GLOSSARY OF TERMS

PRIMARY TREATMENT APPROACH – PRESERVATION

Preservation standards include measures necessary to sustain the existing form, integrity, and materials of a historic property. Work, including preliminary measures to protect and stabilize the property, generally focuses upon the ongoing maintenance and repair of historic materials and features rather than extensive replacement and new construction. Preservation requires the retention of the greatest amount of historic fabric, including the landscape's historic form, features, and details as they have evolved over time. Limited and sensitive upgrading of mechanical, electrical and plumbing systems and other code-required work is permitted.

HOW TERMINOLOGY IS USED IN THE PRESERVATION APPROACH

Maintain – are those standard maintenance practices that are necessary to retain the features of a property as a contributing resource. Maintenance activities are usually not classified as repair, however minor repair such as replacement of posts or railings or segments of paving are included. Limited and sensitive upgrading of building systems (mechanical, electrical, plumbing) and other code related work is appropriate.

Plant – the removal and replanting of landscape plantings and vegetation as part of maintenance activities

Protect – short term and minimal measures used to stabilize and protect features, such as fencing around landscape features

Relocate – the removal and resetting of noncontributing features

Remove – the removal of nonhistoric features

Repair – features, components of features and materials that require additional work. These may include declining building features (e.g., roofing, foundation, mechanical systems) structures, small-scale features (e.g., repair of a railing) or landscape plantings (e.g., repair mass planting by adding infill plantings). Features that are repaired will match the old in design, color, texture, and if possible, material. Distinctive features that are repaired will match the old in design, color, texture, and if possible, material.

Retain – are those actions that are necessary to allow for a feature (contributing or noncontributing) to remain in place in its contributing current configuration and condition.

Stabilize – immediate measures (more than standard maintenance practices) are needed to prevent deterioration, failure, or loss of features.

PRIMARY TREATMENT APPROACH – REHABILITATION

Rehabilitation in intended to return a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values. Rehabilitation allows for repairs, alterations, restoration of missing features, and additions necessary to enable a compatible use for a property as long as the portions or features which convey the historical, cultural, or architectural values are preserved. Limited and sensitive upgrading of mechanical, electrical and plumbing systems and other code-required work is permitted.

HOW TERMINOLOGY IS USED IN THE REHABILITATION APPROACH

Maintain – are those standard maintenance practices that are necessary to retain the features of a property as a contributing resource. Maintenance activities are usually not classified as repair, however minor repair such as replacement of posts or railings or segments of paving are included. Limited and sensitive upgrading of building systems (mechanical, electrical, plumbing) and other code related work is appropriate.

Plant – the removal and replanting of landscape plantings and vegetation as part of maintenance activities or the restoration of missing features.

Reestablish – are those measures necessary to depict a landscape feature as it occurred historically. Reestablishment may include the replacement of missing landscape features such as views, planting patterns, spatial relationships, or small scale features.

Relocate – remove and reset noncontributing features

Remove – removal of nonhistoric features

Repair – features, components of features and materials that require additional work. These may include declining building features (e.g., roofing, foundation, mechanical systems) structures, small-scale features (e.g., repair of a railing) or landscape plantings (e.g., repair mass planting by adding infill plantings). Features that are repaired will match the old in design, color, texture, and if possible, material. Distinctive features that are repaired will match the old in design, color, texture, and if possible, material.

Restore – are those measures necessary to depict a feature or area as it occurred historically. Restoration may include repair of a feature so that it appears as it did historically or it may include replacement of missing features or qualities.

Retain –are those actions that are necessary to allow for a feature (contributing or noncontributing) to remain in place in its contributing current configuration and condition.

Stabilize – immediate, more extensive measures (more than standard maintenance practices) are needed to prevent deterioration, failure, or loss of features.

PRIMARY TREATMENT APPROACH – RESTORATION

Restoration standards allow for the accurate depiction of a property as it appeared at a particular time in its history by means of the removal of features from other periods in its history and reconstruction of missing features from the period of significance. The limited and sensitive upgrading of systems (mechanical, electrical, plumbing) and other code related work is appropriate.

HOW TERMINOLOGY IS USED IN THE RESTORATION APPROACH

Maintain – are those standard maintenance practices that are necessary to retain the features of a property as a contributing resource. Maintenance activities are usually not classified as repair, however minor repair such as replacement of posts or railings or segments of paving are included. Limited and sensitive upgrading of building systems (mechanical, electrical, plumbing) and other code related work is appropriate.

Plant – the removal and replanting of landscape plantings and vegetation as part of maintenance activities or the restoration of missing features

Relocate – remove and reset noncontributing features

Remove – removal of nonhistoric features

Reestablish – are those measures necessary to depict a landscape feature as it occurred historically. Reestablishment may include the replacement of missing landscape features such as views, planting patterns, spatial relationships, or small scale features.

Repair – features, components of features and materials that require additional work. These may include declining building features (e.g., roofing, foundation, mechanical systems) structures, small-scale features (e.g., repair of a railing) or landscape plantings (e.g., repair mass planting by adding infill plantings). Features that are repaired will match the old in design, color, texture, and if possible, material. Distinctive features that are repaired will match the old in design, color, texture, and if possible, material.

Restore – are those measures necessary to depict a feature or area as it occurred historically. Restoration may include repair of a feature so that it appears as it did historically or it may include replacement of missing features or qualities.

Retain –are those actions that are necessary to allow for a feature (contributing or noncontributing) to remain in place in its contributing current configuration and condition.

Stabilize – immediate, more extensive measures (more than standard maintenance practices) are needed to prevent deterioration, failure, or loss of features.

CONDITION ASSESSMENT DESCRIPTION LEVELS

Feature Condition Definitions
(Note: These terms are also applied to the overall structure/building.)

GOOD The feature is intact, structurally sound and performing its intended purpose. The feature needs no repair or rehabilitation, but only routine or preventive maintenance.

FAIR The feature is in fair condition if either of the following conditions is present:

- There are early signs of wear, failure or deterioration though the feature is generally structurally sound and performing its intended purpose – or –
- There is failure of a portion of the feature.

POOR The feature is in poor condition if any of the following conditions is present:

- The feature is no longer performing its intended purpose – or –
- Significant elements of the feature are missing – or –
- Deterioration or damage affects more than 25% of the feature – or –
- The feature shows signs of imminent failure or breakdown.

UNKNOWN Not enough information is available to make an evaluation.

RATINGS OF TREATMENT SEVERITY

An impact is a detectable result of an agent or series of agents having a negative effect on the significant characteristics or integrity of a structure and for which some form of mitigation or preventative action is possible. The assessment should include only those impacts likely to affect the structure within the next five years.

The Level of Impact Severity and their definitions are given below. For all levels, except UNKNOWN, two criteria are given. At least one of the criteria must be met for the declared Level of Impact Severity.

SEVERE	1. The structure/feature will be significantly damaged or irretrievably lost if action is not taken within two (2) years. 2. There is an immediate and severe threat to visitor or staff safety.
MODERATE	1. The structure/feature will be significantly damaged or irretrievably lost if action is not taken within five (5) years. 2. The situation caused by the impact is potentially threatening to visitor or staff safety.
LOW	1. The continuing effect of the impact is known and will not result in significant damage to the structure/feature. 2. The impact and its effects are not a direct threat to visitor or staff safety.
UNKNOWN	Not enough information is available to make an evaluation.

DEFINITIONS OF TERMS

A

AAS: Atomic Absorption Spectroscopy

AC: Alternating current; the movement of current through an electrical circuit that periodically reverses direction. Alternating current is the form of electric power that is delivered to businesses and residences.

ACM: Asbestos Containing Material

Accessibility: a term used to describe facilities or amenities to assist people with disabilities and can extend to Braille signage, wheelchair ramps, elevators/lifts, walkway contours, reading accessibility, etc. According to its website, the Park Service is "committed to making all practicable efforts to make NPS facilities, programs, services, employment, and meaningful work opportunities accessible and usable by all people, including those with disabilities. This policy reflects the commitment to provide access to the widest cross section of the public and to ensure compliance with the Architectural Barriers Act of 1968, the Rehabilitation Act of 1973, the Equal Employment Opportunity Act of 1972, and the Americans with Disabilities Act of 1990. The Park Service will also comply with section 507 of the Americans with Disabilities Act (42 USC 12207), which relates specifically to the operation and management of federal wilderness areas. The accessibility of commercial services within national parks are also covered under all applicable federal, state and local laws" (source: http://www.nps.gov/aboutus/eeo.htm).

AES-ICP: Atomic Emission Spectroscopy – Inductively Coupled Plasma

AIHA: American Industrial Hygiene Association

Air Terminal: A rod that extends above a surface to attract lightning strikes.

AL: Action Level

B

Beam: a structural member, usually horizontal, with a main function to carry loads cross-ways to its longitudinal axis.

Branch Circuit: Insulated conductors used to carry electricity to an associated device or devices that originate from a single circuit breaker.

BTUH: British Thermal Unit per Hour; A traditional unit of energy.

BX Cable: Cable with flexible steel armored outer tube with individual copper conductors insulated with rubber and covered with a cotton braided sheath.

C

Cantilever: refers to the part of a member that extends freely over a beam or wall, which is not supported at its end.

Cast Iron: a large group of ferrous alloys that are easily cast. Cast iron tends to be brittle and is resistant to destruction and weakening by oxidation. The amount of carbon in cast irons is 2.1 to 4 wt%.

CFR: Code of Federal Regulation

Cistern: An underground receptacle for storage of liquids, usually water.

Clay Sewer: Sewer pipe made from vitrified clay that is highly resistant to corrosion.

Column: a main vertical member that carries axial loads from beams or girders to the foundation parallel to its longitudinal axis.

D

DC: Direct current; the unidirectional flow of current through an electrical circuit. Direct current is produced through such sources as batteries, thermocouples, or photovoltaic solar cells.

Dead Load: describes the loads from the weight of the permanent components of the structure.

Deflection: the displacement of a structural member or system under a load.

DRO: Diesel-Range Organics

E

ELPAT: Environmental Lead Proficiency Analytical Testing

EMT: Electro-metallic tubing; A metallic tube raceway that is used to carry and protect current carrying conductors or cables.

EPA: Environmental Protection Agency

F

Flue Vent: A duct or pipe conveying combustion by-products from a heater or furnace.

Fluorescent: A source of light that emits light radiation at longer wavelengths and lower energy.

Footing: a slab of concrete or an assortment of stones under a column, wall, or other structural member to transfer the loads of the member into the surrounding soil.

Foundation*:* supports a building or structure.

