

OPERATIONAL ASSESSMENT REPORT

LION'S HEAD MARINA

LION'S HEAD, ONTARIO



**The Municipality of
Northern Bruce
Peninsula**

LETTER OF TRANSMITTAL

October 27, 2017

The Municipality of Northern Bruce Peninsula

56 Lindsay Road 5

RR#2

Lion's Head, ON

N0H 1W0

Attn: Mr. Bill Jones, CAO

Re: Operational Assessment of the Lion's Head Marina

Planmac Ref. No. 1728

Dear Mr. Jones:

Planmac Engineering Inc. is pleased to submit herewith our Final Operational Assessment Report for the Lion's Head Marina.

This Operational Assessment is based on careful review of the historical drawings, depth readings, videos and photographic information provided to Planmac by the Municipality of Northern Bruce Peninsula (MNBP). Prior to this review, Planmac's team conducted a brief site investigation on June 19, 2017 including Mike Neumann, P.Eng., and Percy Fulford, B.A.Sc., EIT, where information including photos was obtained.

Should you wish to discuss any of the items presented here, please do not hesitate to contact the undersigned.

Yours truly,

PLANMAC ENGINEERING INC.



Robert Maksymec, P. Eng.

Senior Structural & Marine Engineer

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EXECUTIVE SUMMARY

Planmac Engineering Inc., hereafter referred to as Planmac, has been retained by the Municipality of Northern Bruce Peninsula, hereafter referred to as MNBP, to address operational issues associated with the Lion's Head Marina in Lion's Head, Ontario. This includes:

1. Undertake an operational assessment of the existing floating dock system in Lion's Head Marina at 1 Bruin St to determine if future commercial boats could be incorporated and if non-commercial boats could be better accommodated while maintaining appropriate boating maneuverability.

Planmac recommends actions be taken to better shelter the marina's floating dock system from the weather conditions that currently result in a great deal of damage to these docks. Changes should be made to the breakwater system to expand the sheltered area of the harbour to at least reduce the impact of existing issues. If these measures are put in place, it will address the cause of the majority of the operational issues associated with the current floating dock system.

Should the marina staff wish to assign an area of the existing floating docks to commercial vessels, we recommend slips 1, 3, 5 and 7 of Dock C. Should commercial activity in the marina grow beyond the berthing area provided by these four 30 ft slips, this commercial zone could be extended to the odd-numbered slips from 9 to 27 on Dock C. See Figure 0-1 for a diagram showing the location of these slips.

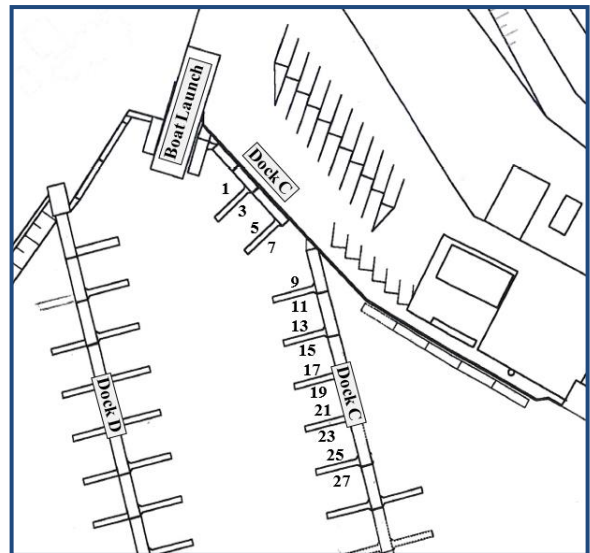


Figure 0-1: Proposed Location of Commercial Zone in Lion's Head Marina

2. Provide input and recommendations on stabilization of floating dock systems adjacent to large vessels with the intent to determine and provide input on a maximum vessel size that may be docked beside the Municipality's standard dock size while still ensuring dock stability and adequate maneuverability. We note that based on our site review, there are recurring dock breakages that are present due to wave action.

Planmac recommends that vessel size in the Lion's Head Marina is limited to the length of its slip's finger dock. This will improve maneuverability and avoid excess strain on docks. Until measures are taken to provide more sheltering from the extreme wind, waves and currents subjected to the marina during severe weather events, Planmac does not recommend the use of longer finger docks to accommodate larger boats. Larger vessels will exert stronger and more hazardous forces on the floating dock system, which already suffers heavy damage under existing conditions.

We also recommend that the existing floating dock system configuration be maintained until measures are taken to improve sheltering in the harbour. The weather conditions experienced in parts of this marina, such as Docks A and B, are very extreme, and will damage the floating docks regardless of their configuration unless improvements are made to the marina's breakwater.

3. Complete a condition assessment and loading review of the armour stone breakwater wall to determine alternative methods for the prevention of further deterioration, and (if necessary) improvements to its existing condition.

We recommend that the existing breakwater structure be removed, and, where possible, salvaged and rebuilt into a new armour stone breakwater structure. This new structure would be taller than the existing structure to more adequately shelter the marina from Lion's Head's strong winds, and would be longer to provide more protection from diffracted waves. The new structure would be built to the east of the existing structure to provide more useable space within the marina.

