DFRP# 67652
FCSI# 67652001 & 67652002

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Structural Review

Michipicoten Island
East End
Light Station

December 2016

Novatech 116136

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2017-03-16

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Attention: **Karen Greer**

Reference: **Michipicoten Island - East End Light Station - Lighthouse and Other Buildings Structural Condition Evaluation**
DFRP: **67652**
Site ID:
FCSI: **67652001**
Our File: **116136**

1 Introduction

1.1 This report describes a visual evaluation of the structures at the Michipicoten Island East End Light Station Site.

1.2 The evaluation was undertaken for BluMetric Environmental in support of a Designated Substances and Hazardous Materials Survey, undertaken by BluMetric for PWGSC.

1.3 Recommendations are provided for repair and maintenance work to maintain the structural integrity of the lighthouse and the other buildings.

1.4 If the condition of the buildings might affect the proposed environmental abatement work, additional recommendations are provided, as required.

2 Methodology

2.1 No record documents were provided. Historical background information was obtained from selected Government and unofficial webpages. The lighthouse is a "Classified Federal Heritage Building", described in the FHBRO "Heritage Character Statement", included in Appendix A. The term "reportedly" relates to information obtained from one or more of these sources.

2.2 The site review was undertaken by Peter James, P.Eng, on September 23rd, 2016. Photographs of typical and notable features are included in Appendix B.

2.3 No invasive tests were undertaken. Existing construction details were identified by visual inspection of physical features, and, where necessary, inferred by reference to typical construction practices. The term "probably" describes conclusions developed by combining visible evidence with knowledge of typical construction practices.

2.4 Sometimes, original construction details may have been incomplete, or inadequate, or modified in an improper manner during the lifetime of a building. Some of these items could be hidden from view - and thus may not be accounted for in this report.

2.5 The term "railing" is used to describe all components that provide (in some manner) the function of guards and/or handrails.

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3 General Description

3.1 The buildings at the site include a lighthouse; a house; a building that was originally a house, but was more recently used as a generator building; two small storage buildings; and several sets of footings or foundations previously used for either tanks or buildings.

3.2 None of the buildings is currently in use. All the buildings were locked (unlocked for the inspection). None of the buildings is heated.

4 Lighthouse

4.1 The lighthouse was reportedly constructed in 1911, using a standard design for flying buttress concrete lighthouses that was developed earlier in the 20th century.

4.2 The main section of the tower is a six-sided reinforced concrete structure, about 18.7 metres high, with each exterior face being about two metres wide. The tower is braced by six tapered flying buttresses, 300 mm wide, and 850 mm deep at grade, reducing to about half that depth where the buttress flares into the tower. The tower is capped with a circular concrete platform, with a diameter of about five metres (estimated). The tops of the buttresses flare out to support the platform. The tower has a hexagonal concrete base, each side about four metres wide. The base is locally extended by about 1.5 m by 1 m at each buttress. Details of the base below grade are not visible.

4.3 The inside of the tower has 12 faces, each about 830 mm wide. The interior width is about 3.1 metres for the full height of the tower (ie the tower is cylinder-like, not tapered). At six faces the walls are about 200 mm thick. The thickness of the walls at other six faces varies from about 200 mm to about 450 mm (estimated). The thickened sections of those faces align with the flying buttresses.

4.4 In addition to the top floor, there are two intermediate floors, and three intermediate landings, at varying spacings that average about 3.1 metres. The top floor extends outward, beyond the tower, to form the circular exterior platform. The intermediate floors and the top floor are concrete, 235 mm thick. The landings are concrete, 150 mm thick. Between the ground floor and the top floor there are six steel ladders, with either 11, 12 or 13 risers (varies with the floor to floor height), and steel pipe railings.

4.5 The lantern room is a two-storey circular metal and glass structure, about 5.9 m internal height, with an open-grate cast-iron upper floor at the glass level. The lantern room is vented. There is an exterior platform, also of open-grate cast-iron construction, at the glass level. Access to the upper floor is by a cast-iron spiral stair, with 10 risers. All the lantern room components are pre-fabricated. Both exterior platforms have railings around their outer edges, fabricated from iron or steel pipe, with threaded fittings at their connections.