FRP: Fiberglass reinforced plastic

Full Sawn (FS): Lumber cut, in the rough, to its full nominal size.

G

Gable: located above the elevation of the eave line of a double-sloped roof.

Galvanized Steel: Steel coated with zinc carbonate to resist corrosion.

GPM: Gallon per minute; a standard unit of volumetric liquid flow rate.

Grade: the ground elevation of the soil.

Gravity Vent: Openings in a roof intended to vent hot air by the action of convection.

Gray Water: Wastewater generated from domestic washing activities and not containing human waste.

GRO: Gasoline Range Organics

H

Header: a member that carries joists, rafters or beams and is placed between other joists, rafters or beams.

Hip Roof: a roof sloping from all four sides of a building.

HUD: Housing and Urban Development

HVAC: Heating, Ventilation, and Air Conditioning.

I

IAQ: Indoor Air Quality

IEUBK: Integrated Exposure Uptake Biokinetic

Incandescent: A source of light that works by incandescence, or works by a heat-driven light emission through black-body radiation.

Inverter: A device that converts electrical direct current (DC) to electrical alternating current (AC).

J

Joist: a horizontal structural load-carrying member which supports floors and ceilings.

K

kVA: Kilovolt-ampere equal to 1,000 volt-amperes. kVA is a unit to express the apparent power consumed in an electrical circuit or electrical device.

kW: Kilowatt equal to 1,000 watts. A kilowatt is typically used to express the output power consumption of large devices or electrical systems.

L

LBP: Lead-Based Paint

LCP: Lead-Containing Paint

LCS: Lead-Contaminated Soils

Leach Field: A drain field used to remove contaminants and impurities from liquid that emerges from a septic tank.

LED: Light emitting diode; a semiconductor light source that can emit light in various colors and brightness.

Live Load: nonpermanent loads on a structure created by the use of the structure.

Load: an outside force that affects the structure or its members.

Louver: An opening with horizontal slats angled to allow passage of air while keeping out rain and snow.

M

Mg/kg: Milligrams per Kilogram

N

NEC: National Electric Code.

NESHAP: National Emission Standards for Hazardous Air Pollutants

Nonpotable Water: Water that has not been approved for safe human consumption.

NVLAP: National Voluntary Laboratory Accreditation Program

O

OSHA: Occupational Safety and Health Administration

Overcurrent Protection: A fuse, circuit breaker or relay that will open the electrical circuit when the downstream electrical current exceeds the stated current rating.

P

Passive Ventilation: Ventilation of a building without the use of a fan or other mechanical system.

Pitch: the slope of a member defined as the ratio of the total rise to the total run.

PLM: Polarized Light Microscopy

PV: Photovoltaic; An array of solar modules or cells that collect solar energy and convert the energy into direct current electricity.

PVC: Polyvinyl Chloride; A biologically and chemically resistant plastic widely used for household sewage pipe.

R

Rafter: a sloped structural load-carrying member which supports the roof.

RBM: Regulated/Hazardous Material

Reaction: the force or moment developed at the points of a support.

RLM: Industrial stem mounted reflector.

Romex: Wiring with rubber insulated conductors in an overall sheath of braided cotton fiber.

S

Seismic Load: loads produced during the seismic movements of an earthquake.

Septic Tank: A sewage tank containing anaerobic bacteria which decomposed waste discharged into the tank.

Shear: forces resulting in two touching parts of a material to slide in opposite directions parallel to their plane of contact.

Snow Load: loads produced from the accumulation of snow.

Span: the distance between supports.

Step-down Transformer: A device that converts a high voltage down to a lower voltage through a series of winding coils.

Structural Steel**:** an iron alloy with a carbon content of 0.16% to 0.29%. Steel is malleable, and easily welded.

Strut: a structural brace that resists axial forces.

Stud: a vertical wall member used to construct partitions and walls.

T

Thermal Expansion Tank: A tank used in a closed water heating system to absorb excess water pressure caused by thermal expansion.

TSI: Thermal System Insulation

Turbine Vent: Vents utilizing rotating wind vanes to create air flow.

V

Vent Stack: A vertical pipe proving ventilation.

W

WAC: Wisconsin Administrative Code

WDNR: Wisconsin Department of Natural Resources

Wrought Iron: an iron alloy with very low carbon content, in comparison to steel. Wrought iron is tough, malleable, ductile, and easily welded.

X

XRF: X-ray fluorescence analyzer

Other

30 µg/m3: 30 micrograms per cubic meter

µg/SF: Micrograms of Lead Dust per Square Foot of Floor Space

1x: Piece of dimensional lumber 1” (nominal) / ¾” (actual) thick

1

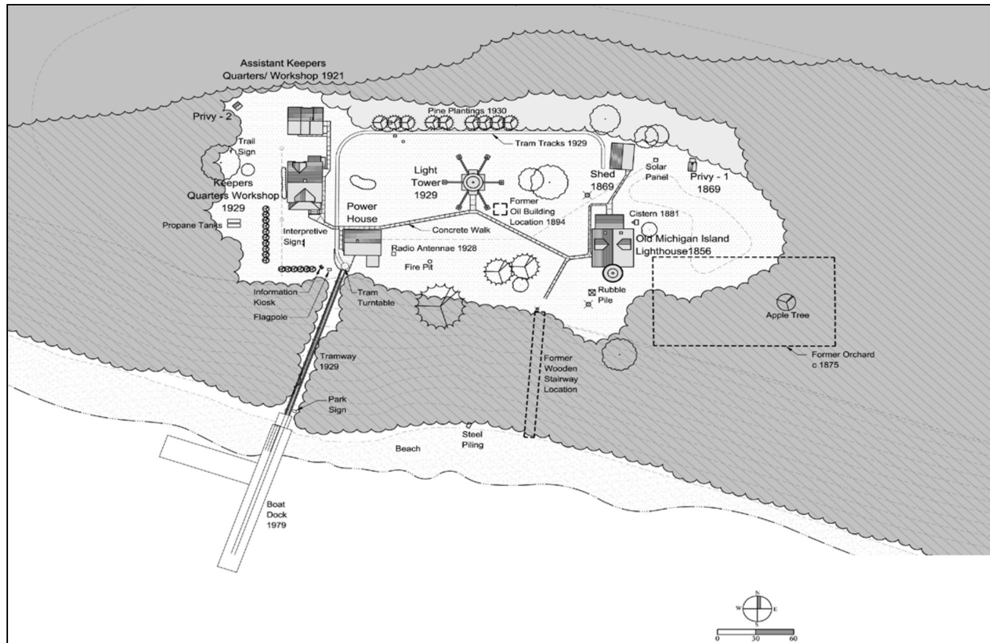
APPENDIX A: MATRIX OF TREATMENT ALTERNATIVE

MICHIGAN ISLAND

Preferred Alternative: Rehabilitation A – Dual Period

A Navigational Continuum

REVISED 03.08.2011



Existing Conditions Site Plan - for reference only

General Description:
This treatment alternative proposes rehabilitating each island's cultural landscape to best portray the continuum of navigational history that characterizes the Apostle Islands as a system of light stations. Each island (and each light station) conveys specific characteristics related to particular periods of development in the navigation of the archipelago. This treatment will reveal this continuum by restoring missing historic features, and by repairing or altering others to convey the full historical significance of the system. Additions that are necessary to enable the compatible use of the light stations or islands are allowed as long as portions or features that convey the historical, cultural, or architectural values are preserved.

Period of Significance: 1856 - 1943

Please refer to the proposed treatments below.

	Old Michigan Island Lighthouse	Second Tower	Keepers Quarters	Assistant Keepers Quarters & Workshop	Power House	Shed	Privy
Proposed Use of Building	Rehabilitate for a pre-1928 condition at the interior, 1929+ at the exterior and allow for self-guided visitor use at Quarters; guided at Tower.	Rehabilitate for self-guided visitor at 1st; guided to tower.	Rehabilitate and maintain current use as seasonal NPS housing and visitor access to 1st floor.	Preserve and maintain current use as NPS storage.	Preserve and maintain current use as NPS storage and systems use.	Preserve for storage for NPS use; possible plexi panel at door to allow visitor visual access.	Rehabilitate; plexi panel at door to allow visitor visual access.
Architecture	Reroof; add gutter/downspout system; increase basement and tower ventilation; repair rust at walk and lantern walls, repaint; seal joints; replace wood wall shingles at dormers; repair windows and repaint; repair all doors and hardware and repaint; paint exterior trim on doors and window; repair masonry walls and repaint; repair damaged plaster at walls and ceilings and paint interior complete; refinish wood floors; add handrails to stairs; repair and paint casework. Add a security gate at the base of tower that allows for air movement. Remove 1929 alterations as possible.	Increase ventilation; investigate replacing one lower sash on a north window for a secure louver; replace missing brass intake caps and verify operation of all others; repair interior plaster/paint damage; repair wood frame at door and paint; verify/provide sealant at all exterior joints; design a security point (barrier) at base of stairs to prevent unguided visitor access	Reroof; repair gutters and downspouts; repaint trim on windows and doors; repair NE stair landing; repair windows and doors; replace missing hardware; repair cracks at plaster and repaint walls and ceilings; refinish trim and wood floor with alligatored finish coat; repair and paint the casework;	Reroof; repair gutters; repaint siding and trim; repair windows and doors	Reroof; add gutters; repair chimney; repair windows and doors; repaint exterior of windows, doors, and trim	Reroof; foundation repair; repaint siding and trim; repair windows and doors and repaint; install plexi panel system (operable) to allow visitor to see in but closeable to maintain security and weather tight closure	Restore roof shingles; repair foundation; repaint windows, doors, siding, and trim; install plexi panel system (operable) to allow visitor to see in but closeable to maintain security and weather tight closure
Structural	Improve basement ventilation or reduce humidity in basement to reduce the moisture content of the first floor framing, properly frame first floor joists at windows and stair	Investigate cracked column bases to determine the structural significance of the cracks, repair or monitor cracks	Properly frame first floor joists at windows, replace concrete stair landing, repair masonry walls at rear stair, investigate load capacity of roof framing and strengthen if necessary	Repair damaged area of roof	Repair masonry walls below concrete roof slab, protect concrete roof slab from continued deterioration	Construct a concrete foundation, repair and strengthen first floor joists or replace with concrete slab-on-grade, strengthen or reframe walls, strengthen or reframe roof	Repair walls of concrete vault, reset or replace both spot footings
Mechanical	Increase ventilation for moisture control. Remove plumbing piping and fixtures. Remove boiler, boiler piping, and radiators.	Increase ventilation for moisture control and visitor comfort.	Clean, inspect, and test sewer/septic system. Repairs as needed for operational system. Increase basement ventilation for moisture control. Replace rusted propane piping. Remove propane piping to refrigerator and stove.	Cap and seal unused plumbing piping. Increase ventilation for moisture control.	Replace tram hoist. Increase basement ventilation for moisture control.	No action at this time.	No action at this time.
Electrical	Provide additional PV power to facilitate running of new ventilation equipment. Remove existing lightning protection system and, after re-roofing, replace with new system. Remove lighting fixtures, receptacles and junction boxes. If required, provide building power distribution and wiring and connect building to site PV system.	Provide additional PV power to facilitate running of new ventilation equipment. Engage an LPI (Lightning Protection Institute) certified inspector to perform an inspection of the lightning protection system and provide findings and recommendations in accordance with LPI-175.	Remove existing lightning protection system and, after re-roofing, replace with new system. Provide additional PV power to building to accommodate new ventilation equipment and new electric refrigerator and stove.	Provide additional PV power, either PV or generator to facilitate running of new ventilation equipment. Replace existing underground power feed and upgrade building wiring to accommodate new ventilation equipment.	Replace existing tram hoist with new as required. Provide site power distribution for other rehabilitated buildings.	No action at this time.	No action at this time.
HazMat	Bat guano abatement; water intrusion/mold mitigation; soil characterization (lead); asbestos sampling of materials to be rehabilitated; remove/stabilize lead paint; remove and replace asbestos roofing.	Soil characterization (lead).	Water intrusion/mold mitigation; soil characterization (lead); asbestos sampling of materials to be rehabilitated; remove/stabilize lead paint; remove and replace asbestos roofing.	Water intrusion/mold mitigation; remove/stabilize lead paint; remove and replace asbestos roofing.	Asbestos sampling of materials to be rehabilitated; remove/stabilize lead paint; remove and replace asbestos roofing.	Remove/stabilize lead paint.	Remove/stabilize lead paint.
Accessibility	Add a freestanding ramp with guardrails at the west entry door and increase the door opening width as well as openings within the first floor. Accessibility by mechanical means to the 2nd floor and Tower is not included at this time.	Program access through interpretive wayside exhibits.	Program access through interpretive wayside exhibits.	Program access through interpretive wayside exhibits.	Program access through interpretive wayside exhibits.	Program access through interpretive wayside exhibits.	Program access through interpretive wayside exhibits.

