# National Capital Commission

# Voyageur Pathway Leamy Creek Bridge
# Gatineau, QC

## Final Design Study Report

Date: 2013-12-16
O/Ref.: P-0001957

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# Gatineau, Quebec

## Final Design Study Report | P-0001957


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## Property and Confidentiality



| RECORD OF REVISIONS AND VERSIONS | | |
|---|---|---|
| 0A | 2013-02-13 | Preliminary version for comment |
| 00 | 2013-03-25 | Final version |
| 01 | 2013-12-16 | English Version |

# 1 INTRODUCTION

The purpose of this report is to present our analysis and assessment of the various options proposed for rehabilitating the pedestrian bridge crossing Leamy Creek, located near Lac Leamy in Gatineau, Quebec. When the National Capital Commission (NCC) realized that the bridge was in a state of extreme disrepair, it decided to rehabilitate the structure and ensure that it was safe once again. This report is part of a final design study and will make it possible to develop a precise picture of the various restoration options possible and validate their technical and financial feasibility, with the ultimate goal of recommending the optimal rehabilitation solution. With that in mind, we reviewed the various studies that had been conducted on the bridge to date and performed additional studies to validate the different assumptions. The time frame of the various sections of the report shows the strategic thinking process that guided us in our investigations, from identification of the problem to final design recommendation.

## 1.1 DESCRIPTION OF MANDATE

The contract awarded to Dessau Inc. by the NCC involved completing a final design study in order to analyze five different proposed options and recommend one, for which we would then prepare a preliminary design and present the associated costs. The purpose of the analysis is to select the optimal rehabilitation or reconstruction solution, taking into consideration the environmental impact, functionality, aesthetics and cost. The guidelines to be used as a framework for our thinking process for the project were to include safety, quality, traffic control during the work and cost of work.

In the event of complete reconstruction, the criteria to be considered are as follows:

- The width of the new bridge may not exceed 3.5 metres.
- The spans must be extended on each end to position new abutments beyond the high water mark in order to comply with environmentally friendly practices.
- The new structure must comply with Fisheries and Oceans Canada's Quebec Operational Statement with respect to clear-span bridges.
- The selection of location and type of bridge must be optimized and the service loads used must comply with the latest edition of standard S6-06. The bridge must be designed to accommodate maintenance vehicles with a maximum axial load of 80 kN.

## 1.2 DESCRIPTION OF STRUCTURE

### 1.2.1 General

The bridge being studied crosses Leamy Creek near Lac Leamy, in the city of Gatineau, Quebec. It is located 130 metres downstream of the Fournier Boulevard bridge and was built in the 1930s. Due to the significant damage to the structure and the foundation units, it is now at the end of its life span. The overall span of the bridge is 56 metres and its extreme width is 5.6 metres. The bridge has four spans varying from 12.3 metres to 14.9 metres in length. The deck has a composite section of five steel girders and a concrete slab and is supported by two abutments and three concrete piers.

Photo 1

Photo2

### 1.2.2 Bridge conditions

The failure to rehabilitate the bridge over the past 80 years accelerated the deterioration and as a result some of the bridge components are in a very advanced state of disrepair. Most of the components have exceeded their useful life, including the abutments, part of the deck, the guardrails and some girders. The bridge was repurposed from a road bridge to a pedestrian bridge, which made it possible to reduce the loads to which the structure was subjected.

The two concrete abutments have suffered serious damage and have separated from their wing walls, which in some places have disintegrated. Movement of the abutments causes a transfer of compressive stress onto the steel girders, some of which are starting to buckle.

The base of the three piers appear appears heavily damaged and the two central piers have settled by about 300 millimetres in the past 80 years. The settling is likely due to soil compaction beneath the foundation footings. The lack of as-built drawings makes it difficult to assess the behaviour of the foundations, because prior to our study, we were unaware whether there were piles beneath the foundation footings.

