that the conversion from oil to electricity as a power source for the light has been the single most significant change in the history of the building. Given that the function of the Oil Room has been to support the power source for the light, it has realized the most change.

Floor: The floor in the Oil Room is 12"x12' marble in a pattern to match the pattern described in the hall. Inserted in the floor are two areas of concrete where the tile was removed and equipment mounted in the past to support power- generation. Like the Hall (OH/100), a 5" band of white marble surrounds the square tile floor pattern.

Walls: The painted brick walls are generally in good condition. The walls on the east and west side of the room accommodate cabinets and benches. The north wall is brick with a cementitious finish. The south wall is substantially filled with the fireplace and the two windows.

Ceiling: The single bead board ceiling appears in sound condition except for the deteriorated area in the northwest corner of the room.

Base: There is no base in this room.

Crown: The crown profile is a two- piece trim at the joint between the wood ceiling and plaster walls. Overall, the trim appears in sound condition.

Fixture: There is an industrial metal shade fixture mounted to a junction box in the ceiling of this room. Its date of installation is not known.

Other Features: There are several features of note in this room. They include:

East and West Walls

- *Butt Shelf Wall:* The cast iron butt shelves held the oil drums during the period when oil was the power source for the light. The original drawing for these shelves, Plate VII, calls out the shelving as 155 lb. and the iron support below as 140 lb. Phoenix T-iron. The shelves are in place and in good condition.
- *Casework above Butt Shelf with Ladder:* The wood casework originally installed above the cast iron butt shelving remains in place, including the metal rails for the steel ladders (based on the 1871 construction documents) that were not observed on site. Overall, the casework is in good condition.

North Wall

- *Electrical Panel and Backboard:* The north wall of the room, east of the door, contains a plywood backboard and an electrical panel supporting the power supply to the electric lamp at the top of the Tower.

South Wall

- *Fireplace:* The fireplace is original, including the mantle and surround, and is in good condition. Of particular note is a hole in the upper part of the fireplace, above the mantle that is often where a flue for a wood- burning stove might have been installed. However, an examination of the original drawings indicates that the opening in the chimney was to accommodate a ventilator for handling and managing fumes from the oil stored in the room. There is no flue pipe connected to the hole in the chimney at this time. The original stone mantle cap is in place. According to the paint analysis, the mantle surrounds and cap have always been painted.
- *Shelving:* The south wall of this room accommodated a workbench in front of the window with casework to the east and west side of each window respectively. These

features do not exist at this time but were presumably installed to address the operational requirements of an oil- fired lamp.

Connecting Hall (H/100)

Floor: The marble floor, identical in layout and treatment to that found in the Oil House, is in sound condition. A 1 ½" white marble band separates the square tile pattern from the wall on the north and south side of the room.

Walls: The painted brick walls exhibit peeling paint and evidence of mildew. A potential cause for this condition is the fact that a significant part of the north and south walls in the room are inside the base of the Tower. The mildew observed in this room supports the conclusion that rising damp and flooding is contributing to the leaching in the exterior stone base, which may remain damp for long periods of time, if not constantly.

Ceiling: The ceiling in this room is 4" tongue-and- groove single bead board similar to the single 4" ceiling board identified in the Hall of the Oil House. The ceiling is, overall, in good condition. At the east end of the Hall, the wood ceiling terminates, and brick arches support the Tower wall at the opening. Peeling paint was observed in this area, suggesting the potential that failure has occurred in the flashing where the Hall roof connects to the Tower.

Base: There is no base in this room. However, the suggestion of a base is painted on the north and south walls to a height of 7".

Crown: There is no crown molding in this room.

Fixture: There is no light fixture in this room.

Conduit for Lamp Power: A significant feature in this room is the conduit that traverses from the electrical panel in the Oil Room of the Oil House through the Hall and into the Tower, where it ascends the Tower wall to the panel in the Watch Room at the top of the Tower. A portion of the brick at the intersection of the Tower wall and the Hall wall at the top of the stairs from the Hall to the Tower has been removed to accommodate the turn of this conduit from the Hall into the Tower.

LIGHTHOUSE

The Light Tower is, effectively, four rooms: the main shaft, the Service Room, the Watch Room, and the Lantern Room. However, given that there are specific conditions to be noted at and between each landing in the Tower, each landing was considered a room for purposes of documenting conditions in the Tower.

Stairs: Since the stairs are common to all levels of the Tower, they are addressed here to best present their condition and characteristics. The original drawings document the characteristics of the stairs in great detail. The Tower stairs and landings (except for the first level which is on fill with marble and stone flooring) are cast iron. There are five cast iron components associated with each tread (see Plate XI. of the 1871 construction documents), which are cast iron with an open- checked plate walking surface.

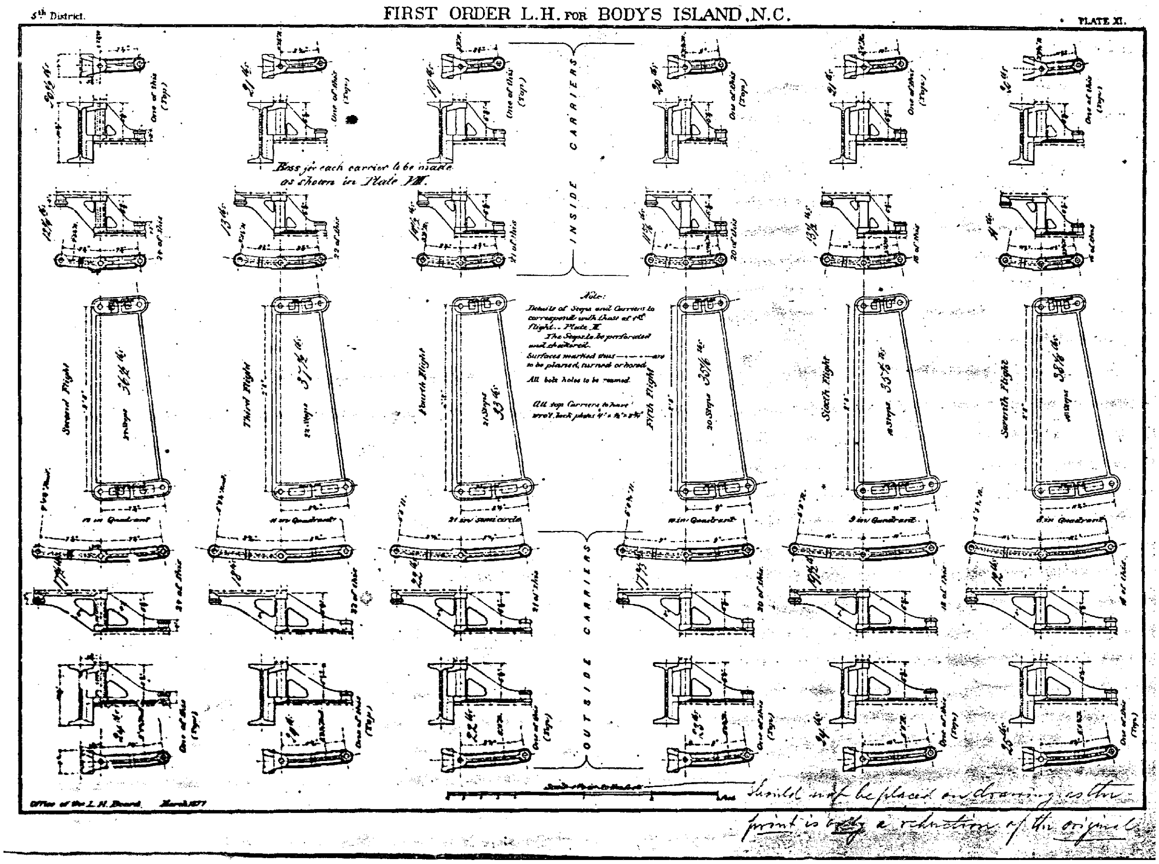


Figure 22 Plate XI, 1871 Drawings.

The landings are cast iron plate with diamond pattern on the walking surface and an integral reinforcing grid on the underside and are supported by a cast iron I- beam at the diameter edge of the landing.

The focus of this assessment is to identify the number of treads on each level and the conditions that deserve attention. The deteriorated conditions noted in the following schedule are based primarily on visual observation of damaged treads. There may be other conditions of damaged cast iron components that deserve

Schedule of Stair Treads & Conditions		
Section	# of Treads	Damaged Treads
Flight 1	1 - 25	19, 23, 24, 25
Flight 2	26 - 50	46, 47
Flight 3	51 - 72	71
Flight 4	73 - 94	82, 84, 85
Flight 5	95 - 114	-
Flight 6	115 - 132	-
Flight 7	133 - 149	-
Flight 8	150 - 179	169
Flight 9	180 - 196	186, 188, 192, 193
Flight 10	197 - 205	-

repair or replacement that have been obscured by successive coats of paint.

Base Level of Tower (LH/100)

The base level of the Tower is approximately 9'- 9" above the prevailing grade and 7'- 8" above the finished floor of the Oil House and Connecting Hall (H/100). The five treads leading from the intermediate level of the room to the main level are granite. The upper level of the stairs is protected by an ornamental cast iron railing (See Plate IX of the 1871 Construction Documents, "Plan of Guard Railing at Entrance Steps").

Floor: The floor of this level of the tower is primarily marble of alternating black and white. The marble squares, however, are not set at the same angle as those in the Oil House and Connecting Hall (H/100). The curved steps on the east side of the room are granite with a granite wall containing the inside of the steps.

Walls: The walls are painted brick, as is the case throughout the Tower. Overall, the walls are in good condition.

Ceiling: The ceiling of each level in the Tower is the underside of the cast iron landing system above. These are painted black. Overall, the under side of the cast iron landing appears to be in good condition.

Base: There is no applied base in the Tower. However, there is a painted base, the characteristics of which are cataloged in the Finish Schedule.

Crown: While there is no crown molding in the traditional sense, at the joint between the Tower and each landing, a four- brick corbelling exists to support the landing at the Tower side. Overall, this detail appears in good condition.

Fixture: The Type 2 fixture, a jelly- jar type industrial fixture, is surface mounted on the north wall. This is typical of the fixtures in the Tower. The locations of the fixtures in the Tower are indicated in the finish schedule.

Other Features:

Security Fence and Door: A recent introduction to the Tower on the lowest level is a chain- link security fence and padlocked door installed in 1985 to prevent unwanted entry to the Tower stairs. This is may be considered a non- contributing feature that could be removed once the use and management program for access to the Tower is in place. It was installed to prevent access by National Park Service visitors to the Tower and is not part of any modifications related to the production or maintenance of the light. Some floor and wall damage will have to be repaired in this area if the fence is removed.

Well: In the center of the ground level is a depressed well approximately 30" deep protected by an original cast iron railing 38" high. The well is constructed of cast iron, with a cast iron wall and cast iron floor, the entire assembly being painted black. The well and railing are in sound condition. The well was reportedly constructed to receive weights used in the operation of a mechanism that would allow the

Figure 23 Well.

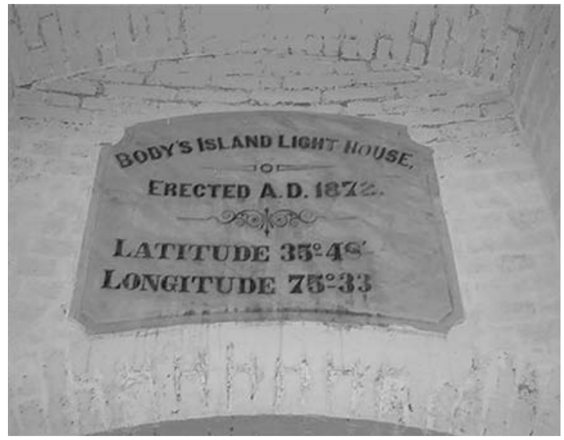


Figure 24 Dedication Plaque.

light to "flash." However, the mechanism was never installed, and, thus, the well was never used as intended in the original design.

Electrical Conduit: Extending into the room from the hall, the electrical conduit carrying the cables that power the lamp is recessed into the corner of the wall of the Tower as it turns south to run horizontally to the center of the south wall where it turns up to the upper level of the Tower. There is also conduit on the south wall to provide service to the light fixtures. There was no evidence of conduit encased in the masonry walls. If there is any concealed conduit, it is likely above the wood ceiling in the adjacent hall.

Dedication Plaque: A marble dedication plaque is mounted on the archway facing the center of the Tower (see picture). There are three points of note regarding this plaque. First, the spelling of "Body" is an early spelling of the name, thus suggesting an early fabrication and installation of the plaque. The second point of note is that the 1871 construction documents do not show a plaque, suggesting one was designed, fabricated, and installed in an exercise separate from the original construction. Thirdly, this is not the first plaque erected. The original plaque listed the members of the Lighthouse Board and the date at the time the construction of the Bodie Island Lighthouse was begun. An image of the drawing for the original plaque is found in the Chronology of Development and Use portion of this report. The drawing indicates that the location of this plaque is also the location of the installation of the first plaque. The current plaque is in excellent condition, but has some overpainting of white, the result of applications of paint to the wall to which it is affixed, that should be removed.

Tower Levels 1 – 7 (LH/101- LH/107)

Floors: From this level to the Watch Room level, the flooring is similar: a half- circle, cast iron floor. The flooring appears in good condition. Like the stairs, the cast iron, non- slip, diamond- pattern flooring is documented in some detail in the original drawings.

Walls: The walls are painted brick. See Finish Schedule for specific masonry conditions identified.

Windows: The windows, though conforming to the original window configuration, were installed in 1997 with hardware that is not historic. The granite window stools were painted black in 1997. According to the paint analysis, the window ledges, historically, were painted. Black was the original color, but they were also painted brown and red- brown over the years. However, the paint layer prior to the 1997 painting was black.

Ceiling: Underside of the cast iron landing above, painted black.

Base: Painted; see Finish Schedule.

Crown: Though there is no crown molding in the traditional sense, at the joint between the Tower and each landing, a four- brick corbelling exists to support the landing at the Tower side. Overall, this detail appears in good condition.

Fixture: See Finish Schedule.

Other Features: None identified.

Tower Level 8 / Service Room (LH/108)

Floor: The floor in the Service Room is cast iron, diamond- pattern plating the full diameter of the Tower at this level except for the curved opening to accommodate the stairs from the level below.

Walls: Cast iron paneling covers the masonry on the north wall. The stair well from below is enclosed by cast iron plating as well on the west side.

Ceiling: The ceiling of the service room is the underside of the grating of level 9. The grating is in good condition.

Base: There is no base in this room, painted or otherwise.

Crown: There are no crown molding features in this room.

Fixture: There is a Type 2 light fixture mounted on the northeast side of the room.

Other Features: None identified.

Tower Level 9 / Watch Room (LH/109)

Floor: The floor of the Watch Room is cast iron grating, fully detailed in the original drawings. It is in good condition.

Walls: The walls of the room are cast iron on the east and west and, otherwise, painted masonry.

Ceiling: The ceiling of this space is the underside of the flooring for the lantern level above. A special feature of the perimeter cast iron "ceiling" is a number of round inserts of prismatic glass designed to provide light to the

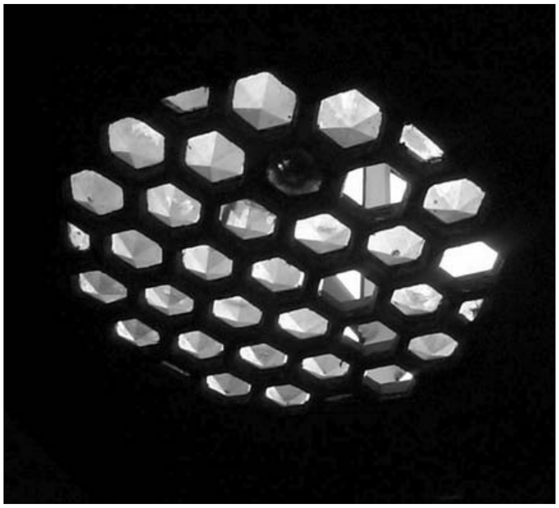


Figure 25 Watch Room ceiling insert made of prismatic glass.

Figure 26 Lens pedestal, original manufacturer's brass plaque.

Watch Room level below the lantern, much like the deck prisms of ships. A number of the glass prisms are missing. The cast iron grating and lens pedestal appear in sound condition. On the southwest side of the Watch Room is a penetration in the ceiling for a vent for earlier coal heat at that level. This source of heat has been abandoned.

Base: See Finish Schedule.

Crown: None.

Fixture: Type 2 on north wall.

Other Features:

Lens Pedestal: The cast iron pedestal that supports the lens and light positioned in the center of the room is supported by the cast iron floor and framing below. The original manufacture's brass plaque, in French, is mounted on the post of the pedestal. The pedestal is in good condition.

Electrical Panel: An electrical panel located on the west wall is served by the main panel on the north wall of the Oil Room.

Tower Level 10 / Lantern Room (LH/110)

Floor: The floor of the Lantern Room is the grating in a perimeter ring around the lens containing the inserts of prismatic glass. The floor inside the lens is cast iron diamond plate, typical of the floors at the Tower levels. The floor, except for missing glass prisms in the grating, appears in good condition.

Walls: The walls of this room are glass in cast iron muntins the full circumference of the room. There are two horizontal muntins in the window framing structure. No visually notable deterioration of structural concern was observed.

Ceiling: The ceiling of this room is the underside of the roof. There were no noticeable leaks or signs of deterioration in the ceiling area, though not all of the roof area was visible due to the size and presence of the hood feature described below.