	Spatial Organization/ Views - Vistas/ Clearing/ Topography	Circulation/ Site Accessibility	Structures	Small Scale Features	Reservation Vegetation	Station Vegetation	
Landscape	1. Selectively cut and remove trees along bank to open views to Light Station from Lake 2. Stabilize slope embankment with planting and erosion control measures where needed 3. Clear trees and brush at Light Station to restore meadow	1. New functional dock in current location 2. Repair tramway to working condition 3. Repair tramway railing (west side) 4. Repair tramway turntable 4. Repair tram tracks to working condition by replacing timbers and resetting tracks 5. Maintain concrete walks in current locations with minor repair 6. Add width to walks for accessibility (see plan), use precast concrete stones. 7. Provide accessible trail to new NPS privy, (location TBD by NPS)	1. Stabilize root cellar (clearing vegetation, repair) 2. Mark location of non-extant Oil Building with concrete corner markers. 3. New NPS accessible privy (location TBD by NPS)	1. Relocate solar panel further east 2. Maintain flag pole (paint) 3. Restore missing small scale features in landscape (birdbath, stone planters) 4. Remove fire pit 5. Reset north radio antennae poles and bases 6. Maintain drainage system 7. Maintain cistern (remove vegetation) 8. Retain oil tanks	1. Remove invasive plant materials from Light Station landscape 2. Continue invasive plant material removal program from adjacent forest	1. Restore orchard planting pattern by planting fruit trees. Prune existing apple tree 2. Restore pine plantings - remove all trees and replant 3. Restore missing features of Old Michigan Island Lighthouse landscape to 1928 - fencing, plantings 4. Restore missing features of Keepers Quarters landscape to 1928 5. Maintain contributing pine west of Old Michigan Island Lighthouse 6. Remove non-contributing trees in lawn area 7. Remove and replant cedar hedge	

APPENDIX B: SUMMARY OF HAZARDOUS MATERIAL FINDINGS

1

OLD MICHIGAN ISLAND LIGHTHOUSE

Building Number	LCS ID 006371
Building Name	Old Michigan Island Lighthouse
>1% Asbestos Confirmed	Heater Component Adhesive
Asbestos Assumed[51]	Wall/Ceiling Plaster, Wall/Ceiling Interiors, Wall/Ceiling Insulation, Adhesives, Thermal Systems Insulation, Roofing Materials, Flooring, Tar and Tar Paper, Brick/Block Filler, Caulk, and Transite
Detectable Lead in Paint Confirmed	Window Sashes and Trims and Door and Door Trims
Detectable Lead in Paint Assumed	Exterior Painted Surfaces and Tower
Lead Dust on Floors >40 µg/SF Confirmed[52]	
Lead Dust on Floors >40 µg/SF Assumed[2]	Throughout
Lead Dust on Floors <40 µg/SF Confirmed[2]	
Visual Mold	Yes
Lead in Soils >50 mg/kg[53]	Roof Drip line
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil
[51] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment.
[52] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[53] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

KEEPERS QUARTERS

Building Number	LCS ID 006389
Building Name	Michigan Island Keepers Quarters
>1% Asbestos Confirmed	Granular Plaster Between Wall Slats
Asbestos Assumed[54]	Wall/Ceiling Plaster, Wall/Ceiling Interiors, Wall/Ceiling Insulation, Adhesives, Thermal Systems Insulation, Roofing Materials, Flooring, Tar and Tar Paper, Brick/Block Filler, Caulk, and Transite
Detectable Lead in Paint Confirmed	Window Sash and Trims, Doors and Door Trims, Walls and Ceilings
Detectable Lead in Paint Assumed	Interior and Exterior Painted Surfaces
Lead Dust on Floors >40 µg/SF Confirmed[55]	
Lead Dust on Floors >40 µg/SF Assumed[2]	
Lead Dust on Floors <40 µg/SF Confirmed[2]	Living Room Floor
Visual Mold	
Lead in Soils >50 mg/kg[56]	
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil

[54] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment.
[55] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[56] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

SECOND TOWER

Building Number	LCS ID 006372
Building Name	Michigan Island Second Tower
>1% Asbestos Confirmed	
Asbestos Assumed[57]	Insulation, Plaster and Adhesives
Detectable Lead in Paint Confirmed	Window Sash and Trims, Doors and Door Trims, Walls and Ceilings
Detectable Lead in Paint Assumed	Interior and Exterior Painted Surfaces
Lead Dust on Floors >40 µg/SF Confirmed[58]	
Lead Dust on Floors >40 µg/SF Assumed[2]	Throughout
Lead Dust on Floors <40 µg/SF Confirmed[2]	
Visual Mold	
Lead in Soils >50 mg/kg[59]	Roof Dripline and Low Lying Areas Outside of Dripline
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil

[57] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment.
[58] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[59] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

ASSISTANT KEEPERS QUARTERS AND WORKSHOP

Building Number	LCS ID 006388
Building Name	Michigan Island Assistant Keepers Quarters and Workshop
>1% Asbestos Confirmed	
Asbestos Assumed[60]	Wall/Ceiling Plaster, Wall/Ceiling Interiors, Wall/Ceiling Insulation, Adhesives, Thermal Systems Insulation, Roofing Materials, Flooring, Tar and Tar Paper, Brick/Block Filler, Caulk and Transite
Detectable Lead in Paint Confirmed	Window Sash and Trims, Doors and Door Trims, Walls and Ceilings
Detectable Lead in Paint Assumed	Interior and Exterior Painted Surfaces
Lead Dust on Floors >40 µg/SF Confirmed[61]	
Lead Dust on Floors >40 µg/SF Assumed[2]	Throughout
Lead Dust on Floors <40 µg/SF Confirmed[2]	
Visual Mold	
Lead in Soils >50 mg/kg[62]	
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	Yes

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil

[60] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment.
[61] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[62] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

POWER HOUSE

Building Number	LCS ID 006386
Building Name	Michigan Island Power House
>1% Asbestos Confirmed	
Asbestos Assumed[63]	Wall/Ceiling Plaster, Wall/Ceiling Insulation, Adhesives, Thermal Systems Insulation, Roofing Materials, Flooring, Gaskets, Brick Filler and Caulk
Detectable Lead in Paint Confirmed	
Detectable Lead in Paint Assumed	Interior and Exterior Painted Surfaces
Lead Dust on Floors >40 µg/SF Confirmed[64]	
Lead Dust on Floors >40 µg/SF Assumed[2]	Throughout
Lead Dust on Floors <40 µg/SF Confirmed[2]	
Visual Mold	
Lead in Soils >50 mg/kg[65]	
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	Yes

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil

[63] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment
[64] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[65] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

SHED

Building Number	LCS ID 006373
Building Name	Michigan Island Shed
>1% Asbestos Confirmed	
Asbestos Assumed[66]	Insulation, Plaster, Transite, Roofing Materials and Adhesives
Detectable Lead in Paint Confirmed	
Detectable Lead in Paint Assumed	Interior and Exterior Painted Surfaces
Lead Dust on Floors >40 µg/SF Confirmed[67]	
Lead Dust on Floors >40 µg/SF Assumed[2]	
Lead Dust on Floors <40 µg/SF Confirmed[2]	
Visual Mold	
Lead in Soils >50 mg/kg[68]	
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	Yes

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil

[66] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment.
[67] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[68] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

PRIVY

Building Number	LCS ID 006385
Building Name	Michigan Island Privy
>1% Asbestos Confirmed	
Asbestos Assumed[69]	Insulation, Plaster, Transite, Roofing Materials and Adhesives
Detectable Lead in Paint Confirmed	
Detectable Lead in Paint Assumed	Interior and Exterior Painted Surfaces
Lead Dust on Floors >40 µg/SF Confirmed[70]	
Lead Dust on Floors >40 µg/SF Assumed[2]	Throughout
Lead Dust on Floors <40 µg/SF Confirmed[2]	
Visual Mold	
Lead in Soils >50 mg/kg[71]	
Lead in Soils <50 mg/kg	
Lead in Soils Assumed	

< = Greater Than
< = Less Than
µg/SF = Micrograms of Lead Dust per Square Foot of Floor Space
mg/kg = Milligrams of Lead per Kilogram of Soil

[69] Materials listed are those identified or assumed to be present during the September 15, 2009 site assessment.
[70] In accordance with EPA 40 CFR part 457 the clearance level for lead dust on floors in child occupied housing is 40 micrograms of lead dust per square foot of floor space.
[71] In accordance with NR720, WIS. Adm Code; 50 milligrams per kilogram, is the conservative acceptable residual containment level for lead in soil based on human health risk from direct contact (ingestion or inhalation) related to nonindustrial land use and considering more than one contaminant may be present in the soil. However, site specific Risk Assessment is recommended to identify the site specific clean up levels for lead contaminated soil at each of these sites.