We also recommend that the Municipality give consideration toward the implementation of a concrete walkway along the lee-side of the new wall. While this will not have a significant structural effect on the wall, it will provide a safer environment for marina visitors wishing to capture photos with the site's iconic lighthouse and vistas.

4. Complete a visual condition assessment and theoretical structural loading review of the supporting slab and foundations under the Lion's Head Lighthouse. Provide recommendations on follow up works as necessary, and prepare a conceptual design for the repair and/or rebuilding of the lighthouse and its supporting slab.

The existing concrete slab supporting the Lion's Head Lighthouse has rotated and shifted due to erosion of fill materials. To remedy this, Planmac recommends the existing slab be demolished and replaced, with the addition of a protective sheet pile wall (as per Section 7.2.3.). This will provide long-term durability and strength to the lighthouse foundation.

5. Provide input on the existing capacity for parking at 1 Bruin St, and whether more parking spaces are required to accommodate the needs of individuals using the vessels moored in Lion's Head Marina.

The existing parking facilities at the Lion's Head Marina provide 80 parking spots, including 10 large spots designed to accommodate cars with boat trailers. Currently, since 164 of the marina's slips are in use by privately owned vessels, the demand for parking requires 163 spots, including 30 longer spots for boat trailers. Should all the marina's slips be put to use, a total of 203 parking spots are needed, including 30 longer spots for boat trailers. Therefore, the existing parking facilities at the Lion's Head Marina are inadequate.

1.0. INTRODUCTION

Planmac Engineering Inc., hereafter referred to as Planmac, has been retained by the Municipality of Northern Bruce Peninsula, hereafter referred to as MNBP, to address operational issues associated with the Lion's Head Marina in Lion's Head, Ontario. This includes:

1. Undertake an operational assessment of the existing floating dock system in Lion's Head Marina at 1 Bruin St to determine if future commercial boats could be incorporated and if non-commercial boats could be better accommodated while maintaining appropriate boating maneuverability;
2. Provide input and recommendations on stabilization of floating dock systems adjacent to large vessels with the intent to determine and provide input on a maximum vessel size that may be docked beside the Municipality's standard dock size while still ensuring dock stability and adequate maneuverability. We note that based on our site review, there are recurring dock breakages that are present due to wave action;
3. Complete a condition assessment and loading review of the armour stone breakwater wall to determine alternative methods for the prevention of further deterioration, and (if necessary) improvements to its existing condition;
4. Complete a visual condition assessment and theoretical structural loading review of the supporting slab and foundations under the Lion's Head Lighthouse. Provide recommendations on follow up works as necessary, and prepare a conceptual design for the repair and/or rebuilding of the lighthouse and its supporting slab; and
5. Provide input on the existing capacity for parking at 1 Bruin St, and whether more parking spaces are required to accommodate the needs of individuals using the vessels moored in Lion's Head Marina.

Planmac's President, Mike Neumann, P.Eng., and Percy Fulford, B.A.Sc., EIT, Project Coordinator and Junior Marine Engineer, visited the site on June 19, 2017 to conduct a brief site review of the Lion's Head Marina.

The purpose of this report is to provide MNBP with an operational assessment of Lion's Head Marina with background information and recommendations on the items listed above.

2.0. BACKGROUND INFORMATION

The following documents were made available to Planmac prior to the completion of this document, and are included as appendices to this document:

- Harbour Water Depths, measured on June 22, 2017;
- Lion's Head Harbour Asset Listing from Fisheries and Oceans Canada (DFO);
- Plan and Description of Lion's Head, ON, MGR Construction & Engineering, revised August 1974;
- Lion's Head Service Dock Repairs Drawings, Riggs Engineering, July 2013;
- Survey of Lion's Head Marina and its Floating Dock System, completed by SMC Geomatics in July, 2017.

3.0. EXISTING CONDITIONS

The Lion's Head Marina is located at 1 Bruin St, Lion's Head, Ontario, in the Municipality of Northern Bruce Peninsula. Lion's Head is a small community on the East side of the Bruce Peninsula. It overlooks

Georgian Bay, and is named for a limestone rock formation resembling a lion's head, which is visible from the marina. While the number of year-round residents is very low, the town's population rises each summer to anywhere from 1000 to 5000 people. The town was established in 1917 and is currently celebrating its 100th year. The marina shares the harbour in Lion's Head with private cottages, a campground, a park and a Harbourside Music stage for community events.

In past years, a limited few slips have been occupied by commercial boats, and there have been no commercial vessels in the marina for the past two years. All slips are currently used by private vessels. The marina provides parking facilities for boaters using these slips, which are shared with boaters using the marina's launch ramps, and with public engaged in other activities, such as trail hiking, kayaking, sightseeing and stargazing. An increasing demand for parking has put a strain on the marina's parking facilities.