Base: There is no base in this room

Crown: There are no crown molding features in this room.

Fixture: The fixture in this room is the light. It is a two bulb “Carlisle & Finch #44768” fixture. While it was not lit the evening of the site visit, there were no obvious signs of physical damage to the fixture and lighting apparatus. Some components of the original assembly to receive and support the earlier oil reservoirs remain.

Other Features:

Lantern Hood: The lens hood is a feature remaining from the days of oil burning lamps. This feature appears substantially intact but, evidenced by the dents in it, may have been moved or removed from time to time to access the ventilation apparatus above.

Lens: The lens is a first order Fresnel lens held in position by a brass and iron frame. There are five distinct sections of the lens defined by the position and configuration of the prisms. Except for a few chipped prisms and one missing prism in the second tier from the top of the southeast quadrant of the lens, the lens appears

Figure 27 First order Fresnel lens.

in sound condition. The frame exhibits a limited amount of oxidation in some parts of the cast iron frame. The bronze components of the lens frame appear in good condition.

Structural Evaluation

The structural evaluation consisted of a visual inspection of the subject structures that could be conducted without benefit of removing historic fabric or constructing scaffolding around the Tower, as well as a review of the following previously- completed evaluations, copies of which were provided by the National Park Service:

“Bodie Island Lighthouse Inspection Report,” by the United States Corps of Engineers for the United States Coast Guard, 1989.

"Bodie Island Lighthouse, Dare County, N.C. Report of Structural Conditions," by Alden and Associates, 1996.

Report of the International Chimney Corporation regarding structural and safety concerns at the Bodie Island Lighthouse, 2000.

In general, the observations of Hartrampf, Inc. concur with previous evaluations, noting that structural deterioration is progressing, and the cost of remediation is increasing. One feature of the Tower which has been of concern since it was first reported in 1981 has been the vertical cracking of the interior face brickwork, which extends from the fourth through the seventh levels. This may even be the cracking noted by the District Engineer in 1877, who reported "very slight" vertical cracks running from the second landing to the seventh and attributed them to stress from lightning strikes. [209] These cracks do not appear to extend to the exterior of the Tower. The finding is that one of the cracks is inactive, that is, not getting worse, and one of the cracks is still active, as evidenced by past repair work that is currently failing. Since 1989, several reports have postulated possible causes of these cracks. In 1989, the U.S. Corps of Engineers suggested that the cracks were caused by the combined effects of corrosion of the support beams and thermal expansion of the wall, though they did not feel that this compromised the structural integrity of the wall at that time. The Coast Guard inspector in 1992 stated that he felt that the cracks in the bricks had weakened the I- beam anchor points for the Watch Room landing, making the structure unsafe for maintenance personnel. The Alden and Associates report in 1996 suggested that cracking was due to severe windloading and that the structural integrity of the tower could be in doubt.

209. Holland, p. 44.

The cause of the cracks is not settlement, a cause suggested by the Coast Guard inspector in his 1992 report on the condition of the Lighthouse.[210] Settlement would be evidenced by corresponding cracks in the foundation, and the cracks do not originate at or propagate from the base of the Tower as they would if settlement was the problem. The location and direction of the cracks indicate that windloading, such as was suggested by Alden and Associates in 1996,[211] is also not the cause. Cracks caused by flexural stresses from lateral loads on a vertical cylinder, which the lighthouse is, would have a horizontal or slightly diagonal pattern, not a vertical pattern such as exists at Bodie Island. The findings of Hartrampf, Inc. on the cause of these cracks and their importance to the structural integrity of the Tower agree with those of the U.S. Corps of Engineers. Corrosion of the steel beams, the corresponding expansion stresses on the surrounding mortar, and thermal expansion and contraction are the likely causes of the cracks. Subsequent moisture infiltration is causing expansion and deterioration of the mortar

210. "Bodie Island Light (LLNR 505) Report for Group Cape Hatteras, aNT, Kennebec," in papers of the Shore Maintenance Detachment, Civil Engineering Unit, United States Coast Guard, Cleveland, Ohio, 1992.

211. Alden and Associates, 1996, p. 7.

surrounding the bricks. This condition, if properly addressed, using a deep- penetration mortar repair, should not undermine the structural integrity of the Tower. Hartrampf found no indication that the I- beam support had deteriorated significantly since the last repair. If necessary, the mortar surrounding these members can be repaired using the same deep-penetration method as that suggested for the repair of the brickwork.

Following are details of the findings of the Hartrampf, Inc. structural inspection and evaluation. Issues not directly related to the structural integrity of the Tower and Oil House, such as windows and hardware, are addressed elsewhere in this report.

OIL HOUSE

The Oil House provided limited access to structural elements. There was no access to the under side of floor or to the roof framing. Some of the architectural finish elements have evidence of rot. This implies that structural elements behind most likely will have rot as well. Specific locations include:

- Ceiling of the Oil Room
- Wall behind northern side of lower cabinet shelf of west wall in Oil Room
- Wall behind southern side of upper cabinet shelf of east wall in Oil Room
- Ceiling of the Work Room

Preservation efforts in these areas should include removal of damaged materials only and replacement to match existing. There was no

Figure 28 South chimney above the Oil Room.

evidence on the exterior of roof framing failure, which might be detected by sagging of the roof at the ridgeline or other framing members.

The southern chimney, above the Oil Room, has a noticeable lean to it above the roofline. Concern has been expressed that the chimney may be unstable. However, there is no apparent evidence of distress to the brickwork. Historic photographs from the 1890s suggest that this chimney was leaning at that time, implying that the chimney may have been originally built out of plumb. The tilt has had no apparent adverse effects on the structural integrity of the chimney. Therefore, recommendations in this report do not include rebuilding or straightening of the chimney.

LIGHT TOWER - EXTERIOR

Some of the exterior granite stonework shows efflorescence and a discharge of mortar material at the joints. These joints do not appear to be failing, and the stonework does not appear to be unstable in any way. There is no visible evidence of movement of the stones. Past suggestions that the foundation is experiencing movement are not supported by physical evidence of separation of the blocks from each other or from adjacent structures.

There are areas of the exterior brickwork above the base granite stonework that show predominantly vertical cracks along the mortar joints. Some, if not all, of these areas have been repaired during previous maintenance projects. Some areas were too high above eye level or the reach of a ladder to investigate properly to determine if any of the cracks were active. The visible cracks are not at the same locations as the cracks on the interior, further substantiating the finding that the masonry of the entire Tower is not under structural distress.

LIGHTHOUSE TOWER – INTERIOR

The structural base for the Tower finished floor is apparently granite blocks on fill. Some of the marble finish floor tile is cracked or missing in places, but there was no visible cracking of the floor structure.

The cast iron metal shapes of the stair treads and stringers, as well as the landings and supports, were evaluated for loads and stresses to inform the National Park Service of the level of public access that could be allowed in the Tower above the ground floor. This evaluation is discussed in detail at the end of the enumeration of findings on each stair flight and landing.

Figure 29 Three treads with notable cracks, below Landing #1.

Stair flight #1: One tread has been strengthened by the addition of a steel plate bolted to the original open- checked plate tread. There are three treads just below Landing #1 (LH/101) that have minor cracks near the toe of the checked plate. These have been marked with spray paint as a caution to visitors.

LH/101: The masonry walls and steel framing are in good condition with very little paint damage on the walls and no visible repair work.

Stair flight #2: Two stairs have been strengthened by the addition of a steel plate bolted to the original open- checked plate tread.

LH/102: The masonry walls and steel framing are in good condition with very little paint damage on the walls. There are minor masonry joint cracks at the interior windowsill, and minor masonry repair work is evident above stair flight #2.

Figure 30 Detail of vertical crack on south side of masonry wall.

Stair flight #3: One stair has been strengthened by the addition of a steel plate bolted to the original open- checked plate tread.

LH/103: The masonry walls and steel framing are in good condition with very little paint damage on the walls. There is minor masonry repair work evident below the beams supporting LH/104.

Stair flight #4: Three stairs have been strengthened by the addition of a steel plate bolted to the original open- checked plate tread.

LH/104: The masonry walls and steel framing show more signs of distress than previously. Repairs of vertical cracks are holding, with no signs of the cracks reopening. However, as you move up inside the Tower from this landing, the brick mortar shows increased evidence of stress. This is indicative of a moisture problem that should be addressed. See the Ultimate Treatment and Use portion of this report for recommendations.

Stair flight #5: No stairs have been strengthened or show any visible cracking.

LH/105: The masonry walls and steel framing show active signs of distress. The previously-repaired vertical crack on the south side has re-opened, and the repair mortar shows cracks as well. The crack repair on the north side appears to be holding. There is a crack on the window-sill. The wood on the window frame is rotting at the base of the window. There are many areas where the paint is peeling and falling off the walls below LH/106.

Stair flight #6: No stairs have been strengthened or show any visible cracking.

LH/106: There have been three major masonry repairs, one above each landing support beam, which continues to the level above and one above the center of the landing, which extends approximately 6 feet above the landing. All of these repairs seem to be holding well, though paint is peeling away in areas along the wall.

Stair flight #7: No stairs have been strengthened or show any visible cracking.

Figure 31 Detail of masonry repair located above landing support beam.

Figure 32 Detail of water collecting on landing that accesses Service Room.

LH/107: There have been two major masonry repairs, one above each landing support beam, which continues to the level below. Both of these repairs seem to be holding well, though paint is peeling away in areas along the wall. There is a crack along the window ledge at the window between LH/106 and LH/107.

Stair flight #8: One stair has been strengthened by the addition of a steel plate bolted to the original open- checked plate tread.

Service Room (LH/108): There is some paint peeling from the walls, and there are some exposed mortar joints. No active cracks are apparent. Water appears to collect on the landing from condensation and minor leaks from above. Resulting moisture here and throughout the stair system can create a slipping hazard.

S*tair flight #9:* Four stairs have been strengthened by the addition of a steel plate bolted to the original open- checked plate tread between LH/108 and the Watch Room (LH/109) above.

The Watch Room (LH/109): This room, providing access to the lens, has paint peeling away from the walls in multiple locations. Some water leakage is evident at the gallery/exterior wall intersection. The leakage is slight and does not significantly affect the structure, but does indicate the presence of moisture infiltration from the exterior at this level.

The Lantern Gallery, the top exterior walkway, shows many areas of distress. The steel plates that make up the exterior wall show rusting through the paint, especially along the plate joints. There are several cross- plate cracks on the east side of the wall, as well. The handrails are badly deteriorated along the entire perimeter, though they have not rusted through yet. They are stronger than they appear, due to some residual strength, but it is doubtful that they could withstand the 200- pound lateral

Figure 33 Detail of peeling paint in Watch Room.

Figure 34 View from Lantern Gallery.

load mandated by current building codes. The top side of the floor plate shows some rusting but is adequate to support a man, though probably not the 100 pounds per square foot mandated by current building codes for public access areas. The brackets which support the gallery could not be closely inspected, due to lack of access, but at least a portion of one of the brackets has fallen to the ground. The condition of the gallery railing, installed in the 1960s, which is severely corroded, can give some indication of the condition of the support metal below the gallery, installed in 1872. It should be noted that these conditions have been in evidence since at least the 1989 structural evaluation performed by the U.S. Corps of Engineers for the Coast Guard, and have been repeatedly mentioned in subsequent reports. These reports and the warnings contained therein should be taken very seriously. Recommendations regarding these components may be found in the "Ultimate Treatment and Use" portion of this report.

Loads and Stress Evaluation

The National Park Service wishes to open the Tower for access to the public. However, past evaluations have intimated that the stair system and exterior gallery may not be safe for the numbers of people the Park hopes to attract. An estimate by a volunteer at Currituck Beach Lighthouse, the sister lighthouse to Bodie Island, concluded that, if the Bodie Island Lighthouse was opened to the public for touring, the park could initially attract 200,000 to 300,000 visitors annually and could eventually attract as many as 500,000 visitors annually.[212] This estimate is based on a two- year survey of visitors to the Lighthouse who wished to climb to the top. In response to this, Hartrampf, Inc. presents the following structural evaluation.

212. McCombs, Jack, to Deborah E. Harvey, e-mail dated 9 May 2002.

Stair System

Fortunately, physical evidence on site and the efforts of an interested volunteer researcher led to the identification of the supplier of the steel shapes in the Lighthouse, such as the beams supporting the landings, as the Phoenix Iron Company, Phoenixville, Pennsylvania.[213] This company was well- known, and frequently used by the government to supply iron shapes for structures, including other lighthouses such as Currituck Beach Lighthouse, which was built in 1873. The company is listed in *Iron and Steel Beams, 1873 to 1952*, a publication that was assembled by the American Institute of Steel Construction (AISC) to document and catalog steel shapes that are no longer produced or that have changed properties over the years. The book contains tables showing, among other things, dimensions, weight, and stress factors for steel and wrought iron shapes produced by the companies listed in it. Unfortunately, the company listed by Holland in *History of the Bodie Island Light Station* as supplying the iron for the Bodie Island Lighthouse, Paulding, Kemble, & Co. of West Point Foundry, New York,[214] was not listed. Therefore, data for shapes from the Phoenix Iron Company were used in the analysis of the steel members of the stairs, as well as being extrapolated from the known properties of wrought iron of the time.

The stairs were analyzed in two parts: the individual treads and the stringers. The handrails were not analyzed. The first part of the analysis concerned allowable loads, that is, how many pounds per square inch the subject component can withstand. According to *Iron and Steel Beams*, wrought iron produced by the Phoenix Iron Company was rated for unit stress at 12 ksi (12,000 lbs. per square inch).[215] The treads were analyzed for the maximum amount of load that would be possible to generate as a result of a 300- lb. visitor standing on the tread. The fact that the stair tread is an open- check, that is, not a solid plate, was factored into the calculations. The effects of stress on the treads as a result of fatigue (age and impact) will be discussed later in this analysis. The result of the load stress calculations was a maximum load of 8.3 ksi, well below the 12 ksi limit. This indicates that the stair treads can withstand the demands of public access based on current building codes. The stringers were analyzed for the maximum weight that would be generated by persons ascending and descending the stairs (100 psf) plus the weight of the stair treads and handrails. This resulted in considerable deflection and a 10.3 ksi load. Although this stress is below the 12 ksi maximum allowed, it is too close for comfort, especially given the age of the wrought iron and concerns about fatigue (see the following paragraph). In addition, the existing stringers do not meet current allowable deflections for public access. To meet current codes, a support would have to be added mid-flight to each flight of stairs. The support must span both stringers rather than support only the one closest to the wall as the current

213. McCombs, Jack, to Deborah E. Harvey, e-mail dated 23 April 2002.
214. Holland, 1967, p. 39.
215. Ferris, Herbert W., comp. and ed., *Iron and Steel Beams, 1873 to 1952,* American Institute of Steel Construction, Chicago, 1985, p. 5.

stringer support at the bottom of the first flight of stairs does. The addition of such a support, which could be attached to the masonry using an epoxy type anchor rather than an expansion anchor to avoid further damage to the masonry itself, would result in the stringer meeting current code requirements for deflections and loading in public access areas.

According to *The Manual of Steel Construction Allowable Stress Design, Ninth Edition*, produced by the American Institute of Steel Construction, "[f]atigue…is defined as the damage that may result in fracture after a sufficient number of fluctuations of stress. Stress range is defined as the magnitude of these fluctuations. …consideration shall be given to the number of stress cycles, the expected range of stress, and the type and location of member…".[216] Early steel and wrought iron has less than 2/3 the strength of modern steel and wrought iron, so fatigue factors come into play when determining the safety of the stair treads and stringers. The stair treads are very close to the limit for fatigue stress. However, this is mainly a concern after a crack has started. Fatigue cracks generally form on the bottom surface of a fatigued member. The National Park Service should implement an inspection schedule of the underside of the stair treads, where cracks are likely to develop first. Fatigued treads should be replaced, and regular inspections made thereafter. Except for the treads that already have fatigue cracks, the existing stair treads are safe for visitors to use.

Landings

The landing plates and beams were also analyzed for load. The landing plates are formed with bracing ribs integral to the plates. The plates could deflect by 1" at a load of 100 lbs. per square inch. This would be noticeable to someone walking across the landing, but is not dangerous. However, the size of the landings prevents that amount of load from ever being present as the dimensions will not allow enough visitors on the landing at the same time to result in a load that could cause such a deflection. Additionally, the integral bracing prevents the plates from deflecting out of plane, so a higher unit stress load (18 ksi) can be used. Based on the structural analysis and a maximum load result of 4.6 ksi, the conclusion is that the landing plates will not fail even if fully loaded. The beams, which are 10 ½" wrought iron, are no longer manufactured. The analysis of the beams includes interpretation of the results of stress fatigue based on methods provided by the *Manual of Steel Construction Allowable Stress Design*. The material of the beam resulted in a stress category designation A: plain material, base metal with rolled or cleaned surface. A stress cycle load was calculated based on the number of visitors that the tower might accommodate daily, given the probable frequency of groups of visitors to the top and number of those visitors in each group that could physically occupy the upper levels. This load resulted in a loading condition num-

216. American Institute of Steel Construction, *Manual of Steel Construction Allowable Stress Design, Ninth Edition,* Chicago, 1989, Appendix K, p. 5-106.

ber 3, approximately 200 applications every day for 25 years. Using these figures, the allowable stress range for the beam is calculated at 24 ksi. The beam, also, is capable of withstanding the demands of public access as defined by current building codes.