4.6 There was no open access to either of the exterior platforms. It was not possible to inspect the top surface of the exterior concrete platform, nor to inspect the platform railings.

4.7 All the concrete components are painted. The paint is generally in satisfactory condition, except where the concrete has deteriorated (discussed below).

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4.8 There is significant concrete deterioration at the outer edge and the underside of the exterior platform. There is a horizontal crack at about mid-depth of the edge of the platform that extends around at least 25% of the perimeter of the platform. There are several spalled areas, and some pieces of concrete have fallen. It can be expected that the top surface of the exterior platform will also have experienced some deterioration. At the ladder opening through the top floor there is significant horizontal cracking that is probably the inward extension of the horizontal crack observed at the edge of the exterior platform.

4.9 There is local spalling of the top-most sections of some of the buttresses, and at the top-most section of one face of the tower. There is also local cracking and spalling at the bases of some of the buttresses.

4.10 Internally, there is minor concrete deterioration of the intermediate floors and intermediate landings, including efflorescence, surface scaling, and local cracking.

4.11 All the metal components are painted. The paint on the ladders is in poor condition. The paint at the lantern room is generally in satisfactory condition.

4.12 There is localized corrosion of some metal components, mostly at the lower supports of the ladders, and at the railing supports.

5 House

5.1 The house is a single-storey wood-framed building with a basement, overall size about 10.5 m by 7.7 m. It is partly built-into a slope, and thus the basement is entered directly from the lower grade level. The primary entrance to the main floor is from the upper grade level via a concrete slab balcony structure. There is a secondary entrance to the main floor via an exterior wood staircase that leads to a small concrete landing.

5.2 The house was probably built in the 1950's. It has a steel-clad hipped roof, of recent vintage. The walls are finished with fibre-cement shingles, probably original. The windows are sealed sliding units, probably installed in the 1980's or 1990's. The windows are in good condition. There is evidence of a roof leak at one bedroom. With that exception, the building is otherwise weathertight, with no visible evidence of any structural deficiencies.

5.3 The foundation walls are concrete. The basement floor is partly concrete, partly soil, and partly rock. The balcony and the landing are supported on the foundation walls, and on seven concrete columns with substantial haunches.

5.4 All the exterior concrete components are painted. The foundation walls are in satisfactory condition. The balcony slab, the column haunches and the columns are in poor condition, including peeling paint, efflorescence, cracking, scaling and heavy local spalling.

5.5 The balcony has a painted metal pipe railing. The stairs and the landing have painted wood railings. The railings are not "sturdy", and they do not conform to current Code requirements for height or pickets / infill panels.

6 Generator Building

6.1 This building was originally a house. Its most-recent function was identified by the presence of a generator and an empty racking system of the type typically used for storage batteries.

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6.2 The main section of this building has two storeys, with a basement, reportedly previously used as a boathouse. It is about 8.1 m by 6.5 m. There is an attached single-storey annex, supported on concrete piers, which is about 5.6 m by 3.7 m. Both the original house and the annex have pitched roofs.

6.3 Both sections of the building are wood-framed. The original building is probably of 1920's vintage. The annex is probably newer. The building is fully-clad with metal siding and metal roofing, of recent vintage. The cladding is generally in good condition, except that several pieces of fascia are missing. The interior faces of the ground floor walls are finished with painted plywood sheets.

6.4 The stairs have been removed. The upper floor was accessed by a ladder. The original windows remain in place, covered by plywood sheets, and the metal cladding. The original interior wall and ceiling finishes are in place. There was no visible evidence of any structural deficiencies.

7 Storage Buildings

7.1 The two small storage buildings are wood-framed, each about 6.4 m by 4 m. Each building is supported on a concrete slab, with the slab edges thickened to follow the ground contours. The pitched roofs and the walls are clad with corrugated fibre-cement cladding. The interior faces of the walls are finished with painted plywood sheets.

7.2 The storage buildings were probably built in the 1970's. They are in good condition.

8 Other Structures

8.1 These include:

.1 Concrete crawl space slab, plus one concrete block foundation wall, for another house. Concrete block debris from the demolition of the other foundation walls is lying on the slab.