3.1. Weather Conditions

While the location and positioning of Lion's Head on the Bruce Peninsula allows the marina to be partially sheltered from most weather, the harbour is extremely exposed to weather originating from the north/northeast. Storms originating from these directions can produce very large and strong waves, which build over a fetch of between 85 and 110 km before reaching the harbour. These conditions overpower the harbour's armour stone breakwater wall, and bring strong winds, high waves and lakebed materials into the marina. These weather events also produce hazardous currents through the harbour mouth. These storms have caused damage to the vessels in the marina, both in and out of the water, as well as the marina's facilities, including its parking facilities, floating docks, lighthouse and breakwater (see Figure 3-2, below). These storms hit the marina a few times per year, and have become a costly hazard.



Figure 3-1: Location of Lion's Head in the Municipality of Northern Bruce Peninsula



Figure 3-2: Weather and Damage During Storms at Lion's Head Marina

3.2. Marina Layout

The Lion's Head Marina consists of the following components (refer to Figure 3-3, below) and, where applicable, their Fisheries and Oceans Canada (DFO) asset numbers:

- | | |
|-----------------------------------|---|
| A. 'A' Dock (#803) | K. Government Wharf/Concrete Lighthouse Base (#401) |
| B. 'B' Dock (#804) | L. Concrete Wharf (#403) |
| C. 'C' Dock (#805) | M. Marina Buildings |
| D. 'D' Dock (#806) | N. Observation Deck |
| E. 'E' Dock (#807) | O. Fuel Pumps |
| F. 'F' Dock (#808) | P. Parking Area 1 |
| G. Boat Launch Ramp (#501) | Q. Parking Area 2 |
| H. Marina Crane and Service Dock | R. Parking Area 3 |
| I. Armour Stone Breakwater (#301) | |
| J. Lion's Head Lighthouse | |