Handrails

The handrails of the stairs and landings were not analyzed for strength. They do not meet current safety codes, which require a 4" or less space between pickets. Modifications to these handrails to meet codes will result in non- historic treatments. One of these treatment options would be to fabricate and install new handrails with the proper spacing. Another would be to install a non- clouding, rigid plastic barrier or a mesh at the railings to prevent falls. Though neither of these options represents an historic treatment, the second is a more reversible modification that is easily identifiable as non- historic, while the first would be permanent and might be mistaken by visitors as representing an original installation.

Gallery

The exterior gallery was not analyzed for public access. Visual observation of the condition of the surface and supports indicates that considerable strengthening of the gallery members would be required before visitors could safely be allowed on the gallery. Such strengthening would include re- fabrication of missing and deteriorated parts, both of the ornamental ironwork and structural components such as

Figure 35 Detail of handrail.

the decking and handrail supports. The handrail has been worn away by weather over time and will eventually need to be replaced regardless of whether the gallery is open to the public. At this time, it is doubtful that it would support the weight required by current codes. The addition of structural strengthening members beneath the deck may be required to meet current requirements for loads on the gallery should the National Park Service wish to allow the public access to it. The inability to access the gallery is likely to be a great disappointment to visitors to the top of the Tower. It is suggested that the door be opened so that visitors can look out, but that a barrier of some kind, perhaps as little as a theater rope or stout chain, be fixed across the door when it is opened to remind visitors not to step out on the gallery until it can be strengthened and made safe for visitation.

The conclusion of the structural analysis is as follows:

- The stair treads, landing plates, and beams are capable of withstanding modern load and stress requirements for public access.
- The stair stringers are not cable of withstanding these requirements and should be braced, mid- flight, on each flight, with an historically- appropriate brace similar to the one at the bottom of the first flight of stairs. This bracing should span both stringers, and could be attached to the masonry surface with an epoxy anchor to avoid additional expansive stresses on the masonry wall. If properly designed, located beneath the stair treads, and painted, such a support should be essentially invisible to the casual visitor.
- The interior handrails do not meet current codes. Modifications to them to meet current safety codes would result in non- historic treatments, either permanent or temporary.
- The exterior gallery should not be opened to public visitation until it has been repaired, and additional structural support and a new handrail installed. Until such repair has been completed, visitors could be allowed to appreciate the view through the door to the gallery but should not be allowed to step out on it.

Data from the structural evaluation may be found in the Appendix to this report.

Electrical Evaluation

The electrical service entrance for the Bodie Island Lighthouse is provided via underground service. The utility meter is mounted on the west side of the entrance to the Oil House, and the meter indicates 120/240 V service (see Figure 36).

The main service conductors run from the meter box to the 100A distribution panel in the Oil Room. The service conductors are routed in electrical tubing and are severely bent in many locations. There is no size indicated on the exterior sheathing, and concerns about possible asbestos insulation prevented examination to determine the size of the conductors. There is a bare copper conductor running from the ground bar of the service distribution panel parallel to the service entrance tubing and into the earth. The ground conductor runs in a flex conduit without protection once it leaves the Oil House.

The routing of the service conductors and grounding cable runs from the utility meter to above the door of the Oil House entrance (see Figure 37), penetrates the door (Figure 38), is routed across the south wall of the Hall to above the Oil Room door, and penetrates the door to the distribution panel (see Figure 39).

The distribution panel is a 12- circuit panel with a 100A main circuit breaker located in the north wall of the Oil Room (see Figure 40).

Figure 36 Detail of utility meter.

Figure 39 Detail of electrical wiring access to distribution panel.

Figure 37 Detail of utility routing through door frame

Figure 40 Detail of distribution panel.

Figure 38 Detail of electrical line.

The 12 circuits are:

- Ckt. #1Room lights (20A)Ckt. # 2Main light (2 pole 40A)
- Ckt. # 3Stair light (20A)Ckt. # 4Main light (2 pole 40A)
- Ckt. # 5Receptacle (20A)Ckt. # 6Light (20A)
- Ckt. # 7Receptacle # 1 (20A)Ckt. # 8 Receptacle #4 (20A)
- Ckt. # 9Receptacle # 2 (20A)Ckt. # 10 Receptacle # 5 (20A)
- Ckt. # 11Receptacle # 3 (20A)Ckt. # 12 Space.

Figure 41 Lightning rod installed on gallery handrail.

Figure 42 Conduit for lightning protection, located at tower base.

Circuit number 5 is the receptacle for the Work Room, and receptacles designated with numbers 1 through 5 are receptacles installed recently to support the ongoing maintenance program by the National Park Service. Cables for circuits number 1, 3, and 6 look older. They may be those installed during the 1992 electrical renovation.

Stair lights consist of a light fixture at each landing level on the north wall of the Tower. With the exception of the ground level landing and the first floor landing, the rest of the lights do not work; either light bulbs need to be changed or wiring problems may exist.

Cables to the main light (circuits number 2 and 4) are in good condition and appear to have been installed recently. The cables are routed through a PVC conduit with fittings from the ground level to the main lights. Conduit and fittings are in good condition. Conduit continues to the control box in the Watch Room level and then to the main light.

There are number of lightning rods installed on the handrail of the gallery and supported by the handrail (see Figure 40) with two opposite down conductors (2/0) on the north and south side of the Lighthouse. The two down conductors are bare copper and are routed exposed to approximately 14' above ground, then routed to a ½" schedule 40 PVC conduit to the earth (see Figure 41). There was no indication of what the down conductors were connected to underground (ground rods, ground ring, or both). The original lightning rod at the top of the ventilator ball is no longer connected to any down conductors. However, a bare copper cable runs from a newel post at the base of the Tower stairs, along the perimeter of the ground floor of the Tower, through the window on the north side of the Hall Connection (H/100), and down the wall on the exterior into the ground. This may be part of the cable installed in 1884 to replace the original lightning protection system. It is not known if this cable is attached to any ground plate or grid underground. It is, however, attached to the bottom newel post of the stairs. This is a safety concern. If it is connected to nothing underground, the possibility exists for a lightning strike to electrify the stairs and landings, which could cause injury to anyone standing on or touching them at the time. If it is desired to retain this feature because of possible historic value, a connection to an underground grounding grid should be verified or made, or the cable should be disconnected from the stairway and secured so that it will not touch the stairs or any other metal. Otherwise, it should be removed.

The Lighthouse is powered by underground commercial power. 1963 U.S. Coast Guard drawings show overhead poles and electrical modifications to install a diesel generator, automatic transfer switch, and fuel tanks inside the Oil Room. However, the generator, intended to be used as a backup to commercial power, and its accessories have since been removed, and the Lighthouse is currently operating with commercial power only.

Requirements for Treatment & Use

Legal mandates and policy directives circumscribe treatment of the Bodie Island Lighthouse. Section 106 of the National Historic Preservation Act (NHPA) mandates that federal agencies, including the National Park Service, take into account the effects of their actions on properties listed or eligible for listing in the National Register and give the Advisory Council on Historic Preservation a reasonable opportunity to comment. NHPA regulations (36 CFR 800.10) mandate special requirement for protecting National Landmarks. Section 110(f) of the Act requires that the Agency Official, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected by any undertaking. The National Park Service's "Cultural Resource Management Guideline" (DO- 28) requires planning for the protection of cultural resources whether or not they relate to the specific authorizing legislation or interpretive programs of the parks in which they lie. The Bodie Island Lighthouse should be understood in its own cultural context and managed in light of its own value so that it may be preserved, unimpaired, for the enjoyment of present and future generations. To help guide compliance with these statutes and regulations, the Secretary of the Interior has issued *Standards for the Treatment of Historic Properties*. The

National Park Service's *Preservation Briefs* also provide detailed guidelines for appropriate treatment of a variety of materials, features, and conditions found in historic buildings.

Historic preservation is the primary component of the National Park Service mission for the Bodie Island Lighthouse. The General Management Plan (GMP) for the Cape Hatteras National Seashore was prepared prior to the National Park Service taking possession of the Bodie Island Lighthouse from the United States Coast Guard. An update of the Cape Hatteras National Seashore General Management Plan should consider and incorporate the Bodie Island Lighthouse.

Given the ownership and mission of the National Park Service at this site, the alternatives for use of the Lighthouse are limited. The appropriate use is for preservation of a significant historic resource and its interpretation as a navigational aid on the coast of North Carolina. This statement of use is the authors', since the currently approved General Management Plan (GMP) was prepared prior to the acquisition of the property by the National Park Service. Thus, there is no direction provided in a General Management Plan for the Bodie Island Lighthouse.

The United States Coast Guard managed and operated the Lighthouse, conducting repairs and maintenance activities as needed, until 2000, when the National Park Service acquired the property on which the Lighthouse sits and all appurtenances thereto except the original Fresnel lamp at the top of the Tower. The Coast Guard expects to operate the light until 2010 and retains access rights and ownership of the lamp. Because the light remains in use as a navigational aid, treatment must not interfere with that use. Existing electrical power and other features directly related to its ongoing use as an aid to navigation must be maintained.

Visitor access is a significant issue for this property. First, it is not possible to provide wheelchair accessibility to any part of the interior of the building without having a significant negative effect on it. Even the installation of a wheelchair ramp to the Oil House would result in either the obliteration of the existing entrance stairway or the creation of a new opening to the building, thus damaging the historic character of the building. This is an undesirable effect. Therefore, under the provisions of ADA, an "alternative minimum" approach to accessibility should be developed by the National Park Service that will allow interpreting the interior of the Lighthouse and the experience of ascending to the lantern level for those who are physically unable to accomplish this. The National Park Service has existing guidelines for developing such a program.

While access by the able- bodied is possible, there are several factors that serve to limit that access as well, even after modifications to the stair stringers has brought them within code

Figure 43 Detail of stair showing tread repair.

requirements. The Watch and Lantern levels at the top of the Tower have a limited physical capacity: possibly no more than four people could be comfortably or safely accommodated within either of these spaces at a time. The landings have decreasing physical capacity as the stairs ascend, and, from a safety perspective, it is undesirable to have people passing on the stairs or standing on the landings for any great length of time. Therefore, only small groups should be allowed in the Tower at a time. Based on the strength and physical capacity of the stairs and landings, it might be possible to have as many as five groups of four in the Tower at one time, but it would be better to manage those groups so that they pass on landings rather than on stairs because of the narrowness of the stairs rather than because of any lack of strength in the stair members. This management could tend to be labor intensive, as it would probably require the services of volunteers based on several levels of the Tower to interpret the Lighthouse and maintain the safety of the visitors and the equipment.

Other safety issues must also be considered. The dimension between the pickets on the interior hand railing is as much as 7", well over the code for child safety and significant modification would be required to meet safety standards for railings. The recommended method for making the landing railings safe is to install clear, non- yellowing, rigid plastic barriers behind the existing historic railings. A second option for the stair railings could be the installation of a metal mesh inside the railing pickets. Either of these barriers would be non-permanent and clearly not historic, and could not be mistaken by visitors for an historic installation. The third option would be to fabricate and install railings with pickets at the spacing currently required for public access areas. These, however, would be a permanent installation that could be mistaken for historic railings.

Another safety concern has been the possibility of visitors falling out of windows. While on the stairs, it would be very difficult for visitors to "fall" out of the windows, as this would generally require climbing over the stair railing and standing on the window stool to accomplish. At the 8th level, however, it might be possible for visitors to get close enough to a window to fall out. Currently, the windows are painted shut or are not operable. However, should the National Park Service follow the recommendations found later in this report to ventilate the Tower by opening the windows, fall protection should be installed to prevent visitors from tumbling out in attempts to see out or to get a photograph from high in the Tower. This fall protection could be something as simple as a bar installed across the window opening at about 4' from the floor to remind visitors not to access the window stool or something more substantial, such as a barred grille, across the lower part of the window. Either such device should be too close to the bottom of the window to allow a visitor to crawl between it and the window stool, and too high for the visitor to climb over.

Visitors should not be allowed on the gallery under any circumstances until it has been strengthened and the railing made safe. The gallery can currently support one or two people on occasion, for maintenance or inspection purposes, but should not be made available to anyone without fall protection. To allow visitors to see out at that level of the Tower, the door to the gallery could be opened, but a barrier should be put across the opening to remind visitors not to access the gallery. This barrier could be something as simple as a theater rope or stout chain, or something as complex and sturdy as a grilled panel.

Consideration should also be given to safety issues regarding electrical power in the building. The main electrical panel is in the Oil Room. Power is delivered to the lamp at the lantern level in a conduit mounted on the wall in the Tower. The conduit is adjacent to the stairs and accessible to visitors. The conduit is new, is contained in PVC, and does not pose a hazard to visitors unless, for some reason, they decide to try to pull it off the wall. Posted warning signs directing visitors not to touch the electrical conduit should be sufficient to protect them from it. However, the electrical panel and wiring in the Oil Room should be protected from visitors, either by restricting access to the room or by building an enclosure around it to prevent visitor access.

There is one other issue associated with use. To properly maintain the masonry walls of the Tower that are showing signs of dampness in the masonry, it is critical to be able to use the original means of venting the building: opening the Tower windows. At this time, the windows are kept shut or are fixed. To most effectively vent the building and keep moisture as close to a desirable level as possible, the use of the designed, natural ventilation is necessary. It is recommended that the National Park Service implement a program of opening the windows on a regular basis to provide ventilation to the interior of the building to mitigate the problem of moisture condensation that is the cause of most, if not all, of the surface finish and feature disintegration. Such a program may not completely alleviate the moisture problems, but it will go a long way to preventing the acceleration of the deterioration of the finishes on the interior of the Lighthouse.

Alternatives for Treatment & Use

The preferred treatment for the Bodie Island Lighthouse is to preserve it, repairing degraded features as necessary for appearance and safety, and to interpret the entire useful history of the Lighthouse, which is not yet at an end. The parameters of such a treatment are outlined in the following section, entitled "Ultimate Treatment and Use." There are, however, alternatives for this treatment that could be considered, either immediately or in the future.

Alternatives for treatment could include:

- To return to one of the oil- powered systems. This would require considerable investment to restore and operate equipment compared to the preferred approach stated above.
- To return to the 1932 lamp and generator- driven power source. The requirements of this approach are similar but operationally less complicated than the oil- powered system approach.
- To return to the 1953 configuration, when commercial power was installed. This would require installation of the same type of equipment as the 1932 approach, plus the reinstallation of such things as power poles and wiring, but would not be as

expensive and complicated to operate as either of the above options.

- To move forward in a manner appropriate to an operating lighthouse. Because the Lighthouse is still in operation and is being put to its original use, the argument could be made that it is still in the formative stages of its history. Should the National Park Service desire to make it possible for many visitors to travel to the top of the Lighthouse and access the gallery for the experience of being in an operational maritime aid to navigation, as opposed to the experience of being in a dormant lighthouse, the structural members could be strengthened in a manner that would still be sensitive to the original design and configuration, and modifications could be made to the handrails, stairs, and windows that would prevent accidental death or injury from falls, thus allowing a greater measure of safety for visitors. This option is close to the one presented in the "Ultimate Treatment and Use" portion of this report.

In both of the first three alternatives, the non-power- related improvements would be similar in scope. For the most part, the modifications to moldings, doors, and windows have been sufficiently recent that the 1953 conditions substantially return to the original details and characteristics of wood moldings and doors as shown in the original construction documents, with the exception of some differing paint finishes on the interior and treatments such as shutters on the exterior. The third alternative would result in some non- contributing modifications that would, nevertheless, expand the range of visitors to the Lighthouse.

Ultimate Treatment & Use

The proposed use is as a visitor interpretation of maritime navigational history on the North Carolina coast while retaining the existing power service and continuing to operate the light as a navigational aid. The proposed treatment is preservation of the existing facility.

The following represents recommendations for treatment of the Bodie Island Lighthouse to accomplish the preservation objective and allow visitors to tour the Oil House and Tower in a safe environment.

The Lighthouse can be divided into four separate work projects, worked either concurrently or individually: the exterior of the Oil House, including the Hall Connection, the exterior of the Tower, the interior of the Oil House, including the Hall Connection, and the interior of the Tower.

The 1996 paint analyses of the Oil House indicated the presence of lead in paint beneath the top surface paint. Lead paint abatement on painted surfaces of the exterior of the Oil House should be performed. After the paint has been removed and before the application of a new coat of paint, an inspection should be made of the granite, brick, and mortar forming the foundation and walls of the Oil House and Hall Connection. It is not anticipated that any structural defects will be found in either the foundation or the brick walls, but the condition of these features should be documented before any masking layers of paint are applied to the surfaces. If repointing is found to be necessary, testing should be performed on the mortar to determine its composition. Repointing mortar should be formulated to match the existing mortar in composition to prevent future stress on the blocks or bricks of the foundation and walls from incompatible mortar. It is not recommended that the existing exterior electrical meter be moved, as it is in its original location. See the electrical recommendations at the end of this section for comments on the possible presence of asbestos wiring insulation. The rotted wood bracket on the northwest corner of the Oil House should be repaired or replaced to match the other bracket. Following inspection, repairs, and, if necessary, repointing, the Oil House and Hall Connection should be repainted. Consult the paint analysis for an appropriate color scheme. It is unclear when shutters formerly attached to the Oil House were removed. If this occurred under the stewardship of the National Park Service, they should be reinstalled and painted a light color as indicated in the most recent pictures in which they appear.

Figure 44 Detail of foundation showing mortar leaching.