.2 Footings and concrete foundation walls for a full-height basement of another building, purpose unknown.

.3 Concrete slab and containment walls for fuel tanks.

.4 Several concrete pads and piers, probably used to support either tanks or equipment.

8.2 None of the other structures was investigated in detail.

9 Comments - Lighthouse

9.1 Concrete spalling is generally the result of a combination of:

.1 Freeze-thaw action on wet exposed concrete, and

.2 Rebar corrosion, typically starting at cracks and/or at locations with insufficient concrete cover over the rebars.

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9.2 The probable existence of horizontal cracking in the top floor / exterior platform slab, extending from the exterior edge of the slab to the ladder opening inside the tower, is potentially a significant problem. The spalling and the cracking are indicative of "top-of-slab concrete delaminations", which occur when expansive forces created by corrosion of the top layer of rebars cause the concrete to fail in tension (crack) in the plane of the rebars, resulting in the concrete above the corroded rebars becoming separated from the concrete below the rebars. When this occurs, the top rebars become debonded, and thus ineffective, resulting in the slab losing its capacity to resist cantilever action. Additionally, the now-separated upper and lower layers of concrete are at greater risk of cracking, and pieces of concrete may fall to the ground.

9.3 Rebar corrosion and concrete spalling at the exterior platform can be expected to continue, probably at a gradually increasing rate due to both the increasing exposure of fractured concrete to freeze-thaw action and the increasing exposure of the rebars to wet conditions. Accordingly, it can be expected that the amount of spalling and top-of-slab delamination will increase, and it can be expected that pieces of concrete will continue to fall. Additionally, the extension of the cracking into the interior section of the top floor slab, as already seen, provides a path for water to penetrate further into the slab, and thus to enter the tower itself, increasing the potential for corrosion and further deterioration.

9.4 At the present time, the primary risk is the risk of injury from falling debris to persons standing near the lighthouse. Deterioration of the top floor slab does not pose an immediate risk to the structural integrity of the lighthouse as a whole. Neither the exterior section of the top floor slab nor the outward flares of the buttresses that support the exterior section of the top floor slab are essential to the integrity of the lighthouse.

9.5 However, if the section of the top floor slab located directly above the walls of the tower, and which supports the lantern room structure, becomes badly fractured, it will eventually lose its capacity to support the loads imposed by the lantern room. Note that the most significant loads on the lantern room structure are wind loads, and to resist the wind loads the lantern room structure must be securely anchored to the tower structure.

9.6 With respect to the primary structure of the lighthouse, the tower and the flying buttresses are generally in satisfactory condition. The condition of the base, which does have some local cracking and spalling, and which is mostly hidden, should be further investigated.

9.7 The exterior concrete platform cannot be considered to be "safe" for access by personnel. The "sturdiness" of the railings has not been assessed. Access to both platforms would require safety harnesses, etc, and secure attachment points for safety lines would be required.

10 Recommendations - Lighthouse

10.1 The purpose of these recommendations is to maintain the structural integrity of the lighthouse, so that any long-term plans for the future of the lighthouse would not be compromised by ongoing deterioration. In particular, proper support to the lantern room structure must be ensured.

10.2 The structural integrity of the top floor / exterior platform slab, as required for it to support all loads from the lantern tower, must be restored. Remedial work to this slab is not a minor concrete-patching repair project, and it will be difficult to undertake effective remedial work on an incremental basis.

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10.3 Depending on available budgets, and objectives, several options could be developed. Option 1 is a "minimum" option that focusses mainly on maintaining support to the lantern room. Option 2 is a "full repair" option that would replace the entire top floor / exterior platform slab.

10.4 Option 1:

.1 Re-support the lantern room structure directly down to the inside faces of the tower walls, anchored to sound concrete below the floor slab.

.2 Remove the full area of the exterior section of the slab (will likely require scaffolding).

.3 Remove the interior section of the slab (could be undertaken from inside the tower).

.4 Replace the interior section either with a concrete slab, or with steel framing.

.5 Provide weather-tight detail at the lantern tower / infill / concrete tower connection.