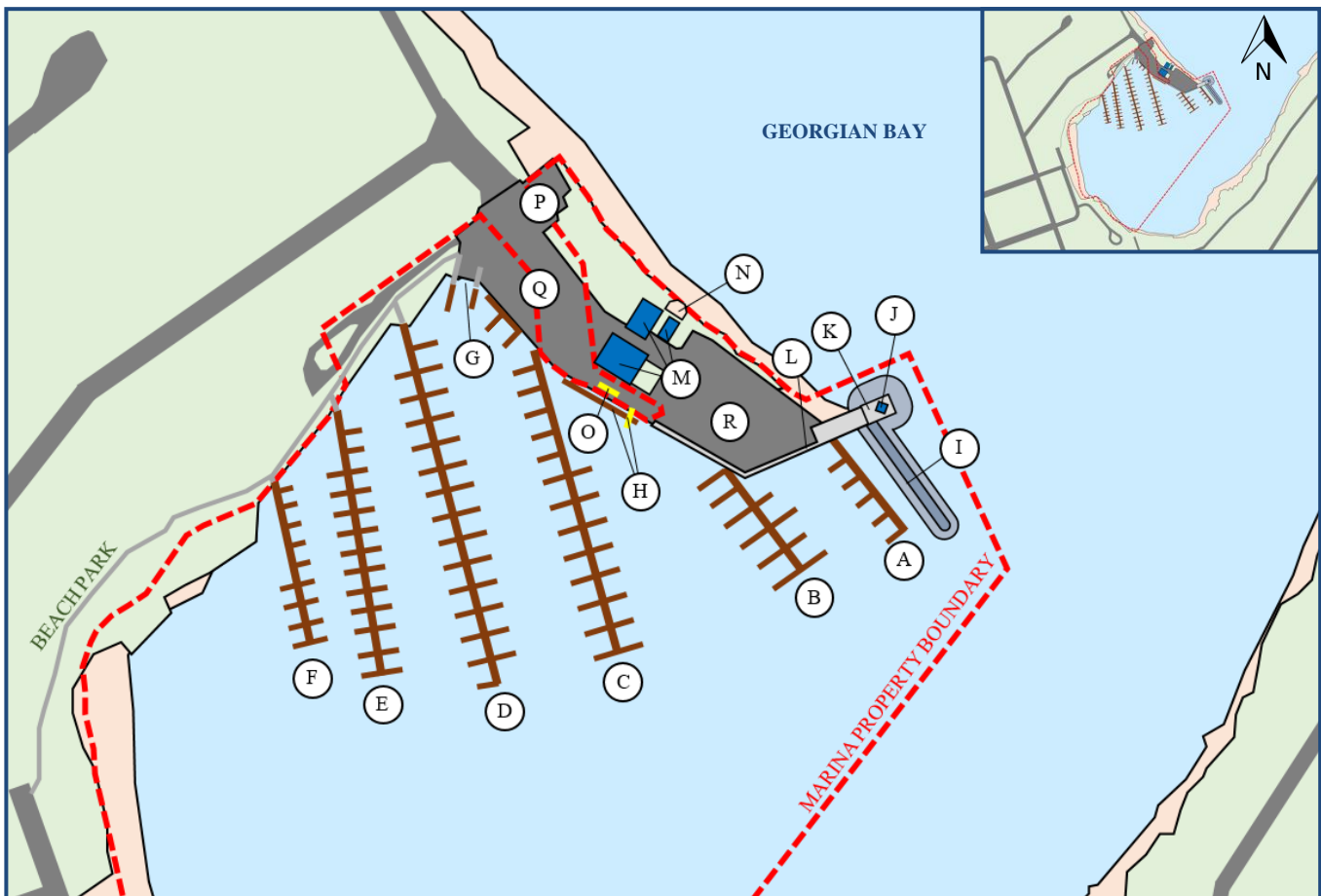


Figure 3-3: Lion's Head Marina Key Plan

4.0. OPERATIONAL ASSESSMENT OF FLOATING DOCKS

4.1. Existing Dock Configuration

The Lion's Head Marina is currently capable of hosting a total of about 208 vessels on its main docks (Docks A-F). Currently, about 164 of these are currently rented out, not including transient or overnight visitors. Historically, most vessels in the marina have been privately owned, with only some owned by businesses or used commercially. However, no commercial boats have been moored in this marina in the past two years.

Should commercial activities develop in the marina, Planmac recommends these vessels be assigned slips 1, 3, 5 and 7 of Dock C. These slips are located along harbour wall adjacent to the boat launch ramp, separate from the main length of Dock C. This area consists of four 30' slips on the two finger docks. Should commercial activities grow, this zone could be extended to slips 9 through 27 on Dock C. This is the portion of Dock C closest to the parking lot, where the dock's fingers only extend to the west. This area would be preferable for commercial vessels due to its proximity to the marina's buildings and parking facilities, and because it is located on slips near dock access ramps. This is important for commercial vessels with large passenger capacities, such as sight-seeing tour boats, as it encourages passengers to stay on land while waiting to board their vessel rather than queue on the narrow and less stable floating docks.

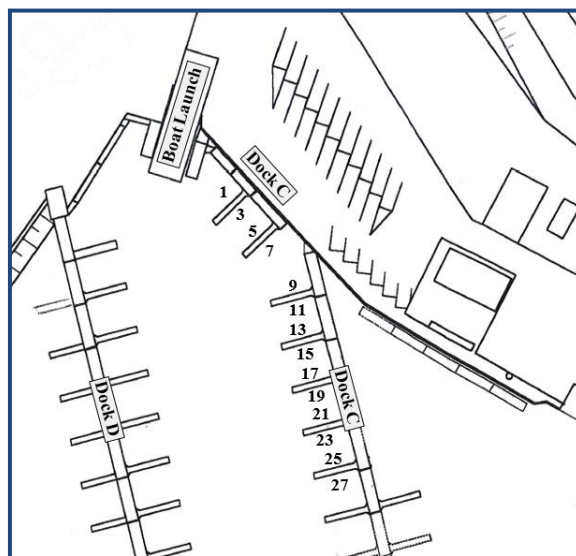


Figure 4-1: Proposed Location of Commercial Zone in Lion's Head Marina

4.2. Alternative Reconfigurations

The existing configuration has relatively few operational issues beyond those caused by the extreme exposure to severe weather conditions. If the floating docks were more sheltered from storm events, especially those with winds coming from the northeast, the existing layout would serve the marina, its other facilities and its customers well. However, the floating dock system's configuration with respect to the harbour mouth and breakwater results in a great deal of damage. The combination of high speed winds, large waves and strong currents result in the need for frequent and costly repairs to the docks' frames, connections and anchorage systems, as well as to harbour customers' vessels. Figure 6-2 on page 12 provides a contour map of wave height throughout the harbour during a typical storm event. This effect could be mitigated by moving slips and dock sections from Dock B and the ends of Docks A and C to other, safer areas of the harbour. However, it is likely that these hazardous weather effects will continue to damage the marina's floating dock system until steps are taken to provide better sheltering to the marina.

This section discusses various ways in which the floating dock system in the harbour could be reconfigured to address these existing operation issues. All alternative dock configurations consist of the same docks and fingers as those currently employed in the harbour. As a result, they provide the same number of slips as the existing layout. This is because not only are there currently vacant slips and therefore room for harbour growth, but also because extension of the docks the existing and proposed alternatives would mean placing docks in highly exposed areas.

4.2.1. Alternative 1



Figure 4-2: Dock Reconfiguration, Alternative 1

The first alternative dock reconfiguration involves moving Dock C to the west, next to Docks D-F, and rearranging the pieces of Docks A and B to form a new Dock B extending from marina wall south of the service docks, as well as a new Dock A running along the marina's south wall before extending out towards the southwest. See Figure 4-2, above, for a conceptual plan.

The key benefit of this layout is that it avoids placing floating dock sections in the area immediately behind the breakwater, which provides the least protection from waves during storms. The new Docks A and B could serve as a good candidate for a commercial zone of the harbour. Due to the new positioning of Dock C further west, Docks A and B are now the only docks accessed from the south parking lot, which could help to separate commercial/tourism parking from residential/private vessel parking. Also, in the existing layout, the public boat launch and service dock are accessed via different waterways, producing additional boat traffic in large areas of the harbour. In this scenario, these are both accessed via the space between Docks B and C, meaning this extra boat traffic would be limited to only one waterway.