The roof of the Oil House and Hall Connection is reaching the end of its useful life. The last known roof installation occurred before 1977. In addition, the copper flashing appears to be in need of replacement. The existing roof and decking should be removed. While it is removed, an inspection should be made of the roof framing over the Oil House and Hall Connection and conditions fully documented. Before a new roof is installed, any rotted members should be replaced. The east chimney, which is leaning, should be inspected to verify that the chimney is not experiencing distress below the roofline. A new roof deck, new roof flashing, and new roofing should be installed using asphalt composition shingles matching the current existing color.

The stone foundation and brick walls of the exterior of the Tower do not appear to be in distress. Leaching of the mortar from the foundation, likely caused by rising damp, is not sufficient to jeopardize the stability of the structure. Cleaning of the exterior joints and repointing will be required periodically, as it would on any stone or brick structure, and should be performed at this time with a mortar appropriate to the existing mortar. However, a closer inspection of the brick Tower, especially of the upper levels,should be performed to document that cracks appearing in the interior of the Tower do not penetrate to the exterior. Like the Oil House, the paint of the Tower contains lead. The paint on the exterior of the Tower should be removed. Paint removal, inspection, and repainting will require the construction of scaffolding or the employment of some other means to reach the top of the Tower. To most efficiently use this means of reaching the upper exterior reaches of the Tower, the paint of all exterior metal portions of the Tower should also be removed at this time and all metal parts thoroughly inspected for damage and documented. In addition, the roof of the Tower, composed of 3/32" sheet copper, and the ventilator ball at the top should be inspected from the outside for damage, and conditions documented. If the Park Service prefers to repair the existing gallery to make it safe for maintenance and inspection activities but not allow visitor access at this time, missing parts should be fabricated and installed, repair welding should be performed on cracks in exterior metal plating and ground smooth to achieve the proper exterior finish, and a new railing should be installed. If the National Park Service is determined to strengthen the exterior gallery to allow visitors access to it, design and contract documents should be drawn based on the verified conditions. It is likely that considerable fabrication and installation of new strengthening members will occur in this case, in addition to repair of existing deteriorated features and replacement of the exterior railing, which should be replaced in either case. The engineers designing the structural strengthening members and the contractors fabricating new parts and making repairs will want close access to the surfaces to field verify conditions found after paint removal and before new paint coats are applied. To maintain the existing presentation of the historic exterior, it is preferable to install a railing that matches the one installed by the Coast Guard in 1965. However, if visitor access is to be allowed in the future, the Park Service may opt to install one that meets current code requirements.

After paint removal, inspection of surfaces, and installation of needed repair materials, the metal and brick surfaces of the exterior of the Tower should be repainted using the historic color scheme that has been in use since at least 1945. This includes painting of the granite surfaces surrounding the windows, which were originally not painted, but have now been painted for nearly sixty years. It does not include painting the vertical surface of the base capstone which was inadvertently overpainted during the 1997 painting of the Tower and should be returned to its historically unpainted condition. If inspection of the copper roof and ventilator ball indicates repair or replacement is necessary, these features should be repaired or replaced at this time. The lamp should be reglazed, with clouded and crazed panes replaced.

On the interior of the Oil House and Hall Connection, lead paint documented in the 1996 paint analyses should be removed. With the paint removed, the brick interior walls and the wooden surfaces should be inspected, documented, and repaired where necessary before repainting. Reinstallation of missing features, such as shelving or power generation equipment, should not be undertaken, though it might be educational to seal the walls exhibiting the ghosts of past shelving against moisture with a clear sealer instead of repainting them. Additionally, it is not recommended to attempt to return to earlier woodwork profiles or door or window hardware. Existing features should be preserved wherever possible or replaced in kind where necessary. The wood floor in the Work Room should be refinished and sealed. If, in the future, it becomes necessary to replace this floor for any reason, the framing below should be inspected, thoroughly documented, and any rotted members replaced. In the Hall, Hall Connection, and Oil Room, the marble floors should be cleaned and any cracked or missing tiles replaced. It is not recommended to replace the cementitious material that marks the locations of former power- generation equipment. The electrical panel must be protected from visitors to the Oil House. This may involve restricting access of visitors to the Oil Room in some way or building a protective screen around the equipment. The equipment should not be moved, as it is in its historic location. The flue vent in the fireplace of the Oil House should not be blocked where the blockage would be visible to visitors, but should be blocked on the interior to prevent insects, birds, and rain from accessing the Oil Room. Since neither fireplace is currently used, nor have they been used for many years, it might be useful to block both of them in this manner. The electrical wiring should be inspected and replaced as necessary. See electrical recommendations at the end of this section. Light fixtures should be inspected and repaired or replaced in kind if necessary. After inspections and repairs have been made, the interior surfaces of the Oil House and Hall Connection that were painted should be repainted. Consult the 2002 paint analysis for a color scheme.

The first step in the preservation of the Tower should be the restoration of the natural ventilation system present in the first design. The Tower windows should be made operable by removing paint that holds them shut and installing appropriate hardware. A systematic program should be implemented to open the windows regularly to provide ventilation and reduce moisture condensation on the interior of the Tower. The finding regarding the vertical cracks on the interior of the Tower is that the cracks are the result of thermal expansion and contraction, exacerbated by moisture infiltration resulting from condensation on the interior of the Tower, not by moisture penetrating the Tower from the outside. Therefore, a reduction in condensation should result in a reduction in the deterioration of the mortar surrounding the brickwork as well as a reduction in the rate of deterioration of the the metal surfaces.

Paint should be removed from the surfaces of the interior of the Tower, both the brick walls and the metal stair and landing system, up to the 8th landing. It may not be necessary to remove paint from the metal well in the center of the ground floor of the Tower or from the railings at the access stairs between the Hall

Connection and the Tower, as these features do not appear to be experiencing distress. However, removal of this paint would result in a uniform appearance of all the metal surfaces in the Tower when repainting occurs. With the paint removed, surfaces should be inspected for cracks that may have been masked by the multiple paint layers, and conditions documented. The mortar should be tested to determine its composition. Only one of the cracks in the Tower is considered to be active. This should not be construed to mean that the Tower walls are unstable. Past repairs to this crack have failed, probably due to faulty surface preparation. Cracks should be repaired using a deep- penetration method and appropriate mortar. Damage around bearing beams at the landings should also be repaired using this method. Deteriorated mortar joints on other parts of the brick interior should be cleaned and repaired with a mortar appropriate to the existing mortar. The underside of the stair treads should be inspected for stress cracks and treads requiring replacement documented. It will probably be necessary to disassemble the stair assemblies to replace damaged stair treads. Damaged stair treads should be replaced with new cast iron treads matching the original design. The original stair fabrication drawings are available to allow an accurate replica to be produced. Bracing should also be installed on each flight of stairs, mid- flight, to bring the stair stringers up to code. These braces should span both stringers rather than just being attached to one stringer as the original bracing at the top and bottom of the stair system is. If installed beneath the stairs, designed in an historically appropriate configuration, and painted to match the stairs, this bracing should be essentially invisible to visitors. After paint removal, inspection, and repair activities are completed, the walls and stairs should be repainted using an appropriate color scheme. This includes repainting the interior window stools, which were historically painted. The metal railings around the well in the center of the ground floor of the Tower and the railings at the stair access from the Hall Connection to the Tower should also be painted. Consult the 2002 paint analysis for appropriate colors. A program should be implemented by the National Park Service to inspect the underside of the stairs on a regular basis to detect any further stress cracks. If not covered by 1/8th inch of paint layers, as they are currently, cracks in the stairs should be detectable before they become severe. After painting is completed, the marble floor tiles on the ground level of the Tower should be cleaned and any cracked or missing tiles replaced to match existing.

The landing level railings should be modified to provide fall protection. This can be done either by fabricating and installing new railings with pickets less than 4” apart or by installing a clear, non- yellowing, rigid plastic barrier or a metal mesh barrier on the inside of the railing. The second option is preferred, as it could be a temporary installation and would be obviously a non- historic addition that could not be mistaken for an original installation. The Park Service should also consider installation of fall protection, possibly mesh, on the inside of the stair railings. The possibility of visitors falling out of windows on levels below the 8th level is remote. On the 2nd and 5th landing levels, visitors could have access to the openings, but the ledges are several feet wide, and falling out would require standing or sitting on the window stool. It is not likely a visitor could fall out of a window simply by leaning over the stool. At the other windows, the stair railing prevents easy access to the window stools. However, if desired, a single bar installed across the opening to the windows at landing levels, at the furthest point in the wall from the window and several inches above the top of the window stool, should deter visitors from accessing the window ledges and possibly falling from windows that have been opened to provide ventilation to the Tower.

Treatment of the 8th level, the Watch Room level, and the Lamp Room level is somewhat different from that of the levels below, and so is discussed separately. On the 8th level and Watch Room level, the walls are both metal and brick. On the 8th level, the floor and ceiling are metal, but on the Watch Room level, the floor is metal, while the ceiling consists of a metal grate with prismatic glass inserts. Moisture control appears to be more difficult in these rooms because of a lack of means of ventilation, though the 8th level does have four windows. These windows could be easily accessed by visitors. Though the exterior ledges are still quite wide, it is recommended that fall protection be provided if these windows are opened for ventilation. A more substantial barrier than that recommended for lower levels, such as a barred grille, should be constructed on the interior of the window at the Tower wall, at least 3' in height to prevent visitors from getting too close to the opening.

Paint should be removed from the brick and metal surfaces of the 8th and Watch Room levels, including the stairs and the support of the lamp, and the surfaces inspected for damage and documented. Some moisture infiltration has occurred at the connection between the masonry and the metal wall surfaces. It appears that this moisture is the result of leaking through cracks and deterioration in the metal surface on the outside of the tower. Repair of these exterior cracks and deteriorated surfaces should solve that problem; however, this surface should be caulked prior to painting to provide a moisture- proof barrier against outside water infiltration. Cracks on the interior metal and brick surfaces of the 8th and Watch Room levels should be repaired as appropriate and as detailed in other parts of these recommendations. There are three metal doors involved in this section of the Tower: one accessing the gallery, one accessing the Watch Room, and one designed to close either opening. They are all historic, being either original or installed by the Coast Guard, and they are in poor condition. The doors and their associated hardware should be repaired or replaced in kind and painted as appropriate. The stairs should be inspected for stress cracks in the same manner as the stairs on the other landings and repaired as necessary. After inspection and repair activities are completed on the walls, floor, ceiling, and stairs of the 8th level and the walls, floor, and stairs of the Watch Room level, these surfaces should be painted using an appropriate color scheme. Consult the 2002 paint analysis for colors.

The paint on the lamp support in the Watch Room does not appear to be in poor condition and probably does not need to be removed or replaced. However, removal of the paint and repainting would result in a surface uniform with the rest of the metal surfaces in the Watch Room and is recommended. Care should be taken not to damage the original historic brass manufacturer's plaque affixed to the lamp support column. The stairs in the Watch Room do not have any railings or other fall protection. In order to allow visitors to ascend to the top of the Tower and view the light and the lens, a standard railing with pickets conforming to current code requirements should be fabricated and installed at the stair from the Watch Room level to the lamp level and painted to match the stairs.

The grating that serves as both the ceiling of the Watch Room and the floor of the lamp level is missing several of the glass prisms installed in the inserts to provide light to the Watch Room below. This grating and the interior of the muntins in the lamp should be stripped of paint, inspected for defects, and repaired as necessary. Replacement prisms should be fabricated and securely installed in the grating. (It is entirely possible that some of them have been removed in the past as souvenirs.) The grating and the muntins should be repainted as appropriate, consulting the 2002 paint analysis for guidance on paint colors.

Figure 45 Detail of Fresnel lens.

The Fresnel lens and the light within are the property of the United States Coast Guard. It is not recommended that the Park Service undertake any repair activities on these features. The hood above the lens and the ventilation tube that connects to the ventilator ball are, however, features belonging to the Lighthouse structure. These should be cleaned, repaired if necessary, and painted if required. The ventilation tube is stopped up with some sort of fabric or paper. This should be removed. However, it is desirable to prevent insects, rain, or birds from accessing the interior of the Fresnel lens, so the tube should be stopped with caulk or other waterproof material at a distance inside the tube that will not be normally visible to visitors.

Though the electrical service was upgraded in 1991, some electrical modifications should be made at the Bodie Island Lighthouse. Ideally, these should be accomplished together rather than piecemeal, and probably after the bulk of the preservation activities have been completed. Electrical modifications include:

- Replacing the service entrance tube with conduit and replacing service entrance cables that have suffered severe bending.
- Bonding the service entrance.
- Replacing branch circuit cables for the stair lights, room lights, and receptacles (circuits #1, 3, 5, and 6) with new cables in accordance with the latest National Electrical Code. Check for asbestos insulation before proceeding with any work.
- Replacing non- working light bulbs or faulty wiring on the landing areas (only lights on the ground level and landing 1 are working).
- Adding lightning protection at the highest point of the Tower with two down conductors.
- Verifying the connection of the existing lightning protection ground conductors. If the connection cannot be verified, consider installing a new ground ring with ground rods. While this is being done, it may be possible to verify the connection of the old bare copper cable that is purported to be part of one of the earliest lightning protection systems.
- Shortening and adequately supporting the two down conductor PVC conduits. They are currently about 14' long and minimally supported. They could be shortened to 3' or 4' and should be better supported.

The National Park Service may want to consider removing the chain link enclosure erected by the Coast Guard in the 1980s to prevent visitors from accessing the stairs to the upper levels of the Tower. If this installation is removed, some repairs to the walls and floor of the ground level of the Tower will be necessary.

The preparers of this report believe that, if the recommendations outlined herein are implemented, the Bodie Island Lighthouse will be in a state of preservation for the enjoyment and education of current and future generations of visitors to the Cape Hatteras National Seashore. Subsequent to these preservation efforts, normal maintenance activities should be sufficient to maintain the Lighthouse in a state of repair and preservation.

Introduction

Project Identification

This project consists of Title I architectural and engineering services. The project is located at the Bodie Island Light Station, at the Cape Hatteras National Seashore, Nags Head, North Carolina. The Park is under the jurisdiction of the National Park Service Southeast Regional Office, located in Atlanta, Georgia. The limits of this project are the top floors of the lighthouse, from the eighth floor to the top of the roof.

Project Statement and Purpose

This Condition Assessment is Volume II of the Appendix to the Historic Structure Report for Bodie Island Lighthouse dated June, 2002. The inspection, assessment, and documentation of the condition of the Bodie Island Lighthouse was prepared to establish a baseline of conditions and a foundation of information upon which to make thoughtful decisions related to the restoration/rehabilitation of the lighthouse. Recommendations for treating the structure, as well as a Class B cost estimate for these improvements, are included in this report.

Definitions

Double Keepers' Quarters: Duplex residence built for light station keepers. At Bodie Island, the Double Keepers' Quarters is now used as a Visitor Center.

Feature Condition: The current existing condition of the named feature regarding degree of deterioration.

Historic Rating: Whether or not the feature is of historic fabric. H = Historic. N = Non- historic. U = Unknown.

Light Station: All property, structures, features, and landscapes associated with a lighthouse.

Lighthouse: The tower and attached buildings; in the case of Bodie Island, the Oil House is part of the Lighthouse.

Preservation: "The act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. New exterior additions are not within the scope of this treatment; however, the limited and sensitive upgrading of mechanical, electrical, and plumbing system and other code- required work to make properties functional is appropriate within a preservation project." (SI, 1995)

Priority: During considerations regarding preservation, rehabilitation, reconstruction, or restoration of a site, building, collection of buildings, or other construction, the ranking the feature merits in restoring or retaining the historic nature of the construction in question or in complying with local, state, or Federal requirements for such a construction.

Reconstruction: "The act or process of depicting, by means of new construction, the form, features, and detailing of a non- surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location." (SI, 1995)

Rehabilitation: "The act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values." (SI, 1995)

Restoration: "The act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period. The limited and sensitive upgrading of mechanical, electrical, and plumbing systems and other code- required work to make properties functional is appropriate within a restoration project." (SI, 1995)

Total Inventory: The total number of one type of feature (e.g. cornice, pier, toilet, etc.) contained in the investigated site or construction.

List of Abbreviations

AIA	American Institute of Architects
comp.	Compiler, comparable
deg.	Degrees
ea.	Each
ed.	Edition, editor
e.g.	For example
H	Historic
IBC	International Building Code
Inc.	Incorporated
ksi	Kilopounds per square inch
lf	Linear feet
lb.	Pound
max.	Maximum
min.	Minimum
N	Non- historic
NPS	National Park Service
P.E.	Professional Engineer
pr.	Pair
psf	Pounds per square foot
psi	Pounds per square inch
sf	Square feet
SI	Secretary of the Interior
U	Unknown
U.S.	United States

Inspection Team Information

The following persons performed an inspection of the light tower at Bodie Island lighthouse on November 12 and 13, 2002:

- Mr. Robert A. Bass, P.E., Structural
- Ms. Chau Tran, P. E., Structural
- Mr. Jack Pyburn, AIA, Historic Preservation Architect
- Mr. Scott Howell, Cast iron expert

Mr. Robert Bass and Ms. Chau Tran may be reached at:

Hartrampf, Inc.
180 Allen Road, Suite 217N
Atlanta, GA 30328
404- 252- 2063
bob.bass@hartrampf.com
chau.tran@hartrampf.com

Mr. Jack Pyburn may be reached at:

Office of Jack Pyburn, Architect, Inc.
1197 Peachtree St., N.E., Suite 533A
Atlanta, GA 30361
404- 685- 9015
jpyburn@ojparchitect.com

Mr. Scott Howell may be reached at:

Robinson Iron
Robinson Road
Alexander City, AL 35011- 1119
256- 329- 8486
scotty@robinson- iron.com

Methodologies

Field Investigation: On the 12th and 13th of November, 2002, a field investigation team visited the site to collect data concerning existing conditions at the Bodie Island Lighthouse Tower, 8th Level and above. The investigative team consisted of Mr. Robert A. Bass, P.E., Structural, and Ms. Chau Tran, P.E., Structural, of Hartrampf, Inc., Atlanta, Georgia, Mr. Jack Pyburn, AIA, of The Office of Jack Pyburn, Architect, Inc., Atlanta, Georgia, and Mr. Scott Howell, cast iron expert from Robinson Iron Company of Alexander City, Alabama. The team made a visual inspection of the exterior of the Tower using a bucket on a crane provided by the International Chimney Corporation. Access to the interior of the lighthouse was via the interior stairs. No destructive inspection methods were used; no coverings, coatings, or materials were removed. Photographic documentation, including 35mm and video photography, was made of all features. Notes on features were taken. On- site National Park Service staff members were interviewed regarding concerns for the structure.