Most of the steel girders appear to be in satisfactory condition. However, in 2002, missing braces were replaced between the outside girders and since then some of the girders have shown signs of weakness, notably permanent deformation and buckling. In addition, steel reinforcements were added to the girders to temporarily support the concrete abutments, which had tilted, and increase resistance to the additional loads transferred to the girders by the abutments. A space left between the reinforcement structure and the face of the abutment for the purposes of investigating the tilting of the abutments had completely closed, a clear indication that the abutments are still actively moving.

The concrete deck is heavily damaged at one end, and scaling beneath the deck is increasing. The guardrails are badly damaged and in some places sections are missing entirely. The concrete curbs have deteriorated and in some places pieces of concrete have broken off.

# 2 PROJECT BACKGROUND AND DEVELOPMENT

## 2.1 BACKGROUND

Two engineering firms (McNeely Engineering and Sauvé Boucher Associates) completed studies of the bridge in 1988 and 2001 to assess its condition and propose rehabilitation solutions. Upon completing their investigations, both firms found that the bridge structure was an extreme state of disrepair and that major repairs and/or replacement had to be undertaken to restore some components of the structure.

In their reports, neither consultant recommended rehabilitating the bridge, given its age and advanced state of disrepair, but also the very high cost of that option. McNeely identified one rehabilitation option, but did not recommend it, due to the exorbitant cost at the time.

Both firms recommended replacing the existing structure, either completely or partially, reusing some components under certain conditions. Other options were proposed, which will be discussed in later sections of this report.

## 2.2 PRESENTATION AND ANALYSIS OF OPTIONS

Five options are up for consideration for the project. They must each be analyzed in depth to determine which solution will provide the best balance between environmental impact, functionality, aesthetics and cost.

### 2.2.1 Option 1: Status quo

This option involves doing nothing, allowing the structure to continue to deteriorate and postponing work to a later date. This solution must be discarded, however, given the advanced state of disrepair of the structure and the safety risk that it represents for users.

### 2.2.2 Option 2: Reroute traffic to Fournier Boulevard

This option is not popular with the NCC, because Fournier Boulevard is a very busy thoroughfare. However, there is an existing emergency parking shoulder on the boulevard. A structural analysis of the bridge would have to be performed to determine whether the shoulder could be widened and converted into a sidewalk for pedestrian use. In that case, all that would need to be done would be to divert traffic to allow a maintenance vehicle to leave the work site, travel over the bridge and re-enter the work site. This option could be less costly if Fournier Boulevard Bridge is structurally adequate and certain modifications can be made. Negotiations would have to be undertaken with the City of Gatineau to obtain approval to widen the bridge.

### 2.2.3 Option 3: Perform emergency repairs

This option involves reducing the safety hazard by performing emergency repairs. This would make it possible to extend the life of the structure, but would not resolve the problem. This option does not appear to be reasonable given the advanced state of disrepair of the structure.

### 2.2.4 Option 4: Partial reconstruction

Partial reconstruction involves replacing the bridge, but keeping some components, such as the steel girders and some foundation units. The advantage of this option is that it makes it possible to save money on construction and to incorporate an environmental approach. This is a very interesting option, but it remains to be seen whether it is workable, because there are a number of unknowns regarding the structural elements that would be kept. We do know that the concrete deck, abutments and guardrails are beyond repair. It must therefore be determined whether the piers can be restored and whether the girders can be reused, keeping in mind that the outside girders are damaged.

### 2.2.5 Option 5: Complete replacement

This option involves simply demolishing the existing structure and building an entirely new one. It would make it possible to eliminate all safety hazards and have a bridge that meets current codes and standards in every detail. Obviously, this option is the most costly, but it provides the greatest flexibility in terms of choice of design, which would make it possible to optimize the decision-making process and better control costs. If the partial reconstruction option is not possible, complete replacement would be the next-best solution.

## 3 INVESTIGATIONS AND CHOICE OF OPTION

As part of our final design study, we carried out investigations designed to identify the general condition of the foundation units (piers). To assess the quality of the existing concrete and determine precisely whether or not there were piles beneath the foundation footings, as well as assess their nature, condition and arrangement, we contracted LVM Inc. and ODS MARINE to perform various types of work. Following receipt and analysis of the reports on their work, we performed an overall project review and identified the directions to take for subsequent project phases, the purpose of the study being to determine whether the structure must be partially or completely replaced.