10.5 Option 2:

.1 Remove the lantern room, either in one piece by helicopter, or by dismantling.

.2 Demolish the entire slab.

.3 Replace slab with a precast concrete slab, or with a lightweight structure - eg steel and fibreglass - with the same appearance as the present slab.

.4 Reinstall the lantern room.

10.6 Option 1 is the minimum recommended "must-do" work. The lighthouse would lose a significant element of its architectural integrity.

10.7 Option 2 is a "full-scope" repair. It would allow undertaking full maintenance on the lantern room structure on the ground, and thus at lower cost. The lighthouse would retain its architectural integrity.

10.8 If no work is planned in the near future, as a minimum precaution against potential damage to the lantern room structure caused by deterioration of the top floor slab, the lantern room structure should be securely anchored to the tower walls. This work could be undertaken from the inside of the tower.

10.9 Other work recommended at the lighthouse:

.1 Investigate the condition of the footings. Undertake concrete repairs to restore the integrity of the footings, as required. Consider protecting the footings and the lower-most sections of the flying buttresses to minimize the risk of future deterioration.

.2 At the interior, repair deteriorated concrete and metal components. Remove efflorescence, surface scaling, corrosion, etc, and repaint.

.3 Repaint the metal components of the lantern room and upper platform. If the paint is removed to bare metal, caulk all joints before the metal is primed and repainted.

.4 Check all components such as windows, doors and hatches, particularly at the lantern level, for weather-tightness, and repair or upgrade as required.

10.10 As noted above, the primary focus of these recommendations is to maintain the structural integrity of the lighthouse. Because the lighthouse is a Heritage Building, other factors outside the "narrow" structural focus of this report must also be addressed in developing a comprehensive remedial plan.

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11 Environmental Abatement Work - Lighthouse

11.1 If any work is to be undertaken in the immediate vicinity of the lighthouse, there is a potential risk of injury to workers from debris falling from the exterior platform.

11.2 If any work is to be undertaken outside the lantern tower, the exterior concrete platform cannot be considered to be safe. It will be necessary to establish alternative methods of access. Full-height scaffolding may be required.

11.3 The budget for external environmental abatement work at the lighthouse should include full allowances for access and protection costs. To develop this budget requires further study of means of access, methods of work, scope of other work that may be undertaken at the same time, etc.

12 Comments - Other Buildings

12.1 The cladding at all the other buildings is generally in good condition. With the exception of a possible leak at the house, all the other buildings appear to be generally weathertight.

12.2 The spalling of the concrete balcony and landing structures at the house has the same causes as the spalling at the lighthouse. Ongoing deterioration can be expected. Ongoing deterioration does not represent a threat to the primary structure of the house.

13 Recommendations - Other Buildings

13.1 The purpose of these recommendations is to maintain the structural integrity of the buildings. These recommendations are not intended to make the buildings suitable for any particular purpose.

13.2 At all buildings, maintain the cladding and other exterior components as required to maintain their weather-tightness.

13.3 At the balcony and landing structures at the house, either:

.1 Remove all loose and deteriorated concrete, efflorescence, surface scaling, etc, from the concrete structures, clean and repaint, or

.2 Consider removing the concrete structures, and provide alternative means of access to the house.

14 Environmental Abatement Work - Other Buildings

14.1 The condition of the other buildings will require no additional precautions other than those normally required for the type of work to be undertaken.

14.2 There should be no additional costs to the budget for the environmental abatement work on account of the structural condition of the other buildings.

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15 Summary

15.1 Lighthouse:

.1 The primary structure of the tower is generally in satisfactory condition. The deterioration of the top floor / exterior concrete platform presents a significant present risk of falling debris, and a future risk to the stability of the lantern room.

.2 The top floor slab / exterior concrete platform should be removed. The exterior platform is not a primary structural element, and thus it does not have to be replaced in its present form.

.3 Additional repair and maintenance work should be undertaken to maintain the integrity of the primary structural system, and to minimize ongoing deterioration of other components.

.4 There may be significant costs for access and protection associated with undertaking the external environmental abatement work.

15.2 Other Buildings:

.1 The other buildings are generally in good condition. Minor maintenance work is recommended to maintain their existing condition.