Collection and Analysis of Data: Information from the Historic Structure Report prepared by Hartrampf, Inc and the Office of Jack Pyburn, Architect, Inc., from the original construction drawings, and from previous inspections of the structure by others were assembled. Ms. Chau Tran modeled the structural components of Levels 8 and upward for strength and deflection, using *Visual Analysis*, a computerized modeling program. Reference works on strengths and characteristics of early cast iron, which is no longer used as a structural component, were consulted.

Determination of Cost Estimates: Mr. Scott Howell, of Robinson Iron Company, provided data to facilitate the estimation of costs for appropriately treating the iron components of the structure. Construction and design contingencies were computed for each item and are reflected in the listed totals. *R.S. Means Repair & Remodeling Cost Data, 2002, 23rd Annual Edition,* and *Historic Preservation Project Planning & Estimating* by Swanke Hayden Connell Architects were consulted as reference guides.

Executive Summary

The Bodie Island Lighthouse was built in 1871- 1872 by the United States Lighthouse Board for use as an aid to navigation in a chain of lighthouses along the East Coast. It was the third lighthouse constructed at this general location. Since that time, the light has been in continuous use as an aid to navigation. Over the years, the power source for the light changed from oil to electrical, but few other changes were made to the structure. The government engaged in only the maintenance activities necessary to keep the light functioning. As a result, deterioration from the harsh coastal climate has impacted the structure, especially the metal components. The Bodie Island Lighthouse was officially transferred to the National Park Service on July 13, 2000 and became part of the Cape Hatteras National Seashore. The Coast Guard retained the original first order Fresnel lens and maintains the light as part of their coastal signal program. This report details the existing physical condition of the structure and makes recommendations to the National Park Service for the preservation and restoration of the facility and to make it safe to open it to the public.

Overall Physical Condition: Due to the wide range of conditions with individual assemblies within the upper levels of the Bodie Island Lighthouse, the overall condition of the part of the Lighthouse addressed herein is considered good to fair. Some significant structural/architectural components, specifically the Watch Gallery Support Brackets, are generally in poor condition.

Period of Significance: As detailed in the Historic Structure Report dated June, 2002, for the Bodie Island Lighthouse, the Period of Significance for this structure is currently undetermined. The authors recommend that the Period of Significance by designated as the period during which the Lighthouse was in use as an active navigational aid. The Lighthouse was completed in 1872 and continues to be used by the United States Coast Guard as an aid to navigation. Therefore, the Lighthouse could be considered to be still in the formative stages of the Period of Significance. This is useful, because it would allow the National Park Service more latitude in dealing with structural and safety issues within the Lighthouse than might normally be expected if the Period of Significance was closed. The Lighthouse is not currently listed on the National Register of Historic Places, but a National Register Nomination has been prepared.

Potential for Use: The potential for the use of the Tower for interpretation and public visitation is significantly influenced by the capacity of certain historic building features and assemblies (e.g. stairs and galleries) to accommodate loads and activities other than those anticipated in the original design.

Public visitation to the upper levels of the Lighthouse of more than a few people at a time will require reinforcing the stair system to assure structural safety. As stated in the Historic Structure Report, the Watch Level of the Lighthouse can physically accommodate only four or five people at a time. Given this space limitation, only the replacement of stair treads designated in this report as in fair or poor condition with new cast iron treads to match the existing in dimension, detail, and finish is required. Structural reinforcement of the stair stringers will not be required if public access is limited to less than nine people on the stairs at a time. The number of people allowed on the 8^{th} and 9th levels should be under direct National Park Service staff supervision to insure against overloading of the stair stringer between these two levels.

However, structural capacity is only one component when considering the issues associated with public access. Railing safety and the conflict between having operable windows for improved ventilation and the associated liability of having unattended visitors in the Tower when the windows are open are also issues to be considered when evaluating the alternatives for managing this historic resource. Responses to identified physical modifications necessary to accommodate public access in the Lighthouse could include barriers on operable windows, supplemental railings and/or supplemental railing components.
Accommodations for public access have the distinct potential to alter the historic character of the Lighthouse and its specific historic features. Therefore, physical responses to public access issues should be considered in their totality and addressed to avoid negative effects on the historic features of the Lighthouse.

Recommendations for Critical Work to Preserve the Upper Levels of the Bodie Island Lighthouse: There are three critical issues to be addressed. At least one requires scaffolding. From an economic standpoint, once a decision is made to scaffold the structure to deal with the critical issues, all the issues in this report should be addressed.

Replacement of Gallery Level Support Brackets: Access to the Watch Level gallery has been closed to the public. While this action eliminates risks associated with public access to the gallery, the potential for parts of deteriorated gallery brackets falling to the ground remains. It is clear from visual inspection that some bracket finials have fallen in the past and others, still in place, are significantly deteriorated and have the potential to separate from their assembly and fall to the ground. The perimeter of the Tower is currently fenced. With the Oil House protecting the area under the west watch gallery, and with the wood fence on the north, south, and east sides of the lighthouse discouraging public access to the area under the gallery bracket finials, the area is, to a degree, secured. Monitoring of access around the Lighthouse is recommended to keep the public out of the fenced area.

Reduction of moisture infiltrating the structure: This issue requires both repairs to the cast iron and comprehensive removal, resealing, and resetting of the glass at the light level, including associated repair and replacement of window system components as detailed in this report. Given the construction characteristics of the Lighthouse and the exposure of the structure to the elements, it is impossible to eliminate moisture from entering the building through the brick and other locations over time. Therefore, ventilation of the tower as discussed below will be very important to the maintenance of the building and its components.

Improvement of interior ventilation of the Tower: The original design of the Lighthouse did not produce a watertight building. The Lighthouse design recognized the importance of ventilation to the proper maintenance of the Tower using operable windows and upper level vents. The systematic maintenance of the natural ventilation of the Tower, using operable windows in their original configuration and the lantern level vents, is critical to properly managing the moisture in the building and maintaining the structure over time.

Requirements for Modification to Allow Public Use: The National Park Service and the Cape Hatteras National Seashore has expressed a desire to open the Lighthouse Tower for public access. Public access will require modifications to the Lighthouse Tower structure to meet code requirements for public safety. Some modifications are to address structural deficiencies and some are to fulfill modern code requirements. These modifications should be made with the understanding that, while the Period of Significance is not closed, such modification is to accommodate a use not integral to the functioning of the building as a lighthouse, and thus, does not contribute to the history of the structure. Consequently, any such modifications should be made in a way that protects the historic structure, features, and finishes and is reversible to allow historic characteristics to be recaptured without degradation to the building's historic features.

Structural analysis of the stairs, landings, and exterior galleries indicate the following work should be performed before public access to the upper levels of the Lighthouse Tower is allowed.

Repair the cornice at the edge of the Gallery Deck: The cornice at the outer edge of the Watch Level Gallery Deck provides support for the deck. While the deck meets the structural requirements in the applicable building code for strength and can support the proposed live load, it does not meet the structural requirements in the applicable code for deflection. In this situation, deflection is **not** a safety concern. However, discernable deflection may be perceived under the anticipated loads and make visitors to the deck uncomfortable. Repair of the cornice will reduce the amount of deflection experienced by visitors to the gallery. The cornice should be repaired to match the original in material, detail, and finish.

Replace Gallery Deck Railing Assembly: The Watch Level Gallery Deck handrails as originally designed meet the structural requirements of the applicable building code. However, in their current poor condition, the railings do not meet the structural requirements of the applicable building code. The Watch Level Gallery Deck handrails should be replaced to match the original design in material, detail, and finish.

The original Watch Level Gallery Deck railing assembly design does not meet current code requirements for safety with respect to free open area between the handrail and the gallery deck, between the two top balusters, and between the intermediate vertical pickets and the handrail posts. Section 1003.2.12 of the International Building Code requires a space of less than 4" in any area of the guard rail assembly up to 34" high and a space of less than 8" above 34" to a height of 42". The space between the lowest horizontal bar of the railing and the deck of the Watch Gallery is about 6¼", and the space between the two upper horizontal bars is 9½", with the intermediate bar rising only 30½" from the deck. The vertical pickets provide a space of less than 4" between them except at the space between the vertical intermediate pickets and the handrail posts, which is 4¼". If public access to the Watch Level Gallery is allowed, and if the applicable code requirements for safety are met, the original railing design will have to be supplemented with non- historic features to achieve the required limitation for free area in the railing assembly. The addition of the features should be separate from the original assembly and not be modifications to the original design. The code- accommodating, non- historic safety features should be sufficiently distinct from the original materials and assembly to be able to clearly interpret the original railing assembly and have a minimal visibility when viewing the Lighthouse from the site or at a longer distance. The addition of non- historic, code- accommodating features should be installed in a way to be reversible and not damage the historic railing assembly.

Treatment of Stair Stringers: Applicable building code criteria for the strength of new stair stringers specifies a 100 lbs. per square foot live load. In practice, a 100 lbs. per square foot represents a person on every tread of the stringer at one time. If a 100 lb. per square foot load were, in fact, allowed in the Bodie Island Lighthouse, a steel bracket support attached to the tower masonry wall and spanning both stringers would be required at mid- flight of each stair stringer. However, practically, such loading is not possible given the limitations of the existing stair width and building configuration, and it is certainly within the means of the National Park Service to assure such loading is not achieved. By restricting the design occupancy to one person every other tread for purposes of load calculation, the need for mid- span brackets is eliminated. It should be within the capability of National Park Service management practices to limit public access to the upper levels of the Lighthouse to achieve the lighter load on the stair stringers.

Treatment of Stair Treads: The other public access issue related to the historically significant stairs is the capacity of the stair treads. The primary issue with the capacity of the treads is the effect of repetition, that is, the number of visitors traversing the stairs over time. The larger the number, the more fatigue is introduced into the stair treads. The more fatigue introduced, the more potential exists for deterioration of an individual tread.

When considering the issue of tread fatigue, structural engineering calculations can correlate the number of repetitions with the potential for tread failure. The effect of fatigue on the cast iron stair treads should be clearly understood. The concept of fatigue includes a finite number of trips on a tread that can be accommodated before the cast iron tread cracks or otherwise deteriorates to a point of failure and must be replaced. When the light keeper was the only user of the stairs, the number of trips up and down the stairs that the light keeper generated, approximately four hundred to eight hundred per year, could be sustained for several hundred years before damage by fatigue took its effect. The increase of traffic generated by visitors to the top of the lighthouse will dramatically shorten the life expectancy of the historic stair treads. In fact, this increased wear will damage all stair treads over time, a much shorter time than intended in the original design, to the point of requiring replacement of all original treads at some point in the future.

The fundamental question, then, becomes: what is the tradeoff between the volume of use and the importance of the stair treads as a significant historic feature? The primary limitation on public access to the top of the lighthouse is the building safety code that limits occupancy of the tower to 25 people at one time and the limited space at the top of the lighthouse, which has the capacity of no more than five people at one time. With a low volume of 80 people per day or less and ranger-accompanied public visitation to the top of the tower, the life of the historically significant stair treads can be substantially extended.

Repair Connection of Lantern Roof to Tower: While this is not a load capacity issue, the deteriorated attachment of the historic roofing to the upper perimeter wall frame should be repaired to ensure that the roof at the light level does not separate from the building under high wind loads. Though this is not an immediate concern, continued neglect and deferral of repairs will inevitably exacerbate the deterioration the roof connection and could result in damage to or loss of some of the historic roofing.

A Class B Cost Estimate has been prepared for this project. Costs are contingent upon the decisions made by the National Park Service for management of the facility. The cost estimate is based on recommendations contained within this report. The total cost of repair and restoration of the Bodie Island Lighthouse Tower Levels 8 and above is projected to be approximately $2,700,000.

Existing Conditions

Identification and Management Information

Building Name: Bodie Island Lighthouse

Building Address: Bodie Island Lighthouse, Nags Head, North Carolina

LCS #: 00114

Construction Date: 1871- 1872

Height: 150 feet from ground level to the focal point of the light; 160 feet from ground level to the uppermost part of the lightning rod atop the ventilator ball.

Modifications and Dates

The only significant modifications made to the Bodie Island Lighthouse have been the result of changes in power systems. No major modifications to the structure have been made since construction was completed in 1872. The following dates have been identified as times when modifications were made, but none of these modifications resulted in actual structural changes:

September 19, 1932: Conversion to electrical light; installation of electrical generator in the Oil House.

October 9, 1953: Installation of commercial electrical power; electrical generators removed, but a small generator installed for back- up power.

February 1964: Replacement of gallery railings.

May 1992: Replacement of electrical conduit to the top of the tower resulted in damage to some of the stair treads.

Graphic Data

The following graphics were prepared as part of the Condition Assessment report for the Bodie Island Lighthouse at Cape Hatteras National Seashore.

Photographic Record: An extensive photographic record of existing conditions as of November 12 and 13, 2002 has been organized and provided as a part of this report. This inventory is provided in printed and electronic format.

Condition Assessment Data Summary

Introduction

The foundation of the Condition Assessment was the identification and analysis of the components that comprise the upper three levels of the Bodie Island Lighthouse Tower. From a historic standpoint, virtually all the features of the area addressed in this report are considered historically significant. The only exceptions are the non- original windows and the electrical panel serving the current light.

Above Level 8, the Bodie Island Lighthouse mostly consists of a limited range of materials, mainly cast iron, glass, brass, bronze, brick, mortar, and paint. The primary concern of this Condition Assessment is with the condition and stability of the cast iron. Because it sits only 3,500 feet from the shores of the Atlantic Ocean and 1,200 feet from Roanoke Sound, the lighthouse is exposed to wind, salt, and moisture. Completed in 1872, the lighthouse has understandably experienced a notable amount of deterioration due to normal aging factors. These are exacerbated by exposure to the elements. The single largest culprit in the deterioration on the upper levels of the lighthouse is moisture. It is a significant challenge to manage the exposure of the lighthouse to moisture and inhibit its effect on the condition of the lighthouse components.

Overall Physical Condition

Overall, the structure and its components above Level 8 are in fair condition. Interior components are in good structural condition, and exterior components are in generally fair condition. However, there are certain components that are in poor condition. The condition of the upper cast iron varies dramatically throughout and, in some cases, from piece to piece for a given feature. The following assessment identifies the condition of each of the components. This assessment provides an accurate and detailed evaluation from which to prepare a management approach and a cost estimate for the restoration/rehabilitation and maintenance of the upper levels of the lighthouse.

Summary of Significant Building Features

The cast iron assembly at the upper levels is a series of interconnected components designed to achieve both structural stability and watertightness. At Level 8, the structure is primarily the masonry walls that support a cast iron deck. At Level 9, the integration of cast iron and masonry share the structural demands of the features there. The wall of Level 9 has both cast iron and masonry components. At Level 10 and above, cast iron and bronze assume the full responsibility for structural integrity. From Level 9 up, there is considerable interdependency between the masonry and cast iron associated with the historic design and assembly of the lighthouse.

Design Deficiency

One deficiency in the original design was identified in the field investigation of the upper levels of the lighthouse. The apparent lack of tolerance between the brick wall and cast iron outer wall at the Watch Level, with the inevitable exposure to moisture, has caused swelling in the structural masonry wall, producing cracks in the exterior cast iron wall at the Watch Level. It is recommended that the exterior cast iron wall be repaired *in situ*. It is anticipated that the other recommendations to manage the moisture in the upper levels of the building will have a positive effect on the performance of the cast iron wall in the future.

Other Issues

The intended future use of the Bodie Island Lighthouse as a tourist destination has dramatic implications for the historic stairs at all levels. The historic stairs are adequate for a person of average weight to traverse the tower on a regular basis as was intended in the original design. When the load of public occupancy is less than one person per every other tread, the stringers are structurally acceptable when analyzed against the applicable building code. The effects of fatigue on the treads are the primary issue with public access. The larger the visitor numbers, the sooner the treads will deteriorate due to the fatigue of increased use. Therefore, maintaining as low an occupancy over time as is acceptable will serve to extend the life of the stair treads. Some treads are already in fair to poor condition. These should be replaced with new treads of the same material, detail, and finish as the original treads.

Approach to Treatment

A characteristic of the construction of the upper levels of the lighthouse is the interconnectedness of the cast iron features. This interconnectedness makes the consideration of the approach to treatment and extent of replacement of deteriorated components and assemblies a significant concern. This assessment has been prepared based on the understanding that as many of the historic features as possible will be retained and treated *in situ*.