## 3.1 UNDERWATER INVESTIGATION

To determine whether partial reconstruction is a viable and realistic option, we first had to resolve some of the unknowns, e.g. determine the actual condition of the concrete, identify whether or not there were piles in place and, if there were, gather as much useful information about the piles as possible. We established an investigation protocol involving first our subcontractor ODS MARINE. On October 19, 2012, the firm spent a day performing surveys beneath the foundation footings. The purpose of the first day of investigation was to determine whether there were piles beneath the footings and if so, what their nature and condition were. At the end of the day, we received confirmation that wooden piles approximately 12 inches in diameter and in relatively satisfactory condition were in place.

That said, the information was as yet incomplete, as we still did not know how many piles were beneath the footings and how they were arranged. Upon reflection, we decided to spend a second day investigating, this time to identify the missing information about the piles. The second day of investigation took place on Friday, November 30, 2012. We discovered that the 12-inch piles were spaced every 116 inches (about 3 metres) in the lengthwise direction of the footing. In the width-wise direction, we travelled just over 2 metres but were unable to find other piles. Given the configuration and size of the footings, we deduced that there were about six piles in good condition beneath the footing.

## 3.2 CONCRETE EXPERTISE

The second component involved contracting another company, LVM Inc., to take concrete samples for analysis. The purpose of this activity was to provide us with as much information as possible on the condition and composition of the concrete. LVM carried out this work on November 23, 2012.

The work confirmed that the concrete was in extremely poor condition. Six concrete samples were taken from the piers and, of those six, only two were sufficiently sound to allow compression testing. The other four samples disintegrated during the core sampling. The granular material used in the formulation of the concrete was extremely coarse and did not appear to contain any reinforcing steel. Concrete defects akin to alkali-aggregate reaction were observed. The condition of the samples is shown in the photos below.


Photo 3

Photo 4


Photo 5


Photo 6


Photo 7


Photo 8


Photo 9

Photo 10

## 3.3 GEOTECHNICAL STUDY

A geotechnical study was carried out to characterize the soil in place, identify the soil's carrying capacity and obtain an idea of the depth of the rock. All of this information combined with the lab's recommendations will be used to generate the design of the new foundation units. See the appended geotechnical study No. 237-B-0001957-1-GE-R0002-0B.

## 3.4 ANALYSIS OF RESULTS

The various investigations confirmed for us that the option involving partial reconstruction of the bridge and reuse of some foundation units and the deck is a valid option.

Upon deducing that there were about six wooden piles 12 inches in diameter in place, we performed a load lowering calculation, using the assumption that the piles were arranged symmetrically. This allowed us to hypothesize that the loads were spread uniformly over the piles. The capacity of a single pile was evaluated using the recommendations in the Wood Design Manual and standard CSA-086. After calculating the weighted static load, we spread the load over the piles and compared it with the carrying capacity calculated for each pile. We concluded that, based on our assumptions, the piles are overloaded.

Analysis of the concrete samples provided an assessment of the advanced state of concrete deterioration. On the underside of the piers, the aggregate is very coarse and we noted a lack of adhesion between the grout mix and the aggregate. Of the six concrete samples taken, only two could be used for compression testing, as the others were too heavily damaged to withstand this type of test. On the upper part of the pier, the concrete appeared to be in better condition. The footings were also in a very advanced state of disrepair. During the underwater investigations, large pieces broke off from the concrete mass. The compression strength levels obtained for the two samples tested were extremely variable. We obtained 20 MPa for one sample and 48.4 MPa for the other. As for the foundation footings, the concrete is heavily damaged.

### 3.5 CONCLUSION AND CHOICE OF DESIGN

After compiling all the different results of the investigations of the piles and the concrete in the foundation units, we performed a comprehensive assessment of the possibility of keeping the foundation units. However, in view of the extreme state of concrete deterioration and our inability to validate a number of data regarding the piles, not to mention their unconventional arrangement, we came to the conclusion that partial reconstruction, with some foundation units being kept, is not a viable or safe option. Almost all of the structural elements of the bridge are in too advanced a state of disrepair and the cost of partial repairs would be too high and would not guarantee a significant extension of the residual life expectancy of the bridge.