The downsides of this layout include the need to rearrange many of the docks, which can be time-consuming and costly. This new arrangement also increases walking time for private/residential boaters from the parking areas. Docks C-F would be placed closer together, but this would not significantly affect maneuverability.

4.2.2. Alternative 2

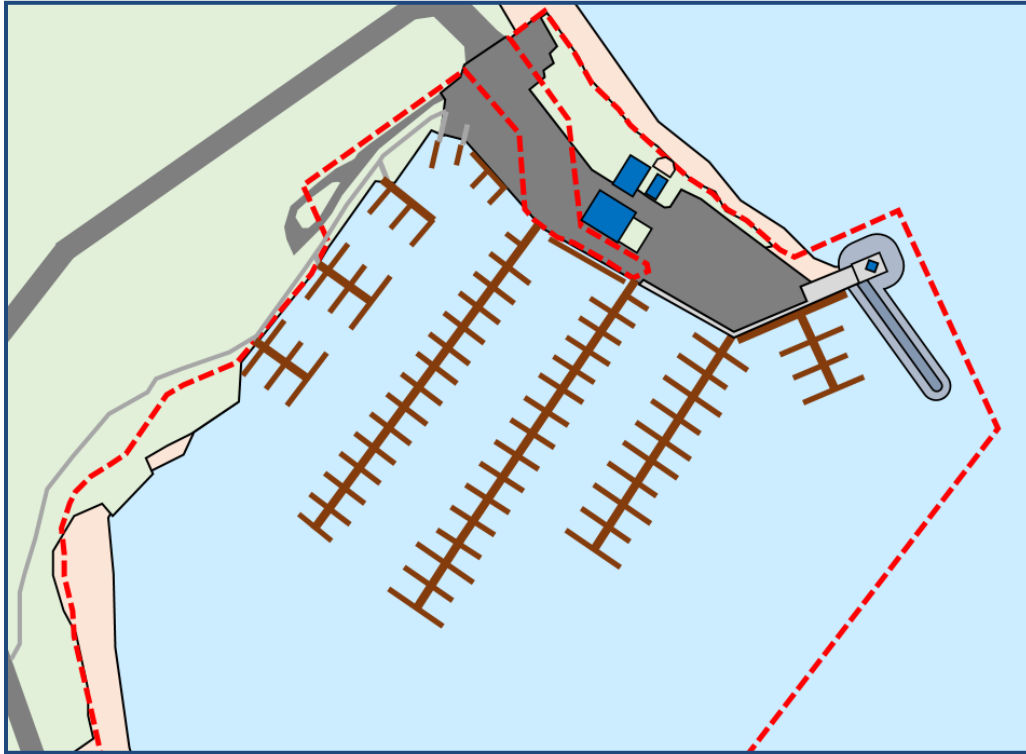


Figure 4-3: Dock Reconfiguration, Alternative 2

The second alternative reconfiguration involves rearranging the alignment of the docks to match that of the service docks and adjacent shoreline to the north. A new dock (new Dock C) can be added on the east side of the service docks. The existing Docks D-F (now Docks E-G) are shortened to become finger docks. See Figure 4-3, above, for a conceptual plan.

In this scenario, the new Dock G, the westernmost short dock, would be a good area for a commercial zone of the harbour. Because of its proximity to Beach Park and its various pedestrian accesses, this location is accessible from a number of areas in the town of Lion's Head. This would help to spread out parking to other lots in the town, easing the strain on the marina's existing parking lot facilities. If the number of commercial vessels in the harbour grows, the new Dock F, and if necessary Dock E, could be converted to commercial docks.

Benefits of this alternative include relocating Docks A and B to avoid the unprotected area behind the breakwater, providing immediate parking lot access to boat users from the parking lots to the vast majority of slips, and wide spacing between the docks, providing improved maneuverability. Drawbacks of this alternative include the need to rearrange many of the dock sections, the lack of direct access between the service dock to the boat launch, and the need for boats to travel further in the harbour on average to get to Georgian Bay from their slip.