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APPENDIX C: MATERIAL ANALYSIS REPORTS, MICHIGAN ISLAND

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MICHIGAN ISLAND ACM SAMPLE CHART

Sample #	Sample Date	API ID	Sample Location	Material Description	Laboratory Result
B-MIAKQ-SF-01	9/14/2009	26589	Assistant Keepers Quarters and Workshop	Green pattern sheet flooring	ND
B-MIS-TP-01	9/14/2009	26585	Shed	Tar paper	ND
B-MIKQ-WT-01	9/14/2009	26766	Keepers Quarters	White texture and White/multicolored paint	ND
B-MIKQ-WP-01	9/14/2009	26766	Keepers Quarters	White granular plaster between slats	2% Chrysotile
B-MIOLH-WP-01	9/14/2009	26572	Old Michigan Island Lighthouse	Wall plaster between slats	ND
B-MIOLH-WM-01	9/14/2009	26572	Old Michigan Island Lighthouse	Black/gray fibrous window matting in tower	ND
B-MIOLH-WT1-01	9/14/2009	26572	Old Michigan Island Lighthouse	Thick troweled on wall texture	ND
B-MIOLH-MA1-01	9/14/2009	26572	Old Michigan Island Lighthouse	Silver mastic on heater	ND
B-MIOLH-MA2-01	9/14/2009	26572	Old Michigan Island Lighthouse	Black mastic between heater components	4% Chrysotile
B-MIOLH-WB-01	9/14/2009	26572	Old Michigan Island Lighthouse	Cement wall board with texture	ND
B-MIOLH-WB2-01	9/14/2009	26572	Old Michigan Island Lighthouse	Cement wall board with texture	ND
B-MIOLH-SF1-01	9/14/2009	26572	Old Michigan Island Lighthouse	Blue/tan square sheet flooring with black backing	ND

ND=None Detected
TR=Trace, <1% Visual Estimate

MICHIGAN ISLAND LEAD SAMPLE CHART

Sample ID	Sample Type	API ID	Sample Location	Sample Date	Sample Area (sq ft)	Lead (ug)	Reporting Limit (ug/sq ft)	Lead Concentration (ug/sq ft)
W-091409-MIKQ-01	Composite Wipe	26766	Keepers Quarters	9/14/2009	0.33	39	15	119

APPENDIX D: FABRIC ANALYSIS

Fabric Analysis
Michigan Island
Apostle Island National Lakeshore
October, 2009

On Tuesday, October 6, 2009, David Arbogast, architectural conservator, of Davenport, Iowa, received a large box containing paint and mortar samples from Elizabeth Hallas, AIA, LEED AP. Senior Associate of Andrews & Anderson Architects, PC of Golden, Colorado. She is in the process of preparing Historic Structures Reports for the historic lighthouse complexes of the Apostle Islands National Lakeshore, headquartered in Bayfield, Wisconsin. As part of the HSRs paint and mortar/plaster analysis is required in an attempt to ascertain historic finishes, mortars, and plasters for the subject structures. The samples were divided into sets contained within large manila mailing envelopes. The analysis follows the order in which the large envelopes have been arranged. The three sets which are contained within this report were from the Michigan Island Lighthouse Complex. There were 26 samples in the first set, of which 21 were paint samples and the final five samples were of plaster and mortar, all of which were collected from the Old Michigan Lighthouse. The second set of samples (nos. 27 – 50) contained 24 samples, of which 22 were paint samples and two (nos. 39 and 40) were of plaster and mortar. These were collected from miscellaneous structures at the complex on Michigan Island. The third set of samples (nos. 51 – 63) consisted of ten paint samples and three mortar and plaster samples (nos. 51, 54, and 60).

During the preceding twenty or more years Mr. Arbogast has performed paint analyses for various structures at the Apostles Islands. Those samples and his reports are in the archives at the headquarters in Bayfield and may be examined in relation to the findings from this analysis.

The paint samples were visually examined on Wednesday, October 7, using an optical Olympus microscope having magnification between 14 and 80 power. Each layer observed was color matched to the Munsell System of Color using natural north light. Only opaque, pigmented layers (i.e. paint layers) were matched. It is impossible to determine colors match for finishes such as metallic paints and leafs and shellacs and varnishes because their color is directly affected by their translucency and reflectance.

The Munsell System of Color is a scientific system in which colors have been ranged into a color fan based upon three attributes: hue or color, the chroma or color saturation, and the value or neutral lightness or darkness. Unlike color systems developed by paint manufacturers, the Munsell system provides an unchanging standard of reference which is unaffected by the marketplace and changing tastes in colors.

The hue notation, the color, indicates the relation of the sample to a visually equally spaced scale of 100 hues. There are 10 major hues, five principal and five intermediate within this scale. The hues are identified by initials indicating the central member of the group: red R, yellow-red YR, yellow Y, yellow-green YG, green G, blue-green BG, blue B, purple-blue PB, purple P, and red-purple R. The hues in each group are identified by the numbers 1 to 10. The most purplish of the red hues, 1 on the scale of 100, is designated as 1R, the most yellowish as 10R, and the central hue as 5R. The hue 10R can also be expressed as 10, 5Y as 25, and so forth if a notation of the hue as a number is desired.

Chroma indicates the degree of departure of a given hue from the neutral gray axis of the same value. It is the strength of saturation of color from neutral gray, written /0 to /14 or further for maximum color saturation.

Value, or lightness, makes up the neutral gray axis of the color wheel, ranging from black, number 1, to white at the top of the axis, number 10. A visual value can be approximated by the help of the neutral gray chips of the Rock or Soil Color chart with ten intervals. The color parameters can be expressed with figures semi-quantitatively as: hue, value/chroma (H, V/C). The color “medium red” should serve as an example for presentation with the three color attributes, 5R 5.5/6. This means that 5R is located in the middle of the red hue, 5.5 is the lightness of Munsell value near the middle between light and dark, and 6 is the degree of the Munsell chroma, or the color saturation, which is about in the middle of the saturation scale.

The paint samples themselves were submitted in zippered plastic bags which were labeled and numbered. The analysis follows the numbering system used in the collection process. The quality of the samples ranged from fair to quite excellent. Because of the exposed nature of many of the samples the paint exhibited weathering and appeared in several cases to be missing older layers seen in other, better samples. The layers are listed from top (most recent) to bottom (oldest). The following results were obtained from the analysis:

Old Michigan Lighthouse

Sample 1	**Munsell**
Dark green	10GY 3/4
Green	5G 5/2

The first sample was collected from the exterior window shutters. There were only two paint layers on its wood surface with the green probably serving as a prime coat. Both were latex paints and could not date from the construction of the building.

Old Michigan Lighthouse

Sample 2	**Munsell**
Dark green	10GY 3/4
Green	5G 5/2
Black	5G 3/1
Dark green	5G 4/2
White	5Y 9/1

The second sample came from the exterior window sash. It revealed several additional paint layers not seen in the first sample, including an oldest layer of white paint.

Old Michigan Lighthouse

Sample 3	**Munsell**
Dark green	5G 3/4
White	5Y 9/1
White	5Y 9/1
Black	5G 3/1
White	5Y 9/1
Black	5G 3/1
Dark green	5G 3/4
Black	5G 3/1
White	5Y 9/1

The third sample was removed from the exterior window trim. Its layers, although thin, were easily discerned with strong differences in color. As in the second sample, the oldest layer was white. This was an oil paint which had yellowed to its present shade but was probably white originally.

Old Michigan Lighthouse	
Sample 4	**Munsell**
White	N 9.5/
White	N 9.5/
White	N 9.5/
White	N 9.5/
White	N 9.5/
White	N 9.5/

The fourth sample was from the exterior wall. There were several layers of stark white paint above multiple layers of whitewash. The whitewash readily dissolved in muriatic acid; the paint did not. Because whitewash does not form distinct layers it was impossible to determine the precise number of layers.

Old Michigan Lighthouse	
Sample 5	**Munsell**
Dark green	5G 3/4
Green	5G 5/2
White	5Y 9/1
Black	5G 3/1
Green	5G 5/2
White	5Y 9/1

The fifth sample was found on the roof trim. Its oldest white layer, like that of the third sample, was cleanly separated from its substrate.

Old Michigan Lighthouse	
Sample 6	**Munsell**
Dark green	5G 3/4
White	5Y 9/1

The sixth sample was collected from the roof trim of the new addition. Like the first sample it retained only two layers of latex paint.

Old Michigan Lighthouse	
Sample 7	**Munsell**
Green	5G 5/4
Dark green	5G 3/4
Dark green	5G 3/4
Very dark green	5G 3/2
Green	5G 5/2
Very dark green	5G 3/2
Dark green	5G 3/4
Green	5G 5/4
Dark green	5G 3/4
Green	5G 5/4
Dark green	5G 3/4
Green	5G 5/4
Dark green	10GY 3/4

Green	5G 5/4
White	5Y 9/1
White	5Y 9/1
Gray	5Y 7/1
White	5Y 9/1

The seventh sample began a series of samples from the interior of the Old Michigan Lighthouse. It was collected from the living room trim. It revealed an extraordinarily large set of thin, evenly applied paint layers. The gray layer was completely detached from the white layer above it. The oldest white layer was very thin and probably served as a prime coat for the gray layer.

Old Michigan Lighthouse

Sample 8	**Munsell**
Off-white	5Y 8.5/1

The eighth sample came from the new living room trim. It retained only one paint layer on its wood surface.

Old Michigan Lighthouse

Sample 9	**Munsell**
Gray	N 7.0/
Gray	N 6.5/

The ninth sample was removed from the living room wall. It retained only two layers of paint. It is quite possible that the wall may have been painted with calcimine paint originally in light of the fact that the exterior was whitewashed. Less likely, although possible, might have been the use of wallpaper on the walls.

Old Michigan Lighthouse

Sample 10	**Munsell**
Light green	2.5BG 7/4
Dark green	5G 3/4
White	5Y 9/1
Gray	N 6.5/

The tenth sample was from the dining room wall. It retained four paint layers with the oldest of the set matching the older of the two paint layers of the living room.