.2 There should be no additional costs for the environmental abatement work on account of the structural condition of the other buildings.

Yours truly,

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Peter James, P.Eng
Senior Project Manager | Structural Engineering & Building Code

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APPENDIX A

HISTORICAL INFORMATION

HERITAGE CHARACTER STATEMENT

The Michipicoten Lighttower was built in 1911 to designs by Lt. Col. Wm. Anderson of the Department of the Marine. It is the property of Transport Canada, Canadian Coast Guard. See FHBRO Building Report 88-145.

Reason for Designation

The lighttower was designated Classified for its historical, architectural and environmental significance.

Its architectural importance is of a high order. It is an advanced example of the reinforced concrete, flying buttress lighthouses developed early in the 20th century in locations requiring strong wind resistance. Its form is an adaptation of a prototype built in Belle Isle, Newfoundland in 1908. The resulting tapered elegance and height of the lighttower form, distinguish it from its predecessors.

The tower also embodies thematic significance. Its construction is associated with efforts to upgrade the quality of lighthouse construction in the early years of the 20th century, following a long period of restrained government spending.

The tower also enjoys significance for the relatively unchanged nature of the site on which it stands, and for its prominent role in establishing the character of the lightstation.

Character Defining Elements

The tower's architectural significance is primarily embodied in its six flying buttresses (each supported by double arches) flanking a tapered tower of particular elegance. Its formal power has been achieved by the use of reinforced concrete in the construction of buttresses, encircling shell and floor, permitting a fully integrated structural response to the increased weight of the improved lanterns and lighting apparatus of the period and the horizontally applied wind loads.

The design characteristics and materials of the original reinforced concrete elements would be important to maintain as repair work is carried out.

The lighttower has been altered little since its construction in 1911-12. To the fog plant an oil shed and boathouse of 1912 have been added, in 1928, the radio beacon building, a bungalow for the lighthouse keeper and a boat landing in 1953. The

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buildings together provide a good example of the utilitarian additions and alterations typically experienced by such stations as they have adapted to changing circumstances. It would be important to give every consideration to ways of maintaining these buildings and the relationship between them in future planning of the site.