4.2.3. Alternative 3

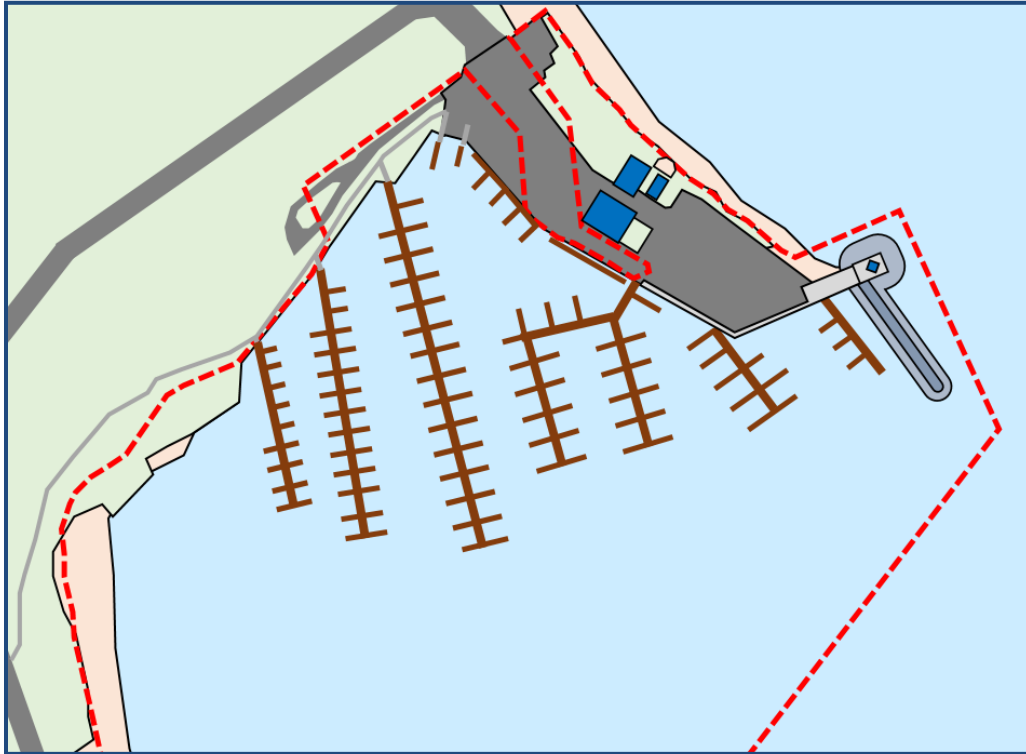


Figure 4-4: Dock Reconfiguration, Alternative 3

The third alternative reconfiguration primarily involves changes to Dock C. Its sections have been rearranged such that the new Dock C is accessed from a point immediately east of the service dock. This dock then branches into Dock C1, which extends southward, and Dock C2, which extends eastward before bending 90° to the south, after which it is aligned with Docks C2 and D. Docks A and B are shortened, and Docks D-F largely remain the same. See Figure 4-4, above, for a conceptual plan.

The docks between the boat launch and service dock, as well as the docks on the north edge of the new Dock C2, would be a good zone for commercial vessels in the harbour. Larger tour boats would have more room to maneuver and these docks would be immediately accessible from the parking areas.

There are a few benefits to this alternative. Firstly, less rearranging of the docks is involved, which will save time and money. Secondly, Docks A and B have been shortened to avoid the unsheltered area of the harbour. Thirdly, the public boat launch and service dock are accessible via the same waterway, which confines their boat traffic to just one area of the harbour.

One main drawback of this alternative is the lack of sheltering from the harbour's rough weather conditions. While Docks A and B have been shortened slightly, the existing issues with damage from weather conditions will largely continue. Another drawback is that at times when the public boat launch ramp, service dock, mast crane and fuel pumps are all in use, the area of the harbour between Docks C and D will become very congested.

4.3. Recommended Alternative

Out of the proposed alternatives, Planmac finds Alternative 3 to be the most preferable dock reconfiguration. This option involves the least amount of dock rearrangement whilst providing increases to maneuverability in the Lion's Head Marina, as well as a well-defined commercial area.

However, Planmac recommends actions be taken to better shelter the marina's floating dock system from the weather conditions that currently result in a great deal of damage to these docks. Changes should be made to the breakwater system to expand the sheltered area of the harbour to at least reduce the impact of existing issues. If these measures are put in place, it will address the cause of the majority of the operational issues associated with the current floating dock system.

Should the marina staff wish to assign an area of the existing floating docks to commercial vessels, we recommend slips 1, 3, 5 and 7 of Dock C. Should commercial activity in the marina grow beyond the berthing area provided by these four 30 ft slips, this commercial zone could be extended to the odd-numbered slips from 9 to 27 on Dock C. See Figure 4-1 on page 4 for a diagram showing the location of these slips.

5.0. STABILITY OF FLOATING DOCKS

5.1. Applied Loads

5.1.1. Wind and Wave Loads

The winds at Lion's Head Marina are excessive. Due to the lack of sheltering, boats and docks in the marina can be hit directly by storms with wind speeds exceeding 40 knots. The docks are also subjected to large waves during these storm events, which can exceed heights of 4 feet in the vicinity of Docks A and B. The combination of these forces comprise this harbour's critical loading conditions, as evidenced by the heavy damage sustained by the floating docks during storms.

5.1.2. Boat Sizing

Boat sizing affects dock stability in a number of ways. It plays a role in wind loading, as the surface area and shape of a hull affects the magnitude of wind loads pushing on dock sections. Larger boats with taller hulls, and therefore exert stronger forces on the docks. They also provide impact loads when mooring. However, the size of boats moored in Lion's Head Marina most greatly affects the maneuverability of vessels through the floating dock system. While the lengths of the majority of vessels are in the 18 ft to 22 ft range, many boats exceed the length of their slips, meaning boats stick out into the waterways between docks, limiting the space required for other boats to travel through the harbour.