Old Michigan Lighthouse

Sample 11	**Munsell**
Tan	2.5Y 7/3

The eleventh sample was found on the kitchen wall. It retained only a single layer of paint on its surface.

Old Michigan Lighthouse

Sample 12	**Munsell**
Tan	2.5Y 7/3
Tan	2.5Y 7/3

The twelfth sample was collected from the dining room/living room/kitchen ceiling. It retained two layers of tan paint on its surface in contrast to the single layer seen in sample 11.

Old Michigan Lighthouse

Sample 13	**Munsell**
Gray	N 6.0/
Tan	2.5Y 7/3
Off-white	5Y 9/2
Red	7.5R 5/6
Off-white	5Y 8.5/1

The thirteenth sample came from the entry wall. It revealed five layers of paint with off-white being the oldest of the set.

Old Michigan Lighthouse

Sample 14	**Munsell**
Off-white	5Y 8.5/1

The fourteenth sample was removed from the watchroom wall. It retained a single layer of off-white paint on its surface.

Old Michigan Lighthouse

Sample 15	**Munsell**
Off-white	5Y 8.5/1
White	5Y 9/1
Tan	2.5Y 7/3
Off-white	5Y 8.5/1
Off-white	5Y 8.5/1
Light blue	7.5B 8/4
White	N 9.5/
White	N 9.5/

The fifteenth sample was from the watchroom ceiling. In contrast with the previous sample, this retained at least eight layers of which the oldest two stark white layers were relatively crumbly and may have actually been whitewash rather than paint.

Old Michigan Lighthouse

Sample 16	**Munsell**
Light green	2.5BG 7/3
Off-white	5Y 8.5/1
White	N 9.5/
White	N 9.5/

The sixteenth sample was found on the wall/ceiling of bedroom #1. Its oldest pair of stark white layers matched those of sample 15.

Old Michigan Lighthouse

Sample 17	Munsell
Light green	2.5G 8/4
Tan	2.5Y 7/3

The seventeenth sample was collected from under the window seat of bedroom #1. It revealed a pair of paint layers with tan as the older of the two.

Old Michigan Lighthouse

Sample 18	Munsell
White	N 9.5/
White	N 9.5/
White	N 9.5/

The eighteenth sample came from the tower window. It consisted of multiple layers of whitewash – the exact number of layers being impossible to determine given the nature of the material.

Old Michigan Lighthouse

Sample 19	Munsell
Off-white	5Y 8.5/1
White	5Y 9/1
Off-white	5Y 8.5/1
White	5Y 9/1

The nineteenth sample was removed from the window trim of the tower. It retained four alternating layers of off-white and white oil-based paint.

Old Michigan Lighthouse

Sample 20	Munsell
White	N 9.5/
White	N 9.5/
White	N 9.5/

The twentieth sample was from the tower wall. Like sample 18, it consisted entirely of multiple layers of whitewash.

Old Michigan Lighthouse

Sample 21	Munsell
Dark brown	10YR 4/1
Black	5Y 2/1
Black	5Y 2/1
Black	5Y 2/1
Black	5Y 2/1
White	N 9.5/
White	N 9.5/
White	N 9.5/

Sample 21 was found on the stair trim of the tower. Beneath multiple layers of black paint were multiple layers of whitewash.

As noted in the introduction above samples 22 through 26 from the Old Michigan Lighthouse on Michigan Island consisted of mortar and plaster samples. These were analyzed on Thursday, October 8 utilizing the standard testing procedure developed by E. Blaine Cliver, Regional Historical Architect of the North Atlantic Region of the National Park Service.

Sample 22 was from the kitchen plaster. It was off-white in color and consisted of small bits of plaster. There was no reaction with the hydrochloric acid, indicating a mixture of gypsum and sand as opposed to lime and sand. The sand sieve analysis revealed relatively fine sand. The portion which passed all of the sieves was white as opposed to the darker color of the sand. It was probably gypsum powder.

Sample 23 was taken from the watchroom plaster. It was similar to the first sample, but with a very thin skim coat of white plaster on its surface. It also contained a few hairs in the plaster. When tested with hydrochloric acid there was a very miniscule reaction which was not measurable. There is no doubt that, like the first sample, this was composed of gypsum and sand and not lime and sand. The sand sample was unusually large. It revealed both sand and gypsum as in the first sample. However, the gypsum appeared at both ends of the spectrum – as white dust passing all of the sieves and as large bits of the white skim coat which were unbroken and undissolved by the acid and which did not pass any of the sieves. Discounting for that factor, the sand appeared to be similar, if not the same, as in the first sample.

Sample 24 was of the mortar of the light tower. It was tan in color and was moderately hard. It had a very prolonged reaction which produced a thick foam. Interestingly, there was a very low water displacement as a result. These two factors – a prolonged reaction with a very low water displacement are typical of cement and sand mortars. The color is not typical, however, nor is the moderate hardness, as well as the moderate filtering time. Portland cement mortars typically produce gelatinous by-products but none were found here. Likewise, they typically take several days to filter, which was not the case here. It appears, then, that natural cement was used with the sand rather than Portland cement or lime. Natural cement, as its name implies, is quarried from the ground and is similar to the cements the Romans used for their construction. Portland cement, named after Portland, England where it was invented and first manufactured, is synthetic cement. The primary difference is that natural cement contains a wider range of possible elements which can affect its performance whereas Portland cement is completely predictable and consistent. As a result, Portland cement is hard, impervious, and brittle. Natural cements tend not to be as hard or impervious or brittle, plus their color is different (shades of gray to white for Portland cement and tan or buff for natural cement). Natural cements were overtaken by Portland cement in the later decades of the nineteenth century as natural cement quarries played out and production costs for Portland cement became competitive. Generally, if one encounters natural cement it is an indication that it is from a nineteenth century structure. The sand sieve analysis revealed very nicely graded, fine sand of which virtually all passed the largest sieve and less than 4% passed all of the sieves. Almost 60% was trapped in sieve #30.

Sample 25 was collected from the closet plaster. Although of a considerably smaller size than sample 23, it was virtually identical to it in its other aspects such as a thin white skim coat, tan plaster, miniscule reaction, and an extraordinarily fast filtering speed. There is no doubt that this is also a gypsum and sand plaster. The sand sieve analysis was also roughly similar with a larger proportion of gypsum powder passing all of the sieves and a smaller proportion of bits of skim coat trapped in the largest sieve.

Sample 26 was from the living room plaster. Its statistical reliability was somewhat hampered by its small size. Although there was a miniscule amount of fines produced, they were not large enough to be weighed. The sample bore the closest resemblance to sample 22. Like it and samples 23 and 25 it gave clear evidence of being a sand and gypsum mixture. The sand sieve analysis resulted in all of the sand passing the largest sieve and a relatively high proportion of gypsum dust passing all of the sieves.

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No.: 22
Building: Old Michigan Lighthouse, Michigan Island, Apostle Islands NL
Location: Kitchen plaster
Sample Description: Off-white, very soft, no reaction, extremely fast filtering time

Test No. 1 – Soluble Fraction

Data:

1. 185.5 Container A weight
2. 208.6 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.00 Liters of water displaced
6. Off-white Filtrate color
7. Tan Fines color
8. No Hair or fiber ______ type
9. 2.7 Fines and paper weight
10. 2.6 Filter paper weight
11. 204.3 Sand and Container A weight
12. 15.0 cc. of sand
13. 47.5 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 23.1 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 18.8 Weight of sand: No. 11 – No. 1
18. .80 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 4.2 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0 00 Gram weight of CaCO3: 100 x No. 20
22. 4.2 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .0568 Mols. of Ca(OH)2: No. 22 divided by 74
24. 4.2 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.00 Gram weight CO2: No. 20 x 44
26. 2.50 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. ------ %CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 23.10 Gram weight of sample: No. 15 – No. 25
29. 0.43 Fine parts/volume: No. 16 divided by No. 28
30. 64.94 Sand parts/volume: (No. 17 divided by No. 28) x No. 18
31. ______ Lime parts/volume: (No. 24 divided by No. 28) x 1.1

Cement (if present)

32. ______ Portland cement parts/volume: (No. 16 divided by No. 28) x 0.78
33. ______ Natural cement parts/volume: (No. 16 divided by No. 28) x 0.86

34.____________Lime with cement parts/volume: (No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	106.8	106.8	0.0	0
No. 20	107.3	106.4	0.9	4.84
No. 30	101.3	99.3	2.0	10.75
No. 40	108.7	100.8	7.9	42.47
No. 50	99.3	93.2	6.1	32.80
Base	72.9	71.2	1.7	9.14

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 23
Building: Old Michigan Lighthouse, Michigan Island, Apostle Islands NL
Location: Watchroom plaster

Sample Description: Off-white with very thin white skim coat, moderately hard, extremely minimal reaction, extremely rapid filtering time

Test No. 1 – Soluble Fraction

Data:
1. 188.9 Container A weight
2. 208.9 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.00 Liters of water displaced
6. Off-white Filtrate color
7. Tan Fines color
8. Yes Hair or fiber______type
9. 3.4 Fines and paper weight
10. 3.3 Filter paper weight
11. 204.5 Sand and Container A weight
12. 12.0 cc. of sand
13. 44.2 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:
15. 20.0 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 15.6 Weight of sand: No. 11 – No. 1
18. .774 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 4.3 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0.00 Gram weight of CaCO3: 100 x No. 20
22. 4.3 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .0581 Mols. of Ca(OH)2: No. 22 divided by 74
24. 4.3 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.00 Gram weight CO2: No. 20 x 44
26. 2.56 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. -------- %CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 20.00 Gram weight of sample: No. 15 – No. 25
29. 0.50 Fine parts/volume: No. 16 divided by No. 28
30. 60.37 Sand parts/volume: (No. 17 divided by No. 28) x No. 18
31. ____ Lime parts/volume: (No. 24 divided by No. 28) x 1.1

Cement (if present)

32. ____ Portland cement parts/volume: (No. 16 divided by No. 28) x 0.78
33. ____ Natural cement parts/volume: (No. 16 divided by No. 28) x 0.86
34. ____ Lime with cement parts/volume: (No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	115.5	106.8	8.7	8.18
No. 20	123.7	106.4	17.3	16.26
No. 30	124.9	99.3	25.6	24.06
No. 40	145.6	100.8	44.8	42.11
No. 50	101.5	93.2	8.3	7.80
Base	72.9	71.2	1.7	1.60

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 24
Building: Old Michigan Lighthouse, Michigan Island, Apostle Islands NL
Location: Light tower mortar
Sample Description: Tan, moderately hard, prolonged and foamy reaction, moderately slow filtering time

Test No. 1 – Soluble Fraction

Data:

1. 185.1 Container A weight
2. 205.1 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.10 Liters of water displaced
6. Yellow-green Filtrate color
7. Tan Fines color
8. No Hair or fiber ____ type
9. 4.0 Fines and paper weight
10. 2.9 Filter paper weight
11. 197.3 Sand and Container A weight
12. 8.7 cc. of sand
13. 40.9 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 20.0 Starting weight of sample: No. 2 – No. 1
16. 1.1 Weight of fines: No. 9 – No. 10
17. 12.2 Weight of sand: No. 11 – No. 1
18. .7131 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 6.7 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. .00041125 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)

21. .41 Gram weight of CaCO3: 100 x No. 20
22. 6.29 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .0849831 Mols. of Ca(OH)2: No. 22 divided by 74
24. 6.59 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.18 Gram weight CO2: No. 20 x 44
26. 3.92 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. 4.59 %CO2 gain: No. 25 divided by No. 26

Conclusions:

28.	19.82	Gram weight of sample:	No. 15 – No. 25
29.	5.55	Fine parts/volume:	No. 16 divided by No. 28
30.	43.89	Sand parts/volume:	(No. 17 divided by No. 28) x No. 18
31.		Lime parts/volume:	(No. 24 divided by No. 28) x 1.1

Cement (if present)

32.		Portland cement parts/volume:	(No. 16 divided by No. 28) x 0.78
33.	4.77	Natural cement parts/volume:	(No. 16 divided by No. 28) x 0.86
34.		Lime with cement parts/volume:	(No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	107.3	106.8	0.5	0.45
No. 20	108.0	106.4	1.6	1.44
No. 30	113.0	99.3	13.7	12.36
No. 40	166.6	100.8	65.8	59.39
No. 50	118.4	93.2	25.2	22.74
Base	75.3	71.3	4.0	3.61

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 25

Building: Old Michigan Lighthouse, Michigan Island, Apostle Islands NL

Location: Closet plaster

Sample Description: Off-white with very thin white skim coat, moderately hard, extremely minimal reaction, extremely rapid filtering time

Test No. 1 – Soluble Fraction

Data:

1. 187.8 Container A weight
2. 206.8 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.00 Liters of water displaced
6. Off-white Filtrate color
7. Tan Fines color
8. Yes Hair or fiber ______ type
9. 3.3 Fines and paper weight
10. 3.2 Filter paper weight
11. 201.1 Sand and Container A weight
12. 10.1 cc. of sand
13. 42.0 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 19.0 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 13.3 Weight of sand: No. 11 – No. 1
18. .7594 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 6.6 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0.00 Gram weight of CaCO3: 100 x No. 20
22. 6.6 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .089 Mols. of Ca(OH)2: No. 22 divided by 74
24. 6.6 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.00 Gram weight CO2: No. 20 x 44
26. 3.92 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. -------- %CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 19.00	Gram weight of sample:	No. 15 – No. 25
29. 0.53	Fine parts/volume:	No. 16 divided by No. 28
30. 53.16	Sand parts/volume:	(No. 17 divided by No. 28) x No. 18
31.____	Lime parts/volume:	(No. 24 divided by No. 28) x 1.1

Cement (if present)

32.____	Portland cement parts/volume:	(No. 16 divided by No. 28) x 0.78
33.____	Natural cement parts/volume:	(No. 16 divided by No. 28) x 0.86
34.____	Lime with cement parts/volume:	(No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	107.0	106.8	o.2	1.52
No. 20	108.3	106.4	1.9	14.39
No. 30	101.2	99.3	1.9	14.39
No. 40	104.1	100.8	3.3	25.00
No. 50	97.6	93.2	4.4	33.33
Base	72.7	71.2	1.5	11.36

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 26
Building: Old Michigan Lighthouse, Michigan Island, Apostle Islands NL
Location: Living room plaster
Sample Description: Off-white, soft, no reaction, extremely rapid filtering time

Test No. 1 – Soluble Fraction

Data:

1. 192.0	Container A weight	8. Yes	Hair or fiber ______ type
2. 197.7	Container A and sample	9. 2.7	Fines and paper weight
3. 761.24	Barometric pressure	10. 2.7	Filter paper weight
4. 23	Temperature	11. 196.3	Sand and Container A weight
5. 0.00	Liters of water displaced	12. 2.7	cc. of sand
6. Off-white	Filtrate color	13. 33.0	Weight of graduated cylinder and sand
7. Tan	Fines color	14. 28.7	Weight of graduated cylinder

Computations:

15. 5.7 Starting weight of sample: No. 2 – No. 1
16. 0.0 Weight of fines: No. 9 – No. 10
17. 4.3 Weight of sand: No. 11 – No. 1
18. .7442 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 1.4 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00 Mols. Of CO_2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0.00 Gram weight of $CaCO_3$: 100 x No. 20
22. 1.4 Gram weight of $Ca(OH)_2$: No. 19 – No. 21
23. .0189 Mols. of $Ca(OH)_2$: No. 22 divided by 74
24. 1.4 Gram total weight of $Ca(OH)_2$: 74 x (No. 20 + No. 23)
25. 0.00 Gram weight CO_2: No. 20 x 44
26. 0.83 Gram weight total possible CO_2: 44 x (No. 20 + No. 23)
27. -------- %CO_2 gain: No. 25 divided by No. 26

Conclusions:

28. 5.7	Gram weight of sample:	No. 15 – No. 25
29. 0.00	Fine parts/volume:	No. 16 divided by No. 28
30. 56.14	Sand parts/volume:	(No. 17 divided by No. 28) x No. 18
31. ________	Lime parts/volume:	(No. 24 divided by No. 28) x 1.1

Cement (if present)

32. ________	Portland cement parts/volume:	(No. 16 divided by No. 28) x 0.78
33. ________	Natural cement parts/volume:	(No. 16 divided by No. 28) x 0.86
34. ________	Lime with cement parts/volume:	(No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	106.8	106.8	o.o	0
No. 20	106.5	106.4	0.1	2.44
No. 30	99.7	99.3	0.4	9.76
No. 40	102.1	100.8	1.3	31.71
No. 50	94.9	93.2	1.7	41.46
Base	71.8	71.2	0.6	14.63

Privy

Sample 27	**Munsell**
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1

White	5Y 9/1
White	5Y 9/1
Silver	--------

Sample 27 was the first of the second set of samples. Analysis of this set began on Friday, October 9. The sample was collected from the interior of the privy. Beneath multiple layers of oil-based white paint were remnants of silver paint which was probably used to enhance the low light levels of the interior. Silver paint is made using powdered aluminum. In light of the fact that commercial aluminum production did not commence until the 1930's, this paint cannot predate that decade.

Privy

Sample 28	**Munsell**
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1

Sample 28 came from the exterior of the privy. Beneath three layers of white paint was extremely weathered wood, indicating paint loss through weathering if, indeed, it was painted. If it was painted there is a strong possibility that it was whitewashed rather than painted, thereby explaining the loss of the finish as whitewash is considerably less durable than paint.

Old Michigan Lighthouse Tower

Sample 29	**Munsell**
Black	N 0.5/
White	N 9.5/
Gray	5Y 7/1

Sample 29 was removed from the exterior window of the Old Michigan Lighthouse tower. It revealed three widely-divergent paint layers with gray being the oldest known layer.

Privy

Sample 30	**Munsell**
Green	2.5G 4/4
Gray-green	2.5G 5.5/2
Dark green	2.5G 3/4
Maroon	7.5R 3/4

Sample 30 was from the privy roof. Three finish layers of green survived, which is comparable in number to those of the exterior sample, no. 28. The oldest maroon layer was probably a red lead prime coat.

Shed

Sample 31	**Munsell**
White	N 9.5/
White	N 9.5/
White	N 9.5/
White	N 9.5/

Sample 31 was found on the exterior of the shed. Beneath a layer of white paint were multiple layers of whitewash which dissolved readily in hydrochloric acid, leaving the paint layer behind.

Shed

Sample 32	**Munsell**
Blue-green	10BG 5/4
Paper	--------
Blue-green	10BG 5/4

Sample 32 was collected from the interior of the shed. It consisted of a very thick and stiff layer of paper, or cardboard, with paint on both sides. The paint was probably applied during the manufacturing process of the paper.

New Tower

Sample 33	**Munsell**
Tan	10YR 8.5/4
White	N 9.5/
White	5Y 9/1

Sample 33 was collected from the interior wall of the new tower light base. It consisted of three layers of latex paint.

New Tower

Sample 34	**Munsell**
Black	N 0.5/
Charcoal	N 2.0/
White	N 9.5/
White	N 9.5/
Black	N 1.0/
Brown	7.5YR 5/6

Sample 34 came from the exterior of the new tower light base. At the bottom of a series of black and white layers were remnants of a coat of brown paint.

New Tower

Sample 35	**Munsell**
White	N 9.5/
Clear varnish	--------
White	N 9.5/

Sample 35 was removed from the exterior of the new tower light base. Its upper white coat was very shiny. Beneath it was a very glossy coat of clear varnish. Beneath the varnish was a layer of stark white paint.

Power House

Sample 36	**Munsell**
White	5Y 9/1
White	5Y 9/1

White	5Y 9/1

Sample 36 was from the interior trim paint of the power house. It revealed three layers of identical white oil-based paint.

Power House

Sample 37	**Munsell**
Blue-gray	5BG 4/1
Gray	5Y 7/1
White	5Y 9/1

Sample 37 was found on the interior of the power house. Like its counterpart, sample 36, it revealed three paint layers of which the oldest was white.

Power House

Sample 38	**Munsell**
Yellow	2.5Y 8/4
Yellow	2.5Y 8/4
Yellow	2.5Y 8/4

Sample 38 was collected from the interior of the power house. It revealed three identical layers of yellow paint.

As noted in the introduction above samples 39 and 40 are mortar samples. These were analyzed on Saturday, October 10.

Sample 39 was from the exterior brick mortar of the power house. It was dark gray in color and gave most indications of being a mixture of Portland cement and sand. It was hard and brittle and had a very small reaction which was quite prolonged. Its unusually small size probably accounts for the relatively rapid filtering time (Portland cement samples frequently take days to filter) and the absence of gelatinous by-products typically found with Portland cement samples. The sand sieve analysis revealed fine sand of which all passed the largest sieve sieves and 14% passed all of the sieves.

Sample 40 was taken from the exterior mortar of the keeper's house. It was gray in color and was moderately soft. Its softness in conjunction with a fast and bubble reaction, a relatively large water displacement, and a rapid filtering time were indications of a lime and sand composition with approximately five parts of lime to seven parts of sand, by volume. The sand sieve analysis Revealed typical sand of which virtually all passed the largest sieve and almost 7% passed all of the sieves.