With that in mind, we turned our attention to the option of completely rebuilding the bridge. We will study and propose a variety of complete replacement designs. However, the possibility of reusing some deck girders will be considered as the project moves forward. We will study and present two main reconstruction methodologies. First, we will study the option of demolishing the existing bridge and rebuilding a new bridge in the same location, which would involve building a temporary bridge or closing the site during the work. The other option would be to build a new bridge beside the existing one and keep the old bridge until the work is complete.

# 4 PRESENTATION OF SELECTED DESIGN OPTIONS

In terms of complete replacement of the structure, two options are mainly being considered. The first involves building a new bridge in the exact location of the existing structure. The other involves building a bridge nearby and demolishing the existing structure once the work is complete. In the following sections, we will present and analyze both options.

### 4.1 OPTION 1: REBUILDING THE BRIDGE IN THE CURRENT LOCATION

This option involves completely demolishing the existing structure and building a new one in the same location. The abutments would have to be constructed beyond the high water mark.

Before the demolition work started, a decision about whether the work site would be closed during the work would have to be made. If the work site were to be closed, there would be no need to build a temporary bridge, as the site would be closed to users throughout the work. However, if it were necessary to keep the work site open and operational throughout the work, a temporary solution would have to be considered. A temporary bridge would have to be built to divert traffic during the construction work. This bridge would then need to be demolished and the landscape restored following completion of the new work.

#### 4.1.1 Signage and traffic detour

The work site would have to be laid out to connect the existing pathway to the new temporary bridge and signage erected.

# Appendix 3 ODS Marine Reports

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COMMERCIAL DIVING • BOAT, BARGE, TUG RENTALS • MARINE CONSTRUCTION & ENGINEERING SERVICES

October 19, 2012

Dessau
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Attn: Oumar-Demba Ba, P. Eng.

Re: Leamy Creek Bridge Diving Inspection

On the 19th of October 2012 ODS Marine was hired by Dessau Engineering to perform an inspection on the Lac Leamy Creek Bridge.

The first and foremost objective of the inspection was to attempt to determine whether or not there are piles underneath the footings of the piers. A minor objective was to do an overall inspection of the bridge and condition of the concrete which made up the piers.

Prior to commencing the underwater inspection we briefly took the Dessau representative, Oumar Demba, around the piers with our boat to do a preliminary assessment. It was noticed that the water depth around all piers was on average 1'-3' deep. The centre pier was the only pier with a visible footing on the upstream east corner. It was decided that if we were to begin excavating that the centre pier would be the most likely area to start.

**Inspection of pier #2 Underwater**

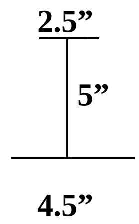
The underwater portion of the inspection began on pier 2 which is the furthest easterly pier.

The diver began the inspection on the upstream nose of pier 2 and travelled along the east side to the downstream nose.

Initial inspection showed that the pier and footing of pier 2 is heavily degraded and the concrete is very brittle and soft. Upon all soundings of the concrete it was very easy to remove large portions of concrete with ease. The footing has no visible straight edges and it was noticed that the current top of the footing slopes downward and away from the pier. The diver was able to find large amounts of loose concrete all the way around the pier and on top of the footing.

Closer to the downstream nose of pier 2 we located steel beams which were poured into the footing. The beams appeared to be visible due to the heavy amount of degradation of the footing. We located 4 steel beams located on the downstream east side of the pier. Each beam was 3' apart and varied in amount exposed of 8"-5' horizontally. It is unable to tell if the beams are I-beams or H-beams due to the deterioration of the steel. When the diver inspected the west side of pier 2 he was not able to locate any more exposed beams.

**Typical Beam**




**Note: To reference the exposed beams on the inspection video start the video at 08:49:00**


After completing 75% of the inspection of pier #2 Oumar Demba requested that we stop any further inspections of the piers and focus on excavating a hole under one of the footings to find any evidence of a pile.