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APPENDIX B

PHOTOGRAPHS

Michipicoten Island - East End Light Station - Structural Review

Overall view of Light Station

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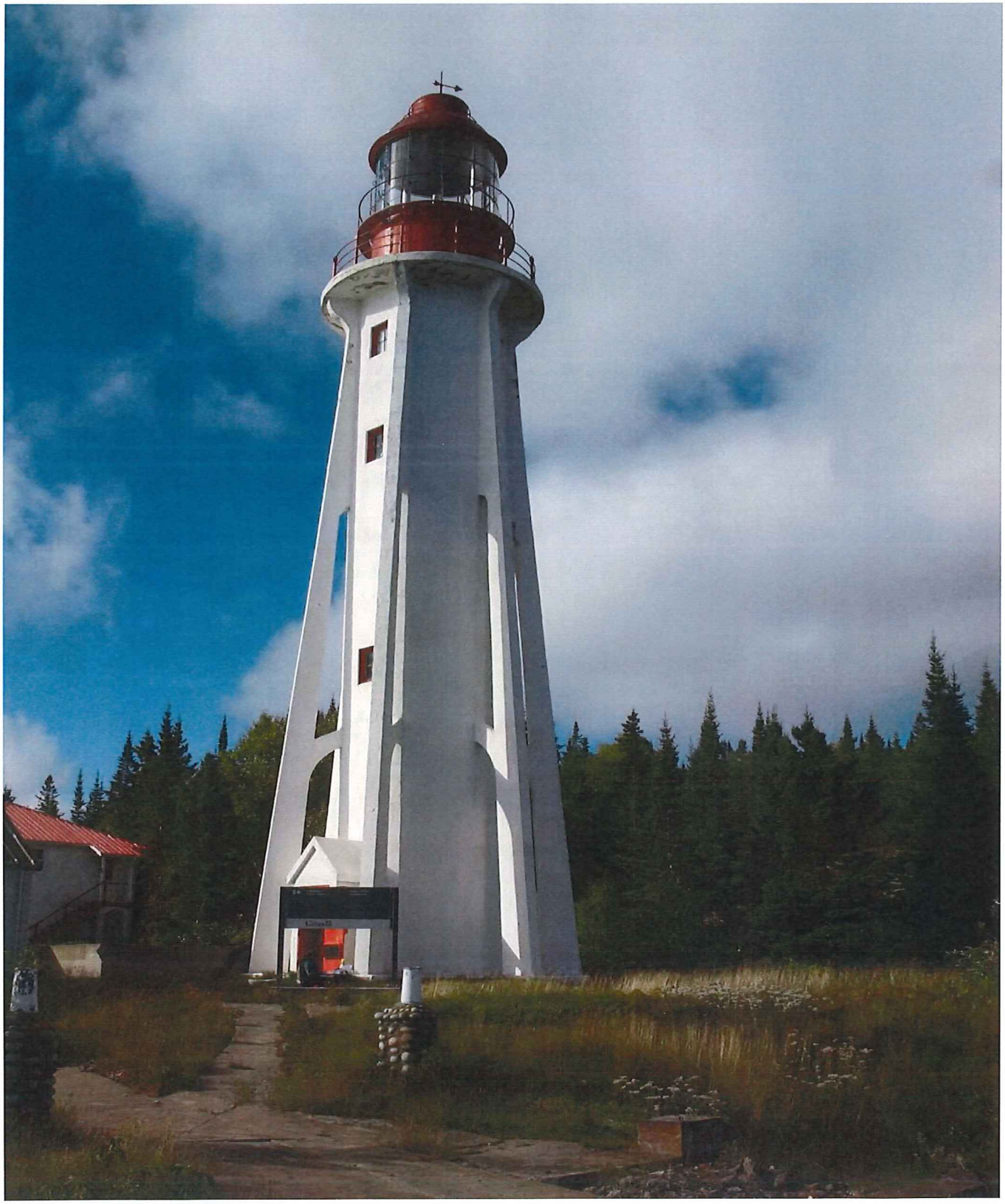

Overall view of Lighthouse. Six flying buttresses. Top floor extends as exterior concrete platform.

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Overall view of house. Concrete balcony, concrete landing at side door.
Roof, siding & windows in good condition.

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Overall view of generator building, annex in shadow, and two small storage buildings beyond.
Metal cladding in good condition, one fascia piece missing.

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Michipicoten Island - East End Light Station - Structural Review

Part-demolished concrete block foundations.

Abandoned concrete foundations.