Special Attention Issues in Condition Assessment

The following items have been identified as special conditions on which the National Park Service desires specific comment. The issues deserving special attention are summarized as follows:

Managing Moisture: The lighthouse is a masonry structure painted on the interior and exterior. Encapsulating the masonry in paint creates the opportunity for moisture to infiltrate the masonry with limited opportunities for it to escape. The lighthouse structure was designed to be ventilated by the operable windows and the now- deteriorated upper level ventilation system. It is important to provide the maximum possible ventilation for the interior of the building to reduce the moisture in the masonry. Material testing should be conducted on the paint on both the interior and exterior to determine the extent of the barrier the existing paint is producing on both the interior and exterior.

Condition of Watch Balcony Brackets: The balcony support brackets are in the worst condition of the cast iron components on the upper levels of the lighthouse. To allow more than minimal maintenance access, these components must be restored and, in many cases, replaced to their original architectural and structural characteristics. In their current condition, they represent a danger from falling bracket finials. Several have fallen to date. No injuries have been reported, and a barrier fence exists around the tower. The National Park Service should maintain sufficient visual control of the fence area to assure that visitors do not enter the perimeter fence until these brackets are restored.

Water infiltration from Lantern Level Glazing System: Considerable water is entering the Lantern Level. This is primarily due to the failure of the window glass sealant system.

Limited structural capacity of stairs: The amount of weight the current stairs can withstand is limited. Stair treads determined to be in fair to poor condition in this report should be replaced to match the original components in materials, detail and assembly. Protecting the stairs from future overstress should be accomplished by limiting the number of visitors in the building at one time and limiting the number of people on a run of stairs at any one time to one.

Meaning of Terms of Condition for Purposes of Cost Estimating

To provide a basis for converting the field judgments to an estimate, the following responses were defined for each judgment of condition:

Poor: Features identified in this category are expected to be replaced to match the original features in material, dimension, and detail based on the existing components in the field and information provided in the original construction documents. There will be some cases where this general approach will be treated *in situ* such as the repair of the Watch Level exterior steel wall.

Fair: These features require significant treatment but will be treated *in situ*.

Good: Some treatment may be required, but the primary actions will be those related to reducing exposure to the elements that accelerate deterioration of historic features.

Excellent: The treatment for features in this category will be primarily maintenance and arresting exposure to conditions that accelerate deterioration.

Key To Condition Schedules: The cast iron design for the upper three levels of the Bodie Island Lighthouse is based on 16 increments (22.5 degrees). To organize field observations and assignment of conditions for each unit of assembly, the notation identified below was established. Tables were prepared for multi- piece assemblies to provide the level of detail necessary to prepare a thorough estimate of improvement costs.

Numbers shown outside the floor plan below identify the 16 axes on which the structural features (particularly cast iron features) of the

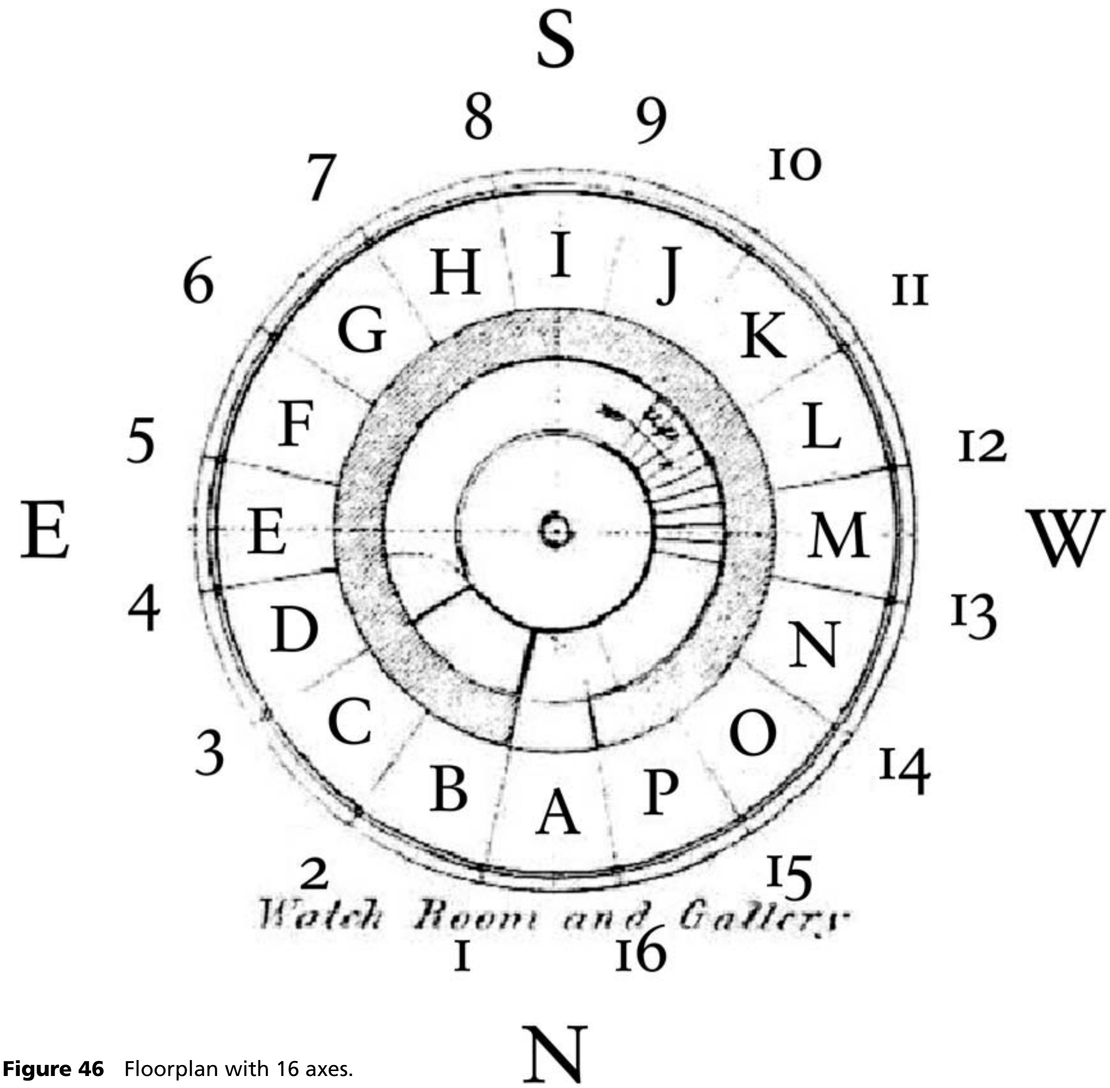


Figure 46 Floorplan with 16 axes.

upper lighthouse construction align. Letters shown above are used to identify the components of the lighthouse that span between the 16 axes.

Legend of Assemblies: The following diagram identifies the primary assemblies of the upper three levels of the lighthouse to assist in orientation to the condition assessment that follows.

1. Pinnacle
2. Ventilator
3. Roof
4. Roof Cornice
5. Window Standards & Rebates
6. Glass
7. Lantern Gallery Railing
8. Lantern Gallery Deck and Cornice
9. Steel Exterior Wall
10. Watch Gallery Railing
11. Watch Gallery Deck
12. Watch Gallery Brackets
13. Lower Collar
14. Ventilator Hood
15. Lamp and Lens
16. Steel and Masonry Walls
17. Stairs
18. Windows

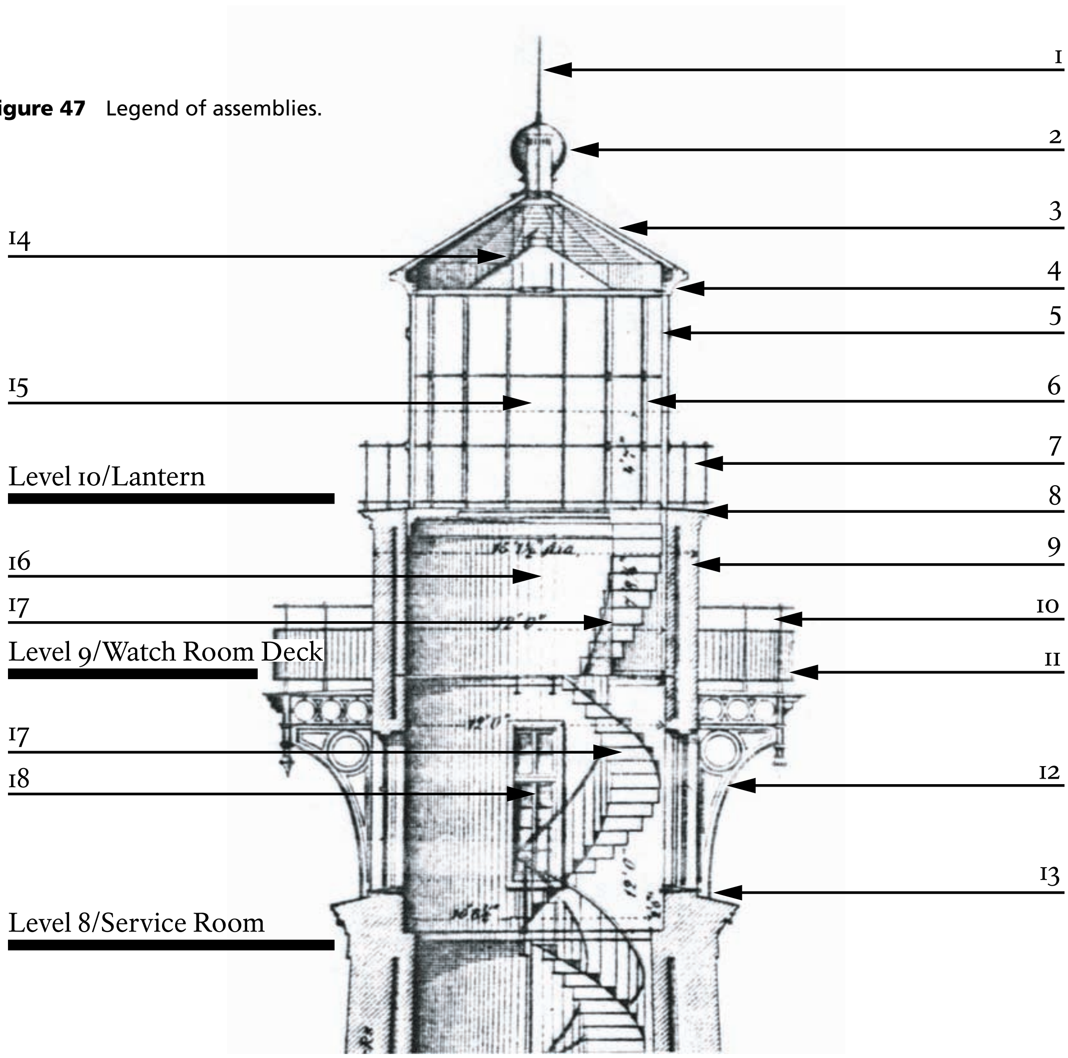


Figure 47 Legend of assemblies.

Overview of Findings

Moisture, combined with the dramatic temperature range at the site, is a major factor in the identified poor cast iron conditions. As would be expected with the exposure of the lighthouse to moisture, wind, and salt, the effect of moisture and temperature on the condition of the lighthouse is most significant. Cast iron and brick expand and contract at two different rates. Adequate tolerances are required to assure both can coexist. In at least one identified case, the tolerances do not appear adequate to avoid damage from movement of the two materials in close proximity to one another.

The second effect is the result of direct contact between salt- laden moisture and metal on the upper levels of the lighthouse. Exposure (and, here, salt is a more significant participant) without adequate, on- going maintenance over time causes damage ranging from pitting to delamination of the iron. Pitting conditions vary from minor to significant. Delamination in some areas produced thin layers or sheets of iron loosely attached.

The masonry tower structure is sound. The masonry tower structure is sound, though it is retaining an undesirable amount of moisture due, in part, to being painted on the interior and exterior, thus entrapping moisture in the masonry walls. In addition, the introduction of fixed windows has significantly reduced the ability of the tower interior to ventilate and aid in the evaporation of moisture in the interior of the tower. Evidence of entrapped moisture is expressed by peeling paint, staining, and spalling on the exterior and interior of the structure, deteriorated mortar joints, and cracking in ridged cast iron assemblies. The tower exhibits evidence of significant cracks on the north and south elevations of the interior that have been patched and are stable. Visual inspection indicates the masonry cracks do not extend through the full thickness of the lighthouse wall.

Interior cast iron is damaged from other than moisture exposure. Damage to the cast iron components of the upper levels of the lighthouse that cannot be directly attributed to the effects of moisture are primarily due to impact. This condition is seen on the stair treads at Levels 8 and 9.

The window system leaks at Lantern Level (Level 10). The window system glazing at the lantern level allows water to penetrate to the interior in a blowing rain of moderate intensity or greater.

Lantern Level window wall frame and roof assembly is in good condition. Though individual components of the Lantern Level window wall system were identified for some level of treatment, the structure above the floor level of Level 10 is in good condition overall. The roof and roof features, pinnacle, and ventilator all appear to be in sound condition. The exception is the trim pieces that contribute to the connection of the metal roof to the window wall system at the eave of the roof.

Exterior cast iron is a primary issue. The exterior cast iron is in the worst physical condition of all the features above Level 8. The effects of the exposure to the elements over time have produced deterioration ranging from cracked horizontal cast iron bands to brackets with missing parts due to delamination and spalling. The deterioration is a result of corrosive action and the associated jacking taking place at connections. In some cases, the retention of moisture inside a cast iron component, such as the fennels, exacerbates the corrosion process. In this example, notable sections of the fennels have popped off, leaving the interior of the fennels and, more importantly, the threaded connecting tie rod to the landing exposed to the elements with the likelihood of accelerated deterioration and escalated risk of the loss of integrity of the balcony structure.

There is no obvious deterioration of the anchorage of the brackets to the masonry, or, for that matter, any cast iron components connected into the masonry.

Cast iron railings have also deteriorated. In the case of the Watch Level gallery railing, the lower railing assembly was replaced in the 1960s. The standards are significantly deteriorated and have lost most of their cross- section in some areas.

A primary issue in addressing the treatment of any part of the upper level cast iron features is that the components are structurally and functionally interconnected. For example, the Lantern Level floor assembly is 16 units extending from the Fresnel lantern base casting to the outside edge of the lantern gallery and including the sill for the glass wall system at that level. Deterioration that requires the replacement of any one component of this casting could result in the disassembly of a much larger set of components.

Specific Findings

Interior of Lighthouse:

Roof: The ventilator hood sheltering the lantern is sagging slightly, and there is some rust evident, but, overall, it is in good condition. Because of the ventilator hood, the zinc ceiling above it could not be fully inspected. However, the slight sag of the ventilator hood is not a structural concern and, indeed, is a function of the original installation that should not be corrected. The crown piece and wrought iron spider frame and tie rods supporting the crown piece are in good structural condition.

Level 8 and 9: The eighth and ninth level landings are in good condition. The seventh, ninth, thirteenth, and fourteenth stair treads between the eighth and ninth levels have been strengthened by the addition of a steel plate to the top of each tread. There is a long vertical crack on the left side of the jamb at the west window on the eighth level. Also on the eighth level, there is a displaced brick above a window. The steel beams supporting the ninth level and the lantern pedestal and support at the ninth level are in excellent structural condition. At the ninth level, paint is peeling on the walls due to moisture in the wall.

Lantern Level: At the lantern level, water is ponding at the window sill rebates. The bolts at the sill rebates are deteriorated and rusted from the water penetration through windows. The interior lantern floor and beams supporting the floor are in good structural condition. The interior and exterior floor plates are composed of one plate every 22.5 degrees. The exterior portion of the plate is supported at its outer edge by the steel exterior wall below and at its interior edge by the masonry wall below. The interior portion of the plate acts as a cantilever and is supported by the masonry wall below. Even though the interior portion of the floor is in good condition, a complete assessment is dependent upon the condition of the exterior part.

Exterior of Lighthouse:

Lantern Level: The exterior portion of the lantern level floor is, overall, in fair condition, but it is continuing to deteriorate as evidenced by the gaps at the joint between the plates and the separation of the deck plate from the corbel at the edge of the deck. There is surface rust on the top surface of the deck, and there could be more rust on the underside of the deck. The underside of the deck could not be examined because of the steel exterior wall surrounding the deck. The railings are in fair condition with some surface rust. The spacing of the rail posts exceeds the maximum allowable per code for public access. The connection of the ladder from the gallery deck to the lantern level exterior deck has deteriorated and is almost completely rusted through. The spacing of the rungs on the ladder from the gallery deck to the lantern level exceeds the maximum allowed by the current building code. The ladder from the lantern level exterior deck to the roof is completely missing, and the rods to which the ladder was hooked are in poor condition. One of the rods is completely gone, and another is almost completely rusted through.

Watch Gallery: The gallery deck, gallery rail and posts, and gallery support brackets are, overall, in fair to poor condition. The rail posts have corrosion on almost all the posts. Some have bad surface corrosion, and some are severely corroded. Corrosion has caused loss of material at the posts. The spacing of the rail balusters and, in some cases, the posts, exceeds the maximum allowable per code for public access. The deck plates are severely corroded on the underside of the deck. The gallery supports have significant structural deterioration including severe corrosion, loss of material, and missing pieces. The cornice at the edge of the deck has cracks at several locations. At some sections, loss of material is evident. The steel exterior wall is in fair to poor condition, with several sections of the wall having large cracks.

Structural Analysis

The structural analysis involved certain assumptions based on field observations and judgment of conditions. The following categories were developed and used in the computer model of the structure to define each component of the structural system for the purpose of analysis:

Excellent: Modeled as shown on original drawings (no evident loss of material/strength)

Good: Modeled with a 10 percent reduction of material due to deterioration, delamination, etc.