## Excavation

Prior to excavation a sediment barrier was installed around work area to isolate any silt and debris.

We choose to excavate the upstream east side of pier 3. Pier 3 would be the easiest and most likely pier to excavate because there was a considerable amount of footing exposed.

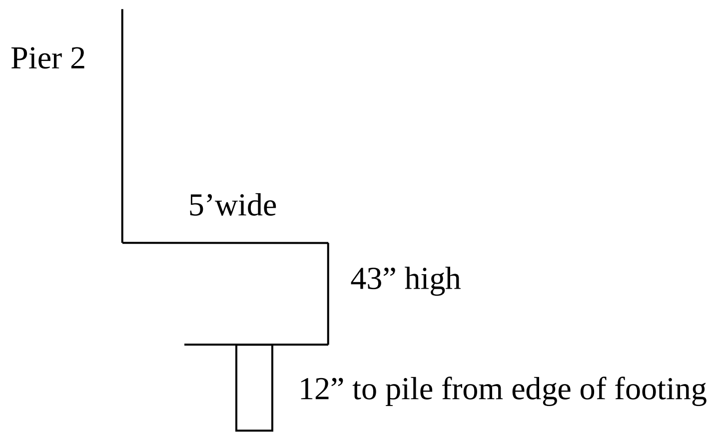
**Silt Curtain**

The material being excavated next to the footing was a mix of rock, concrete, mud and wood debris. The divers used water jets to help move the material away to create a large enough hole to reach the base of the footing. The base of the footing was located and the current height of the footing was 43”. The footing from top to bottom was heavily deteriorated with no noticeable square edges. Form work from the original construction was removed at the face of the footing which allowed the diver to excavate further under the footing.

**Vertical form work**

A pile was located under the footing approximately 12” from the face of the footing. The pile was a round wood pile measuring approximately 12” in diameter. We were unable to excavate a large enough hole to get any images of the pile but it was confirmed by the diver that the pile was firmly planted into the river bottom and the top had been poured into the footing of the pier. The diver also confirmed that we had reached the base of the footing by excavating 28” laterally under the footing.

**Note:** Drawing is not to scale and the current condition of the concrete is not square.




Once we located and confirmed that there were piles under the piers Oumar Demba was satisfied that we had accomplished the overall objective of the inspection. No further inspection was required of the bridge.

Chris Davies
Dive Supervisor

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**Attn**: Oumar-Demba Ba, P. Eng.

**Re**: Leamy Creek Bridge Diving Inspection

**November 30th, 2012 ODS Marine returned to conduct additional investigation work on pier #2. The scope of work was to conduct the inspection under pier 2 with additional excavation to determine the number of wooden piles and their position/spacing. Extensive removal of debris (rocks, wood and hard packed mud) was conducted utilizing a water jet. The plan was to have two divers in the water… After diver 1 started the removal of debris it was requested by diver 1 that we hold off on splashing diver 2. The footing was in such poor condition it was deemed unsafe in zero visibility by the diving supervisor to have diver 2 jetting in close proximity to diver 1 for fear of collapse.**

**Pier 2**
**Concrete footing:**

**Condition state – Very poor**

- **Very severe disintegration of concrete**
- **No evidence of rebar**
- **Concrete was falling off footing during excavation with a noteworthy 24"x 24" x 6" section of the concrete face delaminated and fell off on the diver. The diver moved it aside and continued with the excavation.**