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No.: 39
Building: Power House, Michigan Island, Apostle Islands NL
Location: Exterior brick mortar

Sample Description: Dark gray, hard and brittle, prolonged and bubbly reaction, extremely fast filtering time

Test No. 1 – Soluble Fraction

Data:

1. 185.5 Container A weight
2. 193.1 Container A and sample
3. 769.88 Barometric pressure
4. 23 Temperature
5. 0.10 Liters of water displaced
6. Yellow-green Filtrate color
7. Light gray Fines color
8. No Hair or fiber ______ type
9. 2.7 Fines and paper weight
10. 2.6 Filter paper weight
11. 190.5 Sand and Container A weight
12. 3.8 cc. of sand
13. 33.7 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 7.6 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 5.0 Weight of sand: No. 11 – No. 1
18. .76 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 2.5 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00416 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0 42 Gram weight of CaCO3: 100 x No. 20
22. 2.08 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .028 Mols. of Ca(OH)2: No. 22 divided by 74
24. 2.39 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.18 Gram weight CO2: No. 20 x 44
26. 1.42 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. 12.68 %CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 7.42	Gram weight of sample:	No. 15 – No. 25
29. 1.35	Fine parts/volume:	No. 16 divided by No. 28
30. 51.21	Sand parts/volume:	(No. 17 divided by No. 28) x No. 18
31. ______	Lime parts/volume:	(No. 24 divided by No. 28) x 1.1

Cement (if present)

32. 1.05	Portland cement parts/volume:	(No. 16 divided by No. 28) x 0.78
33. ______	Natural cement parts/volume:	(No. 16 divided by No. 28) x 0.86
34. ______	Lime with cement parts/volume:	(No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	106.8	106.8	0.0	0
No. 20	106.7	106.4	0.3	6.00
No. 30	100.0	99.2	0.8	16.00
No. 40	102.5	100.8	1.7	34.00
No. 50	94.7	93.2	1.5	30.00
Base	71.9	71.2	0.7	14.00

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 40
Building: Keeper's House, Michigan Island, Apostle Islands NL
Location: Exterior mortar
Sample Description: Gray, moderately soft, fast and bubbly reaction, extremely rapid filtering time

Test No. 1 – Soluble Fraction

Data:

1. 188.9 Container A weight
2. 208.9 Container A and sample
3. 769.88 Barometric pressure
4. 23 Temperature
5. 0.56 Liters of water displaced
6. Yellow-green Filtrate color
7. Tan Fines color
8. No Hair or fiber______type
9. 3.2 Fines and paper weight
10. 2.7 Filter paper weight
11. 202.7 Sand and Container A weight
12. 8.0 cc. of sand
13. 42.5 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 20.0 Starting weight of sample: No. 2 – No. 1
16. 0.5 Weight of fines: No. 9 – No. 10
17. 13.8 Weight of sand: No. 11 – No. 1
18. .5797 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 5.7 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.02329 Mols. Of CO_2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 2.33 Gram weight of $CaCO_3$: 100 x No. 20
22. 3.37 Gram weight of $Ca(OH)_2$: No. 19 – No. 21
23. .04555 Mols. of $Ca(OH)_2$: No. 22 divided by 74
24. 5.09 Gram total weight of $Ca(OH)_2$: 74 x (No. 20 + No. 23)
25. 1.02 Gram weight CO_2: No. 20 x 44
26. 3.03 Gram weight total possible CO_2: 44 x (No. 20 + No. 23)
27. 33.66 %CO_2 gain: No. 25 divided by No. 26

Conclusions:

28. 18.98 Gram weight of sample: No. 15 – No. 25
29. 2.63 Fine parts/volume: No. 16 divided by No. 28
30. 42.15 Sand parts/volume: (No. 17 divided by No. 28) x No. 18
31. 31.94 Lime parts/volume: (No. 24 divided by No. 28) x 1.1

Cement (if present)

32. __________ Portland cement parts/volume: (No. 16 divided by No. 28) x 0.78
33. __________ Natural cement parts/volume: (No. 16 divided by No. 28) x 0.86
34. __________ Lime with cement parts/volume: (No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	106.9	106.8	0.1	0.35
No. 20	109.7	106.4	3.3	11.46
No. 30	107.5	99.3	8.2	28.47
No. 40	111.2	100.8	10.4	36.11
No. 50	98.0	93.2	4.8	16.67
Base	73.2	71.2	2.0	6.94

Keeper's House

Sample 41	**Munsell**
White	5Y 9/1
White	5Y 9/1

Sample 41 continued the series of paint samples. It came from the exterior window trim of the keeper's house. It retained two layers of white oil-based paint.

Keeper's House

Sample 42	**Munsell**
Black	N 0.5/
Gray	5Y 7/1
Black	N 0.5/

Sample 42 was removed from the exterior window sash of the keeper's house. It revealed a gray layer sandwiched between two glossy layers of black paint, which is a very typical sash color used in the late nineteenth and early twentieth centuries.

Keeper's House

Sample 43	**Munsell**
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1
Gray	5Y 7/1
Gray	5Y 7/1

Sample 43 was from the exterior wood siding of the keeper's house. The pair of oldest gray layers are typical exterior colors commonly used in the early twentieth century.

Keeper's House

Sample 44	**Munsell**
White	5Y 9/1
White	N 9.5/
White	N 9.5/
White	N 9.5/
Gray	5Y 7/1

Sample 44 was found on the exterior door trim of the keeper's house. It was similar to its counterpart, sample 43.

Keeper's House

Sample 45	**Munsell**
White	N 9.5/
White	N 9.5/
Light gray	5Y 8/1
Light gray	5Y 8/1
Yellow	2.5Y 8/4

Sample 45 was collected from the kitchen wall of the keeper's house. Its oldest layer was a rich yellow color.

Keeper's House

Sample 46	**Munsell**
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1

Sample 46 came from the interior kitchen door trim of the keeper's house. It retained at least six layers of white, oil-based paint.

Keeper's House

Sample 47	**Munsell**
Light yellow-green	7,5Y 8/2
Dark gray	5Y 5/1

Sample 47 was removed from the stair to the basement in the keeper's house. Beneath the upper light yellow-green paint was a distinct, but thin layer of dark gray paint.

Keeper's House

Sample 48	**Munsell**
White	5Y 9/1
White	5Y 9/1
Gray	5Y 7/1

Sample 48 was from the exterior wall of the kitchen porch of the keeper's house. Beneath a pair of white layers was a gray layer matching those of its counterparts, samples 43 and 44.

Keeper's House

Sample 49	**Munsell**
Light yellow-green	7,5Y 8/2

Sample 49 was found on the wall of the stair to the second floor of the keeper's house. It revealed only a single layer of light yellow-green paint matching the top layer of its counterpart, sample 47.

Keeper's House

Sample 50	**Munsell**
Pastel blue-green	5BG 9/1

Sample 50 was collected from the second floor wall of the keeper's house. It retained only a very thin layer of pastel blue-green paint on its surface.

Sample 51 was the first sample of the third set of samples. It continued the mortar and plaster samples. Taken from the second floor plaster of the keeper's house, it was off-white in color and consisted of small bits of plaster. There was a miniscule reaction with the hydrochloric acid, indicating a mixture of gypsum and sand as opposed to lime and sand. The sand sieve analysis revealed surprisingly coarse sand of which 37 ½% was trapped in sieve #20 and, in a statistical anomaly, equal amounts were trapped in sieves #30, #40, and #50.

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 51
Building: Keeper's House, Michigan Island, Apostle Islands NL
Location: Second floor plaster
Sample Description: Off-white, soft, miniscule reaction, extremely fast filtering time

Test No. 1 – Soluble Fraction

Data:

1. 185.1 Container A weight
2. 195.2 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.00 Liters of water displaced
6. Off-white Filtrate color
7. Dark gray Fines color
8. No Hair or fiber ______ type
9. 2.7 Fines and paper weight
10. 2.6 Filter paper weight
11. 191.5 Sand and Container A weight
12. 5.4 cc. of sand
13. 35.1 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 10.1 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 6.4 Weight of sand: No. 11 – No. 1
18. .84375 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 3.6 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0 00 Gram weight of CaCO3: 100 x No. 20
22. 3.6 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .0486 Mols. of Ca(OH)2: No. 22 divided by 74
24. 3.6 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.00 Gram weight CO2: No. 20 x 44
26. 2.14 Gram weight total possible CO2: 44 x (No. 20 + No. 23)

27.___------____%CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 10.10	Gram weight of sample:	No. 15 – No. 25
29. 0.99	Fine parts/volume:	No. 16 divided by No. 28
30. 53.47	Sand parts/volume:	(No. 17 divided by No. 28) x No. 18
31.__________	Lime parts/volume:	(No. 24 divided by No. 28) x 1.1

Cement (if present)

32.__________	Portland cement parts/volume:	(No. 16 divided by No. 28) x 0.78
33.__________	Natural cement parts/volume:	(No. 16 divided by No. 28) x 0.86
34.__________	Lime with cement parts/volume:	(No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	107.2	106.8	0.4	6.25
No. 20	108.8	106.4	2.4	37.50
No. 30	100.3	99.3	1.0	15.625
No. 40	101.8	100.8	1.0	15.625
No. 50	94.2	93.2	1.0	15.625
Base	71.8	71.2	0.6	9.375

Keeper's House

Sample 52	**Munsell**
White	5Y 9/1
White	5Y 9/1
Yellow	2.5Y 8/4

Sample 52 continued the paint sample series. The sample was collected from the second floor hallway ceiling of the keeper's house. It retained three layers of paint of which the oldest was a warm yellow.

Keeper's House

Sample 53	**Munsell**
White	5Y 9/1
Off-white	2.5Y 8.5/2
Pink	10R 8/3

Sample 53 came from the second floor bathroom wall of the keeper's house. Like sample 52, it revealed three layers of paint with pink being the oldest of the three.

Sample 54 continued the plaster and mortar samples. It was a plaster sample from the stair of the keeper's house. It was quite similar to the first sample but with bits of a very thin white skim coat. It also gave every evidence of being a gypsum and sand plaster. Its sand sieve analysis revealed moderately coarse sand of which the largest bits that failed to pass any of the sieves were pieces of the skim coat.