Fair: Modeled with a 25 percent reduction of material due to deterioration, delamination, etc.

Poor: Features in this category must be replaced, so models of existing conditions were not developed.

Using *Visual Analysis*, computer models were built for each of the following: the lantern deck, gallery deck, gallery support, stair landings, and stair flight from the eighth to ninth floor. Models were built and analyses were performed for both the current and the originally designed condition for compliance with current building codes. The gallery handrails were also reviewed for compliance with current building codes.

Live loads used in the analysis were based on Table 1607.1 of the 2000 International Building Code (IBC). From the IBC, the minimum uniformly distributed live loads for stairs is 100 psf, so a 100 psf live load was used in the analysis of the stairs and landings. A 60 psf uniform live load for walkways was applied in the watch gallery deck analysis, and a 40 psf uniform live load designated for catwalks was applied in the analysis of the lantern gallery deck. The reduced loads for the walkways reflect the expectation of a lower use load in these areas than on the stairs and landings. All models were checked for compliance with the 2000 International Building Code based on flexure, shear, and deflection criteria.

Since cast iron is not a product that is used as a structural material today, stress values had to be interpreted from various texts. *Structural Renovation of Buildings* (Newman) gives the typical maximum allowable bending stress for cast iron as 3 ksi with a safety factor of 13.33 and allowable bending stress of 12 ksi for wrought iron based on a safety factor of 4.17. The allowable bending stress of wrought iron matches the value given in *Iron and Steel Beams 1873 to 1952 (AISC)*. Based on the average modulus of rupture value of 40 ksi, the allowable bending stress was obtained by dividing the modulus of rupture by a safety factor, exactly like the method described in *Structural Analysis of Historic Buildings* (Rabun). The safety factor used for cast iron is substantially higher than that used for wrought iron. Cast iron is a brittle material, exhibiting little or no yielding before failure, and is weak and unpredictable in tension and bending. Therefore, a higher safety factor must be used to account for that unpredictability and for the variability of different castings.

When analyzing an existing structure that has been standing for over 130 years, a lower factor of safety can be used than when designing a new structure. With a new structure, there is more uncertainty about how the structure and material will behave. An existing structure has been subjected to various loads throughout its life and, if it is still standing with no signs of distress, it is obvious that it can support those loads. Because structural capacity can be more accurately assessed for existing structures based on the current conditions, a smaller factor of safety than for a new structure can be used.

Because of the brittleness of cast iron, fatigue stress, caused by cyclic loading, is a major concern. Three main factors affect fatigue performance of a structural component: material, loading (stress), and environment. The structural properties of a component, such as its metallurgical and mechanical properties and any discontinuities in the material, have a major effect on how much fatigue it can withstand. External environmental factors, such as temperature, also have an impact on a structure's fatigue life. According to *Fracture & Fatigue Control in Structures*, "the primary factor that affects the fatigue behavior of structural components is the fluctuation in the localized stress,"[217] that is, the number of repeated cycles of loadings to which a component is subjected. Once fatigue cracks develop, they will propagate rapidly as the magnitude of loading cycles increases and will ultimately lead to failure.

Stair System: The stair system was analyzed in two parts: the individual treads, and the stringers. Both the stringers and treads are cast iron. Analyses were performed on the individual stair treads and the stair stringer between the eighth and ninth levels.

The majority of the stair treads are in good condition, though some are in fair or poor conditions. Analyses of a single tread were based on a 300- pound person stepping on the tread (including impact) per the IBC. As originally designed, a maximum stress of 8.1 ksi and a maximum deflection of 0.066 inch were produced. Existing treads in good condition produced a stress of 9.92 ksi and a deflection of 0.09 inch, and existing treads in fair condition produced a maximum stress of 14.2 ksi and a deflection of 0.16 inch.

With the stress results for a 300- pound person, the safety factors are 4.0 for the treads in good condition and 2.8 for the ones in fair condition. Those safety factors are much lower than the recommended safety factor of 13.3 for new cast iron. Because of the variability of the different castings of the treads and the unpredictability of cast iron, the small safety factor exceeds the "comfort zone" of safety for cast iron, and the possibility exists of failure of the stair treads when subjected to the load of a 300- pound person.

However, the likelihood of a 300- pound person walking up and down the lighthouse stair system is slim, so the treads were also analyzed for a more realistic condition, a 250- pound person stepping on the tread (including impact). As originally designed, the maximum stress of the analysis was 6.62 ksi. Existing treads in good condition produced a stress of 8.14 ksi, and existing treads in fair condition produced a stress of 11.6 ksi.

The stress results for a 250- pound person show safety factors of 4.9 for the treads in good condition and 3.4 for the ones in fair condition. Those safety factors are much smaller than the

217. Barsom, John M., and Stanley T. Rolfe, *Fracture & Fatigue Control in Structures – Applications of Fracture Mechanics,* 2d ed, Englewood Cliffs, N.J.: Prentice-Hall, 1987, p. 224.

recommended safety factor of 13.3 for new cast iron. Because of the variability of the different castings of the treads and the unpredictability of cast iron, the low safety factor exceeds the safety "comfort zone" of cast iron, and the possibility of failure of the stair treads exists when subjected to the load of a 250- pound person stepping on the tread. However, the stair treads have withstood the load of personnel using the stairs in the structure for over 130 years and are still in mostly fair to good condition. From the physical evidence of the existing treads, the treads in good condition should be able to support the loading of a 250- pound person stepping on a single stair tread. However, this does not account for the additional stress that will be caused by fatigue.

Over the years, the lighthouse has been accessed by a few people for maintenance purposes and has not been subjected to excessive loading. The two light keepers, working in shifts, walked up and down the lighthouse stairs every day for nearly 60 years until it was converted to electrical light in 1932. Thereafter, fatigue loading cycles were less frequent until 1940, when the Bodie Island became an unmanned light and such loading cycles ceased except for occasional maintenance activities. The stress cracks exhibited in the stair treads are, therefore, considered to be the result of the earlier phase of operation, before 1932. Fatigue loading cycles are taken for a 25- year period. Based on the history of its use, for four cycles per day over the first 25- year period, the stair treads and landings were subjected to 36,500 loading cycles. A National Park Service volunteer has estimated that 250,000 visitors per year will want to climb the lighthouse if it is open to the public, based on surveys of use for other lighthouses in the area. For a 25- year period, the number of loading cycles resulting from this number of visitors would be approximately 6,000,000. Based on the allowable stress range for fatigue at each loading condition, if the lighthouse were to be opened to the public at the number estimated, the increase in loading cycles would decrease the allowable stress of the structural component, specifically the stair treads and landings, by 60 percent over that 25- year period.

If the lighthouse were to be open for public access, the number of loading cycles would increase significantly from its past use. Fatigue cracks have already developed on some stair treads. The presence of those cracks illustrates that fatigue is a factor in the safety of the stair treads. Once cracks have developed, they will propagate rapidly when the number of loading cycles increases. Since the number of loading cycles will be increased more than 150 times its previous loading cycles, the fatigue stress on the stair treads will be increased by 60 percent from its current state. For a tread in good condition, using the 250- pound load, the stress would increase from 8.14 ksi to 13.0 ksi. The fatigue stress of 13.0 ksi exceeds the stress of 11.6 ksi determined for treads in fair condition. The number of loading cycles can be altered so that the fatigue stress on these treads is less than 11.6 ksi. The rationalization is that the existing treads have supported the load of a man for over 130 years and are in fair condition; therefore, as long as stresses are lower than 11.6 ksi, the treads should be adequate. If the number of loading cycles on the stair treads is increased by only 25 times the previous condition, the fatigue stress will be increased by only 40 percent from the current state. A 40- percent increase in fatigue stress would result in a stress of 11.4 ksi for the treads in good condition, which is lower than the stress of 11.6 ksi on the treads in fair condition for a 250- pound load. Based on the rationalization mentioned above, the stair treads in good condition should be able to support a 250- pound person if the magnitude of loading cycles does not exceed 50 cycles per day (25 people walking up and down) for a 25- year period. If the National Park Service wishes to allow more than 25 people per day into the lighthouse, the stair treads would have to be assessed again in several years. For instance, if 68 people were allowed into the lighthouse per day, the stair treads would have to be assessed again in ten years for fatigue. That number can be increased to 95 people per day for assessment in seven years. In any case, if the light tower is opened for public visitation, the National Park Service should implement a program of regular inspections of all stair treads for cracks.

The stair stringer between levels eight and nine was also analyzed using the minimum code recommended live load of 100 psf for public access. As originally designed, the maximum stress of the stringers was 8.9 ksi, giving a safety factor of 4.5. That factor of safety is much lower than the recommended safety factor and exceeds the "comfort zone" for cast iron. Because of the variability and unpredictability of cast iron, with that safety factor, the possibility of failure exists. The maximum deflection of 0.15 inch was below the allowable deflection of 0.65 inch. As originally designed, the stair stringer from the eighth to ninth level meets current building codes for deflection, but, for safety, there is concern because of the low factor of safety results.

The existing stair stringers are in good condition. The analysis of the stringers produced results of 14.5 ksi and 0.19 inch. The deflection results are below the allowable deflection of 0.65 inch, but the maximum stress far exceeds the safety "comfort zone" for cast iron. Therefore, the code- mandated loads for public access indicate a possibility of failure. If a support is added mid- flight to the stair stringers from the eighth to ninth levels, the capacity of the stair stringers will increase substantially. The support must span both stringers and be attached to the masonry, preferably with epoxy anchors. The addition of the support would reduce the stress of the stringers to 5.07 ksi, which is higher than the recommended allowable stress of 3 ksi, but with a safety factor of 7.9, that is still within the "comfort zone" for safety.

Landings: Analyses were also performed on the landing plates and beams at the eighth level as originally designed and in its existing condition. As noted in the Historic Structure Report dated June 2002, the landing plates are formed with bracing ribs integral to the plates. The integral bracing prevents the plates from deflecting out of plane and adds strength to the landing plates. Because of the bracing ribs, the allowable stress can be increased by 50 percent to 4.5 ksi for the landing plates. Using the minimum code recommended live load of 100 psf, the maximum stress of the landing plates as originally designed was calculated to be 8.8 ksi, giving a safety factor of 6.8 based on the additional 50 percent of allowable stress. Although that value is lower than the recommended safety factor for cast iron, it is still a comfortable safety factor since the landing plate showed no apparent signs of cracks. The maximum calculated deflection of 0.68 inch exceeds the allowable deflection of 0.57 inch. In its existing condition, an analysis of the eighth level landing produced stress and deflection results of 11.1 ksi and 0.83 inch. With the additional 50 percent allowable stress, the safety factor for the existing landing plate is 5.4, much lower then the recommended safety factor of 13.3 and exceeding the "comfort zone" for safety. Since analysis of the landing plate produces results that exceed the safety "comfort zone," there is a possibility of failure if the landing is fully loaded to the maximum code- mandated load of 100 psf. To fully load the 100 square foot landing to 100 psf, 40 people weighing 250 pounds per person would have to stand on the landing. It would be physically impossible for 40 people to stand on the landing simultaneously. Additionally, fire and life safety laws for publicly accessed spaces restrict the number of people in the entire light tower to no more than 25 at one time due to the limited means of egress. A more realistic assumption would be 15 people on the landing at one time (one person per 7 square feet,) reducing the load to approximately 40 psf and the stress to 4.5 ksi. The resulting stress would be within the recommended range for cast iron.

Gallery Deck: Two analyses were performed for the watch gallery deck: one of the originally designed condition, and the other of the current condition. As originally designed, the maximum stress on the deck sections is 3.09 ksi, which is close to the maximum allowable of 3 ksi recommended for cast iron. The gallery deck would be adequate for public access as originally designed.

The existing watch gallery deck is in fair to poor condition (see Inventory Data), so a 25 percent reduction of material was taken in the analysis for the sections in fair condition, and no analysis was performed for the sections in poor condition. The deck sections considered poor must be replaced as shown on the original drawings. The results of the analysis of the deck sections in fair condition showed a maximum stress of 5.1 ksi, which would give a factor of safety of 7.8, less than the safety factor of 13.3 recommended for design of cast iron, but still a comfortable factor of safety since the deck showed no signs of cracks. If cracks do start to develop, there is cause for concern, because, as mentioned previously, cracks tend to propagate as the number of loadings increases.

The results of the model of the existing condition showed a maximum deflection of 0.59 inch, which exceeds the allowable deflection of 0.25 inch. The results of the model of the deck in its original condition showed a maximum deflection of 0.27 inch, exceeding the allowable deflection of 0.25 inch. This indicates that deflection in this area has increased over the years.

Below the edge of the gallery deck is a cornice. Since the cornice is in poor condition, it was not modeled. As mentioned previously all components considered "poor" must be replaced. Once the cornice is replaced, it will support the gallery deck at the edge, so, realistically, the deflection that will occur at the deck will be less than the deflection results from the analysis of the model.

The results of the analysis show that the gallery deck sections meet current codes for public access for strength but not for deflection. Deflection is a serviceability concern, **not** a safety concern. Whereas the issue of strength concerns the maximum load that a particular component can safely carry, the issue of serviceability concerns the "comfort" of its occupants. Visitors walking on the gallery deck may feel the deck deflect. It is at the discretion of the National Park Service whether to address this issue.

The wrought iron handrails at the gallery level were also analyzed to determine if they could withstand a 200- pound lateral load per the International Building Code. Calculations were performed for the handrails of the originally designed and existing condition. The existing handrails and rail posts are in fair to poor condition. The results showed that rails as originally designed and in existing fair condition can withstand the 200- pound lateral load and comply with current codes. All rails considered poor should be replaced.

Gallery Support Brackets: The gallery support brackets are in poor condition and must be replaced, so an analysis was not performed of the existing condition. As originally designed, the gallery support brackets comply with current building codes for public access. The maximum stress of 2.4 ksi and the maximum deflection of 0.0027 inch are below the allowable bending stress of 3.0 ksi and the allowable deflection of 0.25 inch, respectively.

Gallery Wall Plates: There are several large cracks along the exterior gallery wall plates. The cracks in the steel plates are not caused by overload but by other factors: the lack of adequate tolerance between the masonry structure and the adjacent exterior wall plate, thermal expansion and contraction of the cast iron, and swelling caused by moisture in the masonry wall behind the wall plate. The cast iron wall plate should be repaired to arrest deterioration of that feature. From the perspective of structural strength, the cracks in the cast iron wall plate are not a safety issue and are not the source of significant moisture infiltration into the masonry behind the wall plate. The primary source of moisture in the masonry at the upper levels of lighthouse appears to be from above the Watch Level at the Lantern Level deck, venting system, and window system. Attention to the watertightness of these assemblies will improve the performance of the masonry and cast iron wall assembly at the Watch Level.

Lantern Level Deck: Two models were analyzed for the lantern level deck: one of the originally designed condition, and the other of the current condition. The current lantern level deck is in fair condition, so a 25 percent reduction of material was taken in the analysis. The results of the analysis showed a maximum stress of 1.64 ksi, which is below the allowable bending stress of 3.0 ksi. The maximum deflection of 0.02 inch is below the allowable deflection of 0.125 inch. Therefore, the lantern level deck meets current codes for strength and deflection, provided it is only used for maintenance purposes and is not open for public access.

Roof: A structural analysis was not performed on the roof. A visual inspection of the interior and exterior of the roof indicates a separation of the bronze trim from the roof panel at the cornice bracket. A few of the bolts that connect the bronze trim to the roof have deteriorated, enabling the trim to separate from the roof. From a structural perspective, because the span of the trim and roof panel (approximately 2'-3") and the forces on the roof are not great, risk of failure of the roof connection is not an immediate concern. However, the greatest risk is an abnormal wind condition that could dislodge the roof and do significant damage to this historic feature that is otherwise sound. Repair to the trim involves removing the paint on the bronze trim to check for any deterioration. If there is no deterioration of the bronze trim, the missing and deteriorated bolts should be replaced with new stainless steel bolts, and the bronze trim reattached to the roof panel and cornice. Missing trim pieces should be replaced to match the original. This treatment should be a priority.

Recommendations

It is impossible to segregate the structural and architectural components in the Bodie Island Lighthouse. Virtually all components on the upper levels of the lighthouse are structural and also contribute to the architectural character of the structure. The primary work recommendations are focused on addressing the structural problems, including the watch level gallery structure, the stair system, and the balance of other more discrete restoration recommendations. These should be repaired or replaced with components that match the original design, material, and assembly. Further, where structural concerns do not necessitate replacement, repairing in place should be the treatment of choice.

The National Park Service is considering alternatives for the management and use of the lighthouse. To protect the historic components and those replaced to match the original, the use of management techniques that limit access so as not to exceed that which approximates the loads and activity levels intended in the original Bodie Island Lighthouse design and use should be given a priority.

This report recommends the following work be undertaken to preserve and restore the Bodie Island Lighthouse Tower from level 8 upward, and to make it safe for controlled and limited visitor access.

Cast Iron Components

Replace the Gallery Level support brackets: Several cast iron finials on the bottom of the cast iron Gallery Level support brackets have deteriorated to the point that they have fallen to the ground. To date, no one has been injured. Inspection of the remaining finials suggests that others could fall at any time. Visitors must not be allowed on the Watch Level Gallery until repairs have been made. All deteriorated support brackets should be replaced with cast iron brackets fabricated to match the original design.