**Performance Deficiency – Load Carrying Capacity**

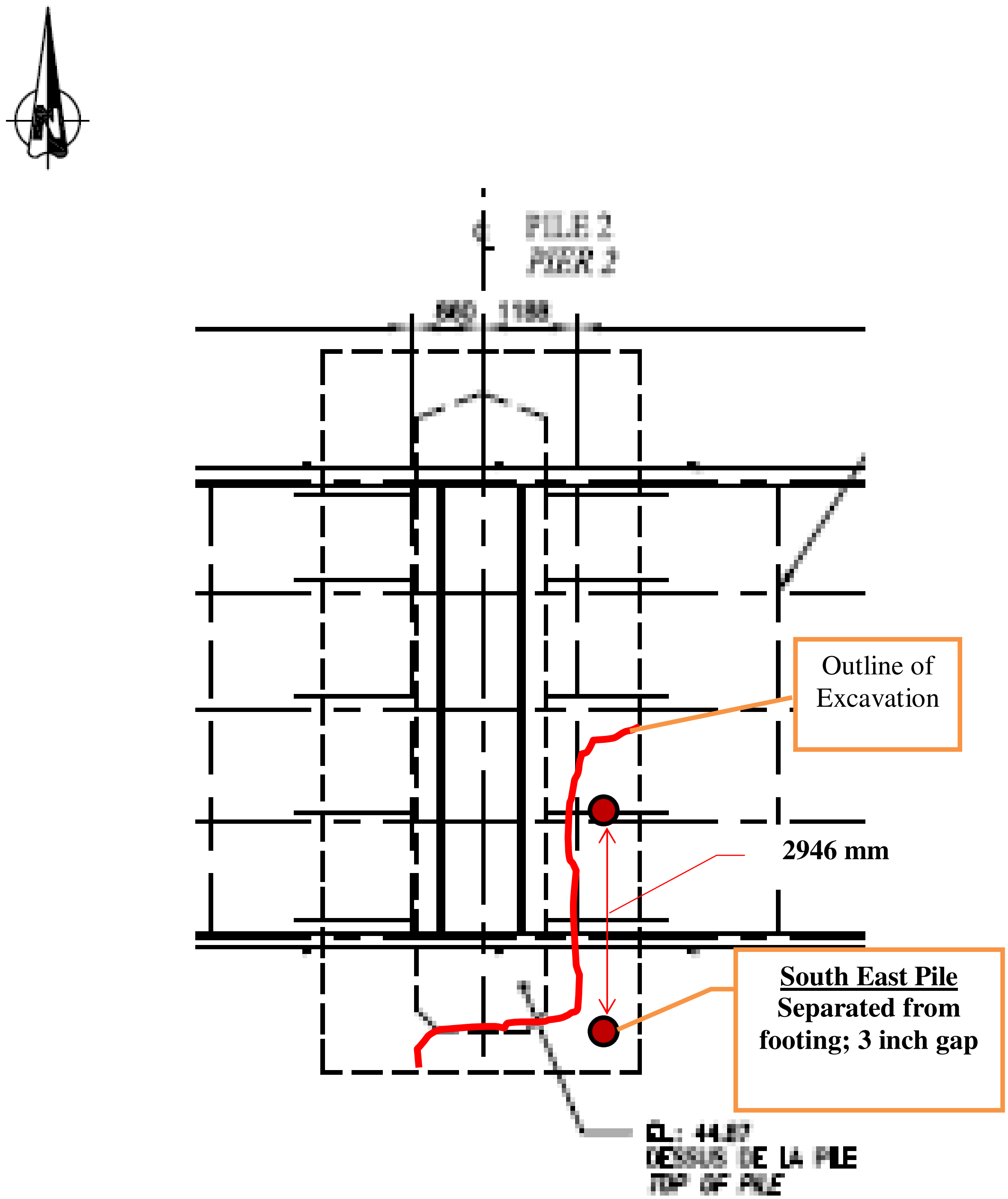
- **Severe concrete loss with no evidence of structural steel critically affecting the strength of the footing. An evaluation of the overall footing is required to determine the extent of strength reduction.**

**Wooden piles:**
**Condition state – Poor**

- **2 – 12 inch diameter vertical wooden piles were exposed under the footing on the east side of the pier**
- **Positioned approximately 116 inches apart with no evidence of piles located between.**
- **Sounding returns on the wood were excellent.**
- **Core sample of wood pile supplied to client.**
- **South east corner pile has 3 inch separation from footing; no bearing load on the pile in this location**

**Performance Deficiency – Load carrying capacity; Continuation of disintegration of concrete footing to pile interface.**

**Note: due to the conditions found any further investigation work to be conducted under footing will require shoring to ensure the safety of the diver.**




**Ken Rule**
**Operations Manager**