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No. 54

Building: Keeper's House, Michigan Island, Apostle Islands NL

Location: Stair plaster

Sample Description: Off-white with very thin white skim coat, moderately hard, extremely minimal reaction, extremely rapid filtering time

Test No. 1 – Soluble Fraction

Data:

1. 187.8 Container A weight
2. 205.4 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.00 Liters of water displaced
6. Off-white Filtrate color
7. Tan Fines color
8. No Hair or fiber ______ type
9. 2.7 Fines and paper weight
10. 2.6 Filter paper weight
11. 202.0 Sand and Container A weight
12. 10.4 cc. of sand
13. 42.9 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 17.6 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 14.2 Weight of sand: No. 11 – No. 1
18. .7324 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 3.3 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.00 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0.00 Gram weight of CaCO3: 100 x No. 20
22. 3.3 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .00446 Mols. of Ca(OH)2: No. 22 divided by 74
24. 3.3 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.00 Gram weight CO2: No. 20 x 44
26. 1.96 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. -------- %CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 17.60 Gram weight of sample: No. 15 – No. 25
29. 0.57 Fine parts/volume: No. 16 divided by No. 28
30. 59.09 Sand parts/volume: (No. 17 divided by No. 28) x No. 18
31. ______ Lime parts/volume: (No. 24 divided by No. 28) x 1.1

Cement (if present)

32. ______ Portland cement parts/volume: (No. 16 divided by No. 28) x 0.78
33. ______ Natural cement parts/volume: (No. 16 divided by No. 28) x 0.86
34. ______ Lime with cement parts/volume: (No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	107.3	106.8	0.5	3.60

No. 20	110.0	106.4	3.6	25.90
No. 30	102.6	99.3	3.3	23.74
No. 40	105.5	100.7	4.8	34.53
No. 50	94.6	93.2	1.4	10.07
Base	71.5	71.2	0.3	2.16

Power House

Sample 55	**Munsell**
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1

Sample 55 continued the paint sample series. It was removed from the exterior window of the power house. Its analysis revealed three layers of white paint atop a putty substrate.

Assistant Keeper's House

Sample 56	**Munsell**
White	5Y 9/1
White	5Y 9/1
White	5Y 9/1

Sample 56 was from the exterior siding of the assistant keeper's house. It retained three layers of white paint over an extremely weathered wood substrate.

Assistant Keeper's House

Sample 57	**Munsell**
White	5Y 0/1
White	5Y 9/1
White	5Y 9/1

Sample 57 was found on the exterior trim of the assistant keeper's house. Like its counterpart, sample 56, it retained three layers of white paint, but the wood substrate was unweathered.

Assistant Keeper's House

Sample 58	**Munsell**
Off-white	5Y 8.5/2
White	5Y 9/1
Gray	5Y 7/1

Sample 58 was collected from the stair well wall of the assistant keeper's house. Its analysis showed three layers of paint, of which the oldest was a typical gray paint.

Assistant Keeper's House

Sample 59	**Munsell**
White	5Y 9/1
Gray	5Y 7/1
Yellow	2.5Y 8/4

Gray	5Y 7/1

Sample 59 was collected from the second floor wall and ceiling of the assistant keeper's house. It revealed four layers of paint, of which a typical gray was the oldest layer.

Sample 60 continued the plaster and mortar samples. It was collected from the chimney mortar of the assistant keeper's house. The sample size was quite small with the result being that its statistical reliability is open to question. It showed characteristics of a lime and sand sample with approximately equal parts of each, by volume. The sand sieve analysis revealed very fine sand of which over 30% passed all of the sieves, all of it passed the two largest sieves, and over half was trapped in the finest sieve.

Mortar/Plaster/Stucco Analysis Test Sheet

Sample No.: 60
Building: Assistant Keeper's House, Michigan Island, Apostle Islands NL
Location: Chimney mortar
Sample Description: Off-white, soft, fast and bubbly reaction, extremely rapid filtering time

Test No. 1 – Soluble Fraction

Data:

1. 192.0 Container A weight
2. 198.7 Container A and sample
3. 761.24 Barometric pressure
4. 23 Temperature
5. 0.10 Liters of water displaced
6. Off-white Filtrate color
7. Tan Fines color
8. Yes Hair or fiber ______ type
9. 2.8 Fines and paper weight
10. 2.7 Filter paper weight
11. 196.3 Sand and Container A weight
12. 2.5 cc. of sand
13. 33.0 Weight of graduated cylinder and sand
14. 28.7 Weight of graduated cylinder

Computations:

15. 6.7 Starting weight of sample: No. 2 – No. 1
16. 0.1 Weight of fines: No. 9 – No. 10
17. 4.3 Weight of sand: No. 11 – No. 1
18. .5814 Sand density: No. 12 divided by (No. 13 – No. 14)
19. 2.3 Weight of soluble content: No. 15 – (No. 16 + No. 17)
20. 0.0041125 Mols. Of CO2: No. 5 x No. 3. x 0.016 divided by (No. 4 + 273.16 C.)
21. 0.41 Gram weight of CaCO3: 100 x No. 20
22. 1.89 Gram weight of Ca(OH)2: No. 19 – No. 21
23. .0255 Mols. of Ca(OH)2: No. 22 divided by 74
24. 2.19 Gram total weight of Ca(OH)2: 74 x (No. 20 + No. 23)
25. 0.18 Gram weight CO2: No. 20 x 44
26. 1.30 Gram weight total possible CO2: 44 x (No. 20 + No. 23)
27. 13,85 %CO2 gain: No. 25 divided by No. 26

Conclusions:

28. 6.52 Gram weight of sample: No. 15 – No. 25

29. 1.53	Fine parts/volume:	No. 16 divided by No. 28
30. 38.34	Sand parts/volume:	(No. 17 divided by No. 28) x No. 18
31. 36.95	Lime parts/volume:	(No. 24 divided by No. 28) x 1.1

Cement (if present)

32.____	Portland cement parts/volume:	(No. 16 divided by No. 28) x 0.78
33.____	Natural cement parts/volume:	(No. 16 divided by No. 28) x 0.86
34.____	Lime with cement parts/volume:	(No. 16 x o.2) divided by No. 28 x 1.1

Test No. 2 – Sand Sieve Analysis

Sieve	Sieve w/ sand weight	Sieve weight	Sand weight	Sand ratio
No. 10	106.8	106.8	0.0	0.00
No. 20	106.4	106.4	0.0	0.00
No. 30	99.4	99.3	0.1	2.33
No. 40	101.4	100.7	0.7	16.28
No. 50	95.4	93.2	2.2	51.16
Base	72.5	71.2	1.3	30.23

Assistant Keeper's House

Sample 61	**Munsell**
Gray	5Y 7/1

Sample 61 continued the last three paint samples of the set. It was from the garage wall of the assistant keeper's house. It retained only a single layer of standard gray paint on its wood substrate.

Assistant Keeper's House

Sample 62	**Munsell**
Dark gray	N 4.0/
Gray	N 5.75/
Gray	N 5.75/

Sample 62 was removed from the interior trim of the assistant keeper's house. Its gray paint was darker than the typical gray paint seen elsewhere and was not yellowed.

Assistant Keeper's House

Sample 63	**Munsell**
Off-white	5Y 8.5/2
White	5Y 9/1
Gray	5Y 7/1

Sample 63 was from the first floor entry stair wall of the assistant keeper's house. It revealed a relatively typical set of three paint layers with the oldest being a standard gray.

A number of conclusions can be drawn from the analysis, as follow:

1. There was a low degree of consistency between the samples, making it difficult to draw any firm conclusions.

2. A number of samples had so few layers that one of the following conclusions can be reached:

    a. The oldest layers had either weathered away over time, which is probable with exterior paint.

    b. They may have been stripped. This would be especially true if the older finish was a calcimine paint, which is impossible to cover with any coating, including calcimine paint itself. It was an extremely popular paint for interior plaster surfaces during the nineteenth and early twentieth centuries. In light of the use of whitewash, which is a related waterborne paint, the probability of calcimine paint here is very high.

    c. The element itself had been replaced or is of recent date.

    d. Other coverings such as wallpaper or calcimine paint may have preceded the paint and were removed prior to painting. Wallpaper was a popular covering, especially for damaged plaster.

    e. Because very little is known today about calcimine paint a few comments are in order to explain it, as follow:

        It was immensely popular throughout the nineteenth century and into the early twentieth century. It was cheap, easily applied and removed, had a very soft and lustrous sheen, and could be mixed and used by the average homeowner who could not afford a painter. In this case it could have been applied by Coast Guard personnel rather than painters. Decorative painters frequently used it because of its sheen. It is still in production to this day, although it is very rarely used.

        It is waterborne glue distemper paint which, unlike its cousin, whitewash, must be entirely removed prior to repainting. The difference between calcimine paint and whitewash is in the formulation. Calcimine paint was developed for interior use only and was developed to carry a pigment whereas the high lime content of whitewash prevented it from taking on a pigment. Whitewash was primarily used for exteriors and for dark service areas of interiors.

        Nothing will stick to it, including calcimine paint. Its absence, therefore, is about the only means of its detection. This is a real Catch-22. Because it was typically removed prior to repainting its presence is usually indicated either through historic documentation (which is very rare) or the very small number of layers where many would normally be found or where other, similar surfaces retain considerably more.

3. There is no doubt that many of the tower elements were whitewashed as their probable original finish.

4. Of the other samples, only sample 7 appears to have the most complete, by far, stratigraphy. It was truly excellent in its quality leaving little doubt that gray was the original color in that situation.

5. As can be seen with many of the mortar sample discussions no relative ratios of sand to Portland cement or sand to Portland cement and lime has been stated. The acid reduction method which was used is better than other methods for determining lime to sand ratios. Hence, they were provided

for those samples composed of sand and lime. For samples containing Portland cement, the best this form of testing can do is to indicate the presence of Portland cement and the sand itself.

The primary goal in repointing is to achieve a compatible mortar. This can be done for lime and sand samples that were analyzed. It can also be done for Portland cement samples with a bit of trial and error. If the mortar is very hard then a higher ratio of Portland cement to sand will work. One must take into consideration any deterioration of the masonry as a result of the mortar. If this has been the case it may be advisable to use a softer mortar for repointing.

The other primary mode of mortar analysis is spectrographic testing. Unfortunately, it also cannot accurately determine exact ratios of Portland cement to sand and/or to lime.

The secondary goal is to match the appearance of the mortar, which depends to a very large extent on the sand. This is where acid reduction testing shines. It provides and exact calculation of the sand grain sizes as well as a sample of the sand for matching of color. If the sand is carefully matched then the appearance will be successful. This is especially critical in partial repointing and patching.

6. There are instances where the narrative of the mortar make up refers to Portland – but the data sheet following does not include it in line #32. The reason for this is that rather than a number for lime content, the calculation is made for lime with Portland cement content. If the sample merely had Portland cement and sand there would be a number for Portland cement.

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