Repair the cornice at the edge of the Gallery Deck: The cornice at the edge of the Watch Level Gallery Deck supports the edge of the deck. While the deck meets codes for strength and can support the proposed load, it does not meet codes for deflection. Deflection is **not** a safety concern, but too much deflection may make visitors to the deck feel unstable and, thus, uncomfortable. Repair of the cornice will reduce the amount of deflection experienced by visitors to the gallery. Deteriorated pieces should be replaced.

Replace Gallery Deck handrails: The Watch Level Gallery Deck handrails in their originally designed configuration meet current building codes for strength. However, they are currently in poor condition and must be replaced if visitors are to be allowed on the Watch Level Gallery Deck. The original Watch Level Gallery Deck railing assembly design does not meet current code requirements for safety with respect to free open area between the handrail and the gallery deck, between the two top balusters, and between the intermediate vertical pickets and the handrail posts. Section 1003.2.12 of the International Building Code requires a space of less than 4" in any area of the guard rail assembly up to 34" high and a space of less than 8" above 34" to a height of 42". The space between the lowest horizontal bar of the railing and the deck of the Watch Gallery floor is about 6¼", and the space between the two upper horizontal bars is 9½", with the intermediate bar rising only 30½" from the deck. The vertical pickets provide a space of less than 4" between them except at the space between the vertical intermediate pickets and the handrail posts, which is 4¼". A new railing should either meet those requirements or should be fabricated and installed as originally designed with the addition of a barrier that both meets code and has minimal or no visual effect on the character of the tower from the site and distant views of the lighthouse.

Repair wall plates (interior and exterior): The wall plates are cracked. While this is not a structural safety issue, it is a maintenance concern as it may allow moisture to infiltrate behind the plates and cause damage. The cracks should be repaired from the interior by removing the masonry, inserting and attaching a backup cast iron plate, and reinstalling the brick. New mortar used to reinstall historic brick must match the historic mortar in color, composition, and strength.

Repair or replace damaged components of the Level 8 lower collar: At the time of replacement or repair, a method should be implemented to allow for expansion and contraction in the collar assembly to avoid recurring cracking.

Repair or replace cast iron window frames on 8th Level: Return the windows to their original, operable condition. In addition to an accurate presentation of the original windows, operable windows will provide much needed and originally- intended ventilation to the upper part of the Lighthouse Tower.

Provide fall protection at 8th Level windows: If the Park Service chooses to make the 8th Level windows operable in order to improve ventilation at the top of the Lighthouse Tower, barriers across the 8th Level windows must be provided to prevent visitors from falling as a result of leaning over the ledges to see outside. This barrier could be temporary and moveable, but it would be preferable to install a barrier substantial enough to resist being moved by a determined visitor. This condition is another pressure on the historic fabric of the lighthouse caused by public access. Window barriers can have a dramatic negative impact on the visual character of the lighthouse if not designed in a sensitive manner. Once public access is allowed, this issue must be addressed whatever amount of public access is accommodated.

Repair or replace metal doors to Watch Level; repair or replace hardware: Every effort should be made to save and repair the original doors. Replace hinges to match original design. Clean, restore, and reuse as much of the original hardware as possible.

Replace all stair treads in fair or poor condition: All treads in poor or fair condition must be replaced to match the historic treads in material, detail, and assembly. The remaining treads can withstand the load of a 250- lb. visitor standing on one tread. The Park Service may choose among several options to mitigate the lack of structural capacity to handle the scope of proposed public visitation. One option is to implement a weight restriction for visitors ascending to the top of the Lighthouse Tower to less than 250 pounds and limit the number of people using the stairs on a daily basis to fewer than 90. A second option is to strengthen the treads with steel plates attached to the underside of the treads. A third option is to replace all historic treads with new treads fabricated as originally designed. New cast iron treads are the most expensive alternative. A fourth option, and the preferred one, is to manage the occupancy of the stairs to minimize damage to the treads as described below.

Manage occupancy to minimize damage to historic stairs and stringers: To accomplish this objective, two management actions are required. First, no more than one person should be allowed on a run of stairs at a time. This will maintain the level of use intended in the original design. Second, if public access is imperative, the number of visitors should be maintained at the lowest possible daily level. It should be understood that each visitation beyond that intended in the original design, two to four trips per day by a single person, has the effect of shortening the life of the historic stairs due to fatigue. Any increase in the number of trips per day accepts the accelerated deterioration of the stair treads that eventually will result in replacement of these historic components. Further, given the limited capacity of the Watch Room Level, four or five people at a time, one person per stair run is a reasonable and appropriate means of managing the flow of visitors through the structure.

To meet current building codes for allowable occupancy on a flight of stairs (one 300- lb. person per tread), a support must be added mid- flight to each stair stringer. The support must span both stringers and be attached to the masonry wall. However, this requirement can be eliminated with proper management of stair occupancy. Restricting the number of people on a run of stairs at one time to fewer than nine people will eliminate the requirement for the additional support. Restricting the number of people on a run of stairs to one person at a time will result in an occupancy far below the number that would require the additional stringer support. Therefore, the preferred method for managing the stair system is to restrict the number of people allowed on a run of stairs to one person at a time.

Replace or modify interior handrails: The existing interior handrails of the stairs and landings do not meet code requirements for safety which require a space of less than 4" between pickets. The current spacing on all landings is about 5" between pickets, resulting in a 4½" space between them. Stairs have one picket per tread, which results in a variable spacing depending on the flight. However, all spaces are greater than 4". Modifications to the handrails to meet safety requirements will result in non- historic treatments. If public visitation to the tower is allowed, this issue will exist. If there is a management approach to control of public visitors without supplemental railing features to meet code, that approach would be preferable. However, if supplemental treatment is required, it should be separate from and not impact the historic railing assembly and should be light weight enough not to alter the structural integrity and load- carrying capacity of the stair assembly.

Replace missing skylight in Watch Level ceiling: Recast missing skylight component to match existing. The missing skylight is a significant historic feature of the upper level of the tower. There are certainly other such skylight features to interpret the skylight assembly. It is believed that the missing skylight was removed to accommodate a stove flue to the roof. An alternative to replacing the skylight is to interpret the installation of a stove on the Watch Level and what was required to vent the stove through the skylight level to the Lantern Level.

Repair Lantern Level/Gallery Deck: This feature, cast as a single unit, includes the interior gallery deck, the Lantern Level window sill and vents, and the exterior gallery floor. To address deterioration on any one segment of this assembly will require considerable disassembly of the entire upper cast iron structure. Therefore, repair in place is the most desirable approach based on the conditions observed and documented at the Lantern Level Gallery deck in this report.

Provide a barrier or a handrail from Watch Level to Lantern Level: While the light is still being used by the Coast Guard as an aid to navigation, it may be desirable to restrict access to the interior Lantern Level to maintenance personnel only. If this is the case, a barrier should be provided at the base of the stairs to the Lantern Level to prevent public access. The stairs to the Lantern Level are steep, narrow, curving, and have no handrail. If visitor access to the Lantern Level is desired, a safety handrail should be installed. The rail should be constructed to be easily recognized as not part of the original installation and should be installed so that the installation is reversible without damage to the historic fabric.

Restrict visitor access to the Lantern Level: According to the structural analysis, the Lantern Level gallery deck does not meet current building code strength requirements for public access. It is, however, sufficiently strong to accommodate one person at a time. Therefore, visitor access to this level should be restricted to one person at a time. Given the limited number of people that can be accommodated in the Watch Level below, only four or five people at a time, it should be within the management capability of the Park Service personnel to enforce this restriction.

Replace handrail around Lantern Level gallery: The existing exterior handrail is not original and is deteriorating rapidly. Fabricate and install a new handrail to match the original design. Because this gallery is for maintenance purposes only, it is not necessary to meet building code requirements for publicly- accessed spaces.

Replace or replicate and install the exterior ladder to the Lantern Level Gallery: If this ladder still exists, it should be reinstalled in its historic location; if not, it should be replicated to match the historic ladder and installed in place. Visitors should not be allowed to access the exterior Lantern Level Gallery. Prevent such public access by installing signage or other non- invasive means at the base of the ladder.

Replace cornice bracket and bars at Lantern roof level: Replace exterior cornice sections of upper wall assembly where bracket deterioration will not allow the reinstallation of the wrought iron bars. Replace missing wrought iron bars.

Repair the connection of Lantern Roof to Tower: While this is not a structural strength issue, the connection should be repaired to ensure that the roof of the light does not separate from the building during periods of high wind. This treatment should be undertaken in the near term.

Masonry Components

Examine the paint history of both the interior and exterior of the tower and develop the optimal approach to the treatment of the original paint and subsequent painting to improve breathability of the masonry and durability of the coatings. It is clear from field observations that the exposed paint layers of both the exterior and interior coatings of the masonry walls are modern paints with notably different characteristics than those likely used in the original and early coatings. It is expected that the combination of the type and number of modern coatings on both the interior and exterior of the lighthouse have much less capability to transmit moisture out of the brick than the early coatings. The alternating black and white markings on the tower contribute to the historic character of the building and should be retained. The less precise definition of the period of significance, given the continued use of the structure as a navigational aid, does not provide a specific framework for the rationale for treatment of the paint condition. Because the existing layers of paint are likely causing damage to the structure, it is recommended that, based on an understanding of the existing paint strata on the lighthouse, later layers of paint be removed to the point of improved breathability while retaining the alternating black and white pattern on the tower.

Given the similarities between the Currituck Lighthouse and the Bodie Island Lighthouse and the fact that the Curritcuk Lighthouse was never painted, a comparison of the brick conditions and history between the two could shed some additional light on the role of the paint finish on the Bodie Island Lighthouse on the condition of the brick at that structure.

Upon completion of the analysis of the existing strata of interior and exterior masonry coatings and comparative analysis with the Curituck Lighthouse, if applicable, a final direction regarding the coating of the Bodie Island Lighthouse should be to return to a historic coating that provides the optimal breathability while retaining a distinct black and white horizontal banding pattern of the tower.

Repoint Masonry: Inspection of both the interior and exterior masonry pointing was limited, except in isolated cases, to observations of indentations in the painted joints revealing loss of mortar over time. On the areas of mortar exposed due to moisture- induced delamination of paint, the mortar is granulated and loose. It is likely that the amount of moisture in the masonry has been sufficiently high over a long period of time that the mortar has deteriorated and is substantially loose, particularly at the outer edges of the walls. If exposed, it is likely that the masonry joints of most of the building, if not the entire building, would require pointing. A comprehensive approach to the treatment of the lighthouse masonry will likely expose much of the deteriorated masonry joints. While it is difficult to anticipate the full extent of the mortar deterioration, it is appropriate to project, for scope of work and budgeting, that the entire tower would be rehabilitated in the restoration of the lighthouse. The repointing mortar should match the historic mortar in composition and color, and the joints should match the historic joint characteristics. Particular attention should be given to the protection of the brick, which is soft, in the preparation of the joints for repointing.

Glass Components

Fabricate and install replacement prisms in Watch Room Level ceiling grating: The grating should be inspected for defects and repaired as necessary. Its original coating should be replaced after testing to determine appropriate composition. The existing prisms should be removed, cleaned, and reinstalled, with new prisms installed where prisms are missing from the grating.

Replace broken glass pane in Lantern: Remove all glazing strips, recaulk all glazing, and reinstall all glazing strips.

Other Work

Remove paint from painted surfaces, inspect for damage, repair as necessary, and repaint with material to match the historic finish.

Remove paper from ventilation tube at the hood above the Fresnel lens. The ventilation tube is part of the original ventilation system design of the lighthouse. If bugs or debris entering the Lantern Level through the ventilation tube prove to be a problem, install screen wire at the bottom of the tube in a manner that will allow it to be easily removed for cleaning without damaging the ventilation tube.

Summarized Cost Data

The Class B cost estimate for the recommended work is based on the inventory data and condition assessment. The estimate was developed using square footage data where appropriate. Due to the specialized nature of the cast- iron work addressed in the assessment, Mr. Scott Howell, President of Robinson Iron Works in Alexander City, Alabama provided support for this estimate. The estimated cost to implement the recommendations in this report is $2,693,747. There are several major components of work within the total estimate. They include:

Scaffolding the Lighthouse: This is a significant cost of $307,000. It will be most efficient to accomplish the maximum amount, if not all, of the work on the lighthouse that will benefit from scaffolding at the time it is erected.

Restoring the Level 10 Deck: A complicating factor of this work is the fact that the exterior deck, windowsill, and interior deck at this level are one piece. The estimate for this work is $125,642.

Level 9 Deck and Structure: This work is estimated to be $131,130.

Repair/Restore/Replace Watch Gallery Support Brackets: This is a major item. The estimated cost for this work is $365,053.

Repair Belt Course: This assembly is interconnected with both the Watch Gallery Support Brackets and the cast iron components of the windows at the Service Room level. The estimated cost for this work is $235,727.

Strip, Repoint, and Repaint Tower: To address ongoing moisture damage to the brick structure, the existing paint layers should be removed to a breathable layer and the mortar repointed as necessary. The tower should be repainted using the historic paint scheme. The estimated cost for this work is $470,770.

Sources of Information for Part 1 and Part 2

Albee, Peggy, Northeast Building Conservation Branch, National Park Service, to Jack Pyburn, AIA, in e- mail, 28 May 2002.

American Institute of Steel Construction, *Manual of Steel Construction Allowable Stress Design, Ninth Edition,* AISC, Chicago, 1989.

Ferris, Herbert W., comp. and ed., *Iron and Steel Beams, 1873 to 1952,* American Institute of Steel Construction, Chicago, 1985.

Gaskill, John, to Deborah E. Harvey, in e- mails, April, 2002.

Gaskill, Lloyd Vernon, collection of papers relating to service of L.V. Gaskill during tenure as lighthouse keeper with the Board of Lighthouses and the United States Coast Guard held at the National Park Service, Cape Hatteras National Seashore headquarters, Manteo, North Carolina, 1911 – 1945. Original documents are in the possession of John Gaskill.

Holland, Francis R., Jr., *A History of the Bodie Island Light Station,* National Park Service, U. S. Department of the Interior, 1967.

McCombs, Jack, to Deborah E. Harvey, in e- mails, April, 2002.

National Park Service, collection of papers relating to Bodie Island Light Station, held at Cape Hatteras National Seashore headquarters, Manteo, North Carolina, 1987 – 2002.

National Park Service, Northeast Cultural Resources Center, Building Conservation Branch, "Historic Paint Finishes Study – Bodie Island Lighthouse and Oil House," 2002.

Phoenix Iron Company Business Ledgers, Phoenixville, Pennsylvania, currently stored at the Hagley Museum and Library, University of Delaware, Wilmington, Delaware. Images used by permission.

Shelton- Roberts, Cheryl, to Deborah E. Harvey, in e- mails, April, 2002.

Shelton- Roberts, Cheryl, and Bruce Roberts, *Lighthouse Families*, Cranehill Publishing, Birmingham, 1997.

United States Coast Guard, 5th District, collection of documents and photographs relating to Bodie Island Light Station, held at 5th District Headquarters, Portsmouth, Virginia, 1909 – 2000.

United States Coast Guard, 9th District, collection of microfilmed documents and photographs relating to Bodie Island Light Station, held at Shore Maintenance Detachment, Civil Engineering Unit, United States Coast Guard, Cleveland, Ohio, 1871 – 2000. Some of the originals are in the National Archives, Philadelphia, Pennsylvania.

United States Lighthouse Board, "First Order L.H. for Body's Island, N.C." original construction drawings, 21 plates, 1871. Originals are in the National Archives, Philadelphia, Pennsylvania.

Sources of Information for Condition Assessment

American Institute of Steel Construction. *Manual of Steel Construction Allowable Stress Design*, Ninth Edition, Chicago: AISC, 1989.

Barsom, John M., and Stanley T. Rolfe. *Fracture & Fatigue Control in Structures - Applications of Fracture Mechanics*, 2d ed, Englewood Cliffs, N.J.: Prentice- Hall, 1987

Ferris, Herbert W., comp. and ed. *Iron and Steel Beams*, 1873 to 1952, Chicago: American Institute of Steel Construction, 1985.

Holland, Francis R., Jr. *A History of the Bodie Island Light Station*, Washington: National Park Service, U. S. Department of the Interior, 1967.

National Park Service, collection of papers relating to Bodie Island Light Station, held at Cape Hatteras National Seashore headquarters, Manteo, North Carolina, 1987 - 2002.

National Park Service, Northeast Cultural Resources Center, Building Conservation Branch, "Historic Paint Finishes Study - Bodie Island Lighthouse and Oil House," 2002.

Newman, Alexander. *Structural Renovation of Buildings, Methods, Details, and Design Examples*, New York: McGraw- Hill, 2001.

Rabun, J. Stanley. *Structural Analysis of Historic Buildings*, New York: John Wiley & Sons, 2000.

Secretary of the Interior. *The Secretary of the Interior's Standards for the Treatment of Historic Properties*, Washington: United States Department of the Interior, 1995. (SI)

United States Coast Guard, 5th District, collection of documents and photographs relating to Bodie Island Light Station, held at 5th District Headquarters, Portsmouth, Virginia, 1909 - 2000.

United States Coast Guard, 9th District, collection of microfilmed documents and photographs relating to Bodie Island Light Station, held at Shore Maintenance Detachment, Civil Engineering Unit, United States Coast Guard, Cleveland, Ohio, 1871 - 2000. Some of the originals are in the National Archives, Philadelphia, Pennsylvania.

United States Lighthouse Board, "First Order L.H. for Body's Island, N.C." original construction drawings, 21 plates, 1871. Originals are in the National Archives, Philadelphia, Pennsylvania.

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D- 433 January 1997