5.2. Anchoring Methods

Based on the layout of the docks, Planmac proposes that one or more of the following anchoring methods be used for Lion's Head Marina's floating dock system.

5.2.1. Deadman Anchors

Deadman anchors are a very common anchoring method. They employ heavy 'deadman' weights, which are secured to the docks with a chain (see *Figure 6.1*). This method is generally used in sheltered water with a depth of 4 feet or more. To obtain optimal lateral stability, the length of the chain is approximately 2 to 3 times the depth of the water. When designing the weight of these anchors, it is important to take into account the buoyancy of various materials. Concrete, for example, weighs only 57% as much when underwater than it does on dry land.

This is the current anchoring method used for Lion's Head Marina's floating dock system. Every other floating dock section in the Lion's Head Marina are secured by two (2) 1-tonne concrete weights. The concrete weights are connected to the dock sections via chains which are angled at about 30° from horizontal.

There are a number of benefits to using this anchoring system. First of all, this method is much less expensive than alternative methods, as it requires very few specialized materials and can usually be installed without heavy equipment. This method is also very adjustable compared to other techniques. The deadman weights can be easily relocated or adjusted to adapt to changing water levels.

However, compared to the other methods listed in this report, deadman anchors are the least stable. As the weights are not driven or dug into the waterbed, they can be moved or shifted by much smaller forces than those required to move soil anchors or piles. The stability of deadman anchors depends on the size of the weights used, where heavier weights result in increased stability, as well as the type and quality of the soil at the surface of the waterbed, where siltier, clay soils provide less support than sandier soils.

5.2.2. Soil Anchors

Soil anchors work similarly to deadman anchors in that they are attached to the floating docks via angled chains. However, rather than providing stability through weight, soil anchors are buried into the harbour bed.

This method provides more holding strength than the deadman anchoring method. Whereas deadman weights are prone to lifting and sliding along the waterbed, soil anchors use the weight and cohesion of the soil to resist these forces. The strength of soil anchors is affected by the depth at which it is buried, the size of the anchor, and the properties of the soil.

The disadvantages of using soil anchors include higher costs than deadman anchors, as well as increased difficulty of implementation. Also, once put into place, soil anchors are hard to shift or relocate without being dug out of the ground, which is also very costly. However, once implemented, small adjustments can be made to the length of the chains which attach them to the docks in order to account for changes in water level or small adjustments to the positioning of the floating docks.

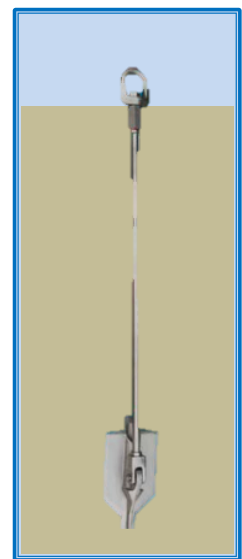


Figure 5.2: Soil Anchor

5.2.3. Pile Anchors

The pile anchoring method involves securing the floating dock sections to structural piles that are driven deep into the waterbed, or drilled into bedrock. In this method, the floating docks are typically attached directly to the pile anchors, as shown in *Figure 6.3*.

Of the three anchoring methods listed in this section, this method provides the most stability. If properly designed and braced, pile anchors could support very large vessels in Lion's Head Marina. Also, since the floating docks are attached directly to the piles, they experience limited lateral displacement when compared to the methods above which use chains. This connection only allows for vertical movement, to account for changes in water level.

However, this method is also the most expensive out of the three listed. Even after implementation, removing, cutting or relocating the piles is also very expensive. While Planmac has not been provided with site-specific geotechnical information, we know that the geology of the Bruce Peninsula area consists primarily of limestone, so securing new piles into the bed of Lion's Head Marina could be difficult and expensive.

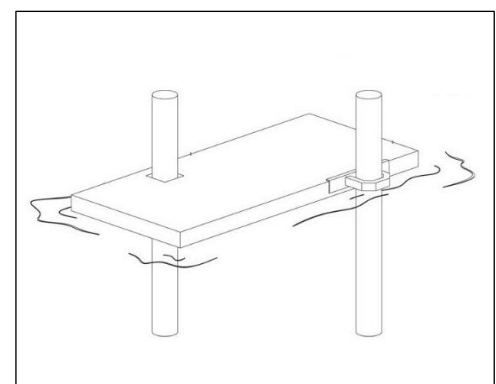


Figure 5.3: Pile Anchoring Method

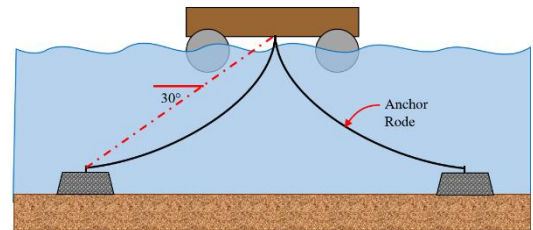


Figure 5.1: Deadman Anchoring Method

5.2.4. Adequacy of the Existing Anchoring Method

As mentioned in section 5.2.1, above, the floating docks in the Lion's Head Marina are concrete deadweight anchors. For the most part, these anchors are capable of holding their docks in place. However, due to the extreme and severe weather conditions acting on the floating dock system, the floating dock system fails. Planmac does not believe, however, that the failure of the docks during storms is a result of the anchoring method. The docks are subjected to such large forces during these events that if a stronger anchor were able to hold the docks in place, they would simply fall apart and detach. While past storms have caused anchors to shift and move, they have also caused welded steel joints to tear apart and anchor rodes to snap.