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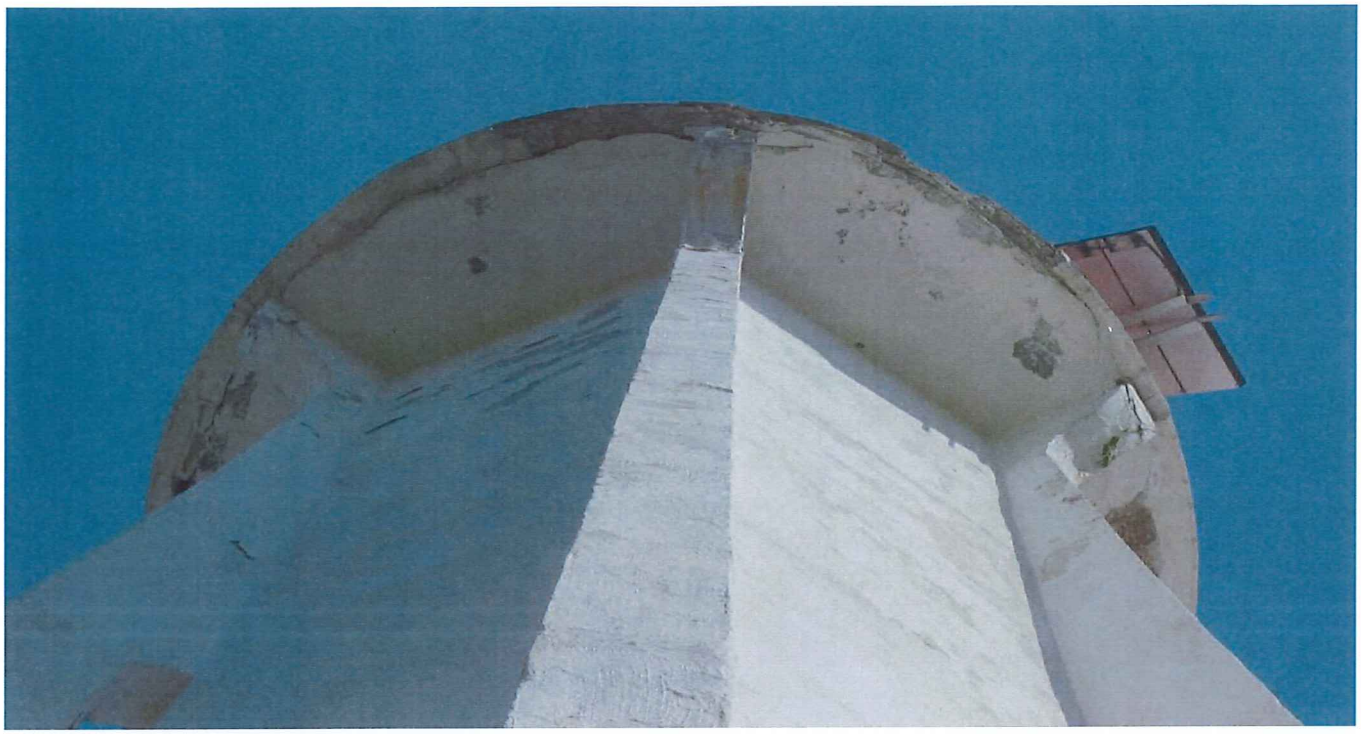
Concrete spalling at exterior concrete platform. Note horizontal crack at edge of slab. See P8. P6



Concrete spalling on wall face and at buttress flares.

Concrete cracking and spalling at base of buttress.

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Ladder opening through top floor. Horizontal crack in slab is probably same crack visible at outside edge of exterior concrete platform. See P6.

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Lantern room: Metal-plate wall, open-grate cast iron upper floor. Condition generally satisfactory.

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Exterior platform: Open-grate cast-iron with steel pipe railing. Local corrosion.

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Typical ladders, pipe railings, concrete landing. Note walls generally in good condition.

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Typical condition of ladders and railings at supports. Peeling paint, local corrosion.

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Significant spalling of slab edge. Loss of integrity at base of railing post. Peeling paint on slab soffit.

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Balcony slab. Cracking at column haunches. Paint fully peeled-off slab underside.

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Generator Building & Annex. Metal cladding in good condition, several fascia pieces missing.

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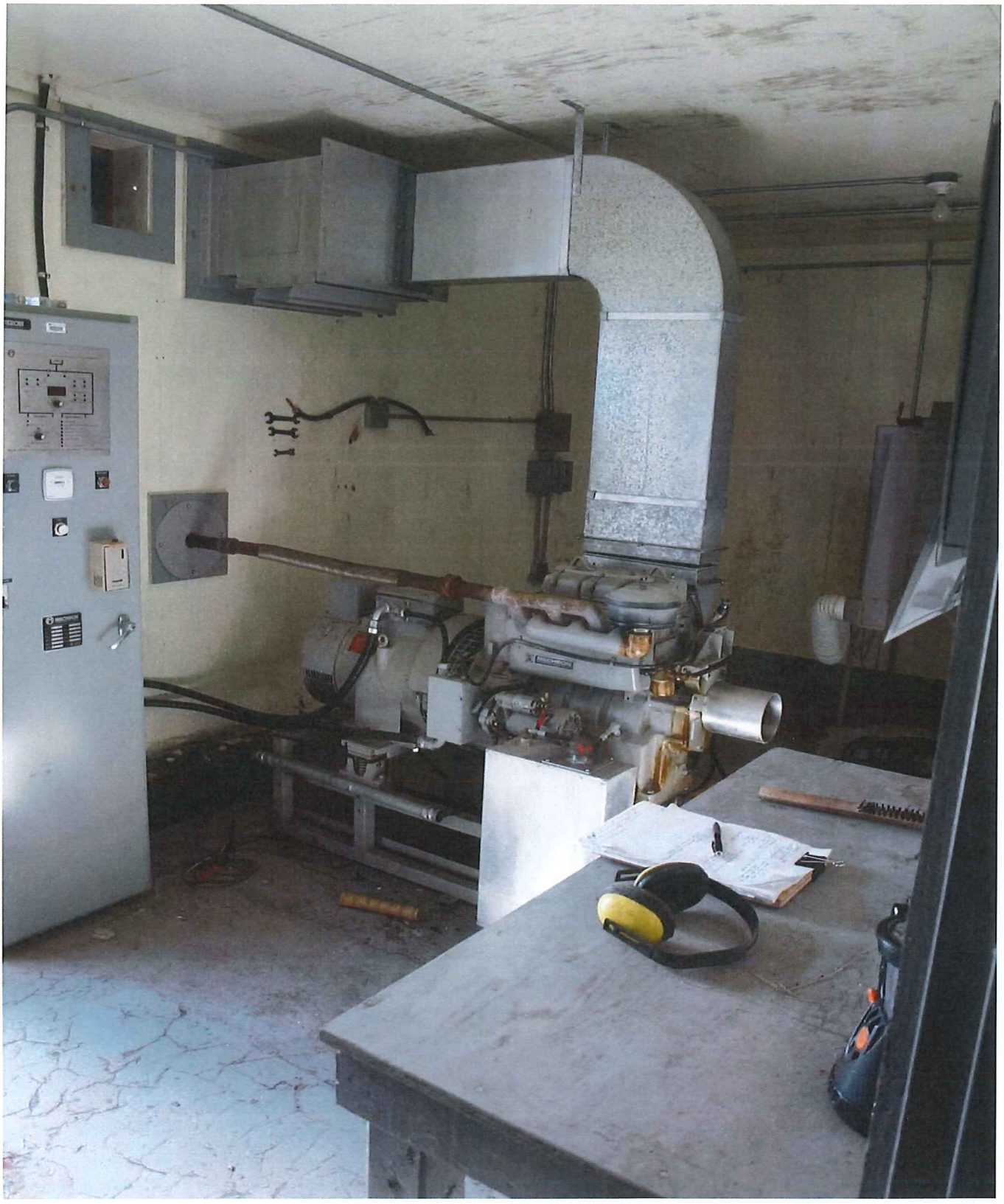

Generator.

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Annex to Generator Building: Interior view.

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Generator Building: Second floor - boarded-over window, original finishes.

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Two small storage buildings. Generally good condition.

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2017-05-01

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Attention: **Karen Greer**

Reference: **Michipicoten Island - East End Light Station - Lighthouse and Other Buildings Structural Condition Evaluation - Budget**
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1 Introduction

1.1 This budget should be read in conjunction with our Structural Condition Evaluation issued in March 2017.

2 Repair Budget

2.1 Budget costs are presented for the items of work recommended in the report, broken down as follows:

	Work Item	Reference from Report	Comments	Budget
1	Stabilize the lighthouse lantern structure	10.8 (also 10.4.1)	This is the minimum work that should be undertaken	$12,500
2	Option 1 - Remove the lighthouse top floor / exterior platform, replace only the interior section	10.4, excluding 10.4.1	The work of stabilizing the lantern structure (item 1) will also be required	$85,000
3	Option 2 – Replace the entire lighthouse top floor / exterior platform	10.5	This is an alternative to Option 1. If this option is selected, but delayed, the work of stabilizing the lantern structure (item 1) will also be required	$175,000
4	Other maintenance work at the lighthouse	10.9	This work would be undertaken in conjunction with, or after, Option 1 or Option 2	$50,000
5	Maintenance work at the house	13	This work is independent of the work at the lighthouse	$10,000

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2.2 These budgets are based on the assumption that the repair work will be undertaken at the same time as the environmental remediation work – and thus the infrastructure for working on the island, and scaffolding for access to the lighthouse, etc, will already be in place.

2.3 Soft costs, such as engineering design, tender documents, tendering & contract admin, internal management costs, etc, should be added to these budgets.

Yours truly,

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