5.3. Recommendations

Planmac recommends that vessel size in the Lion's Head Marina is limited to the length of its slip's finger dock. This will improve maneuverability and avoid excess strain on docks. Until measures are taken to provide more sheltering from the extreme wind, waves and currents subjected to the marina during severe weather events, Planmac does not recommend the use of longer finger docks to accommodate larger boats. Larger vessels will exert stronger and more hazardous forces on the floating dock system, which already suffers heavy damage under existing conditions.

We also recommend that the existing floating dock system configuration be maintained until measures are taken to improve sheltering in the harbour. The weather conditions experienced in parts of this marina, such as Docks A and B, are very extreme, and will damage the floating docks regardless of their configuration unless improvements are made to the marina's breakwater.

6.0. BREAKWATER CONDITION ASSESSMENT

6.1. Existing Condition of Breakwater

We understand from our meeting and site review on June 19, 2017 that there is a potential concern with the current condition of the armour stone breakwater wall that extends into the harbour mouth. The Municipality would like input and advice on methods for the prevention of further deterioration and, if required, improvements to the condition of the breakwater wall.

6.2. Breakwater Improvement Alternatives

Improvements to the harbour's breakwater can be broken into three main actions:

6.2.1. Repair of the Existing Breakwater Structure

This would be the cheapest option, but also the least durable. Rubble mound breakwaters work well when secured on a base of smaller, finer, fill materials, on which sits a layer of mid-size rocks, capped off by large armour stones. The existing breakwater's armour stones largely remain, but since the foundation of smaller, finer stones they once sat on has been washed out, the armour stones are now slipping and displacing. Restoring the foundation by replenishing fill and mid-size stones through the gaps of the breakwater wall would cost much less than other alternatives, but this fix would be short-lived and would not restore the strength it once had.

6.2.2. Replace Existing Breakwater with Identical Structure

Replacing the existing breakwater wall with a new, identical structure would be more expensive, but would last much longer. The existing harbour wall served the marina for many decades before its condition started to deteriorate. A similar longevity could be expected from a replacement. However, this would do little to remedy the many issues in the harbour caused by lack of sheltering from extreme weather

conditions. Unless changes are made to the breakwater structure, these issues will continue to cause costly damage to the marina.

6.2.3. Removing Existing Breakwater and Building New Breakwater Structure

While this option may be the most expensive, its cost is comparable to replacing the breakwater with an identical structure. If properly designed, it will also greatly reduce the cost resulting from damage to the marina's facilities that result from exposure to harsh weather conditions.

There are many factors to consider when choosing a new breakwater structure:

Breakwater Type

The type of breakwater structure implemented depends largely on the weather conditions, but also on operational considerations. Types of breakwater structure include vertical sea walls, floating offshore breakwaters and curved breakwater walls. However, the most durable type under the extreme conditions experienced at Lion's Head is a rubble mound breakwater. This is the same type of breakwater as the existing structure, consisting of layers of rocks and fill of varying size. However, this breakwater method can be altered to suit the needs of the harbour, and can be built with armour stone all around, with a concrete walkway on the lee side, or as a composite of a rubble mound and concrete vertical wall, as shown in Diagrams A, B and C of Figure 6-1, respectively. A concrete walkway would provide a safe area from which Lion's Head visitors could photograph the iconic lighthouse, without the dangers associated with climbing across armour stone. A composite mound-vertical wall could provide a solid wharf on which larger vessels could be moored, increasing the useable mooring space of the harbour. The concrete components of these types of breakwater structures provide more utility, but add to the cost of the wall's construction as well as its design. Other types, such as partial depth or pneumatic breakwaters could also be considered.

Breakwater Size

Larger breakwaters cost more, but provide much more protection. Longer breakwaters provide more protection from waves to the area behind them, as waves must diffract more, thus reducing their energy. Taller breakwaters provide more sheltering from wind, as well as from waves transmitted through the structures, since taller breakwater mounds must also be wider to maintain the necessary slope.

Location and Configuration

Although the area of the harbour currently occupied by Dock A and Dock B is behind the breakwater wall, it still experiences very rough conditions during storms. While some larger waves are able to overtop the wall, most of the damage is caused by the proximity of the end of the wall to these docks. Because of its positioning, the wall is not able to properly diffract and de-power the waves before they hit enter this area. Instead, it diffracts large and high-powered waves directly into the harbour wall, which reflects the waves back into the area, causing even larger waves. For a contour map of wave heights within the marina's property limits during typical storm events, expressed in fractions of incident wave height, see Figure 6-2, below. This diagram is representative of the height, period and speed of waves observed in on-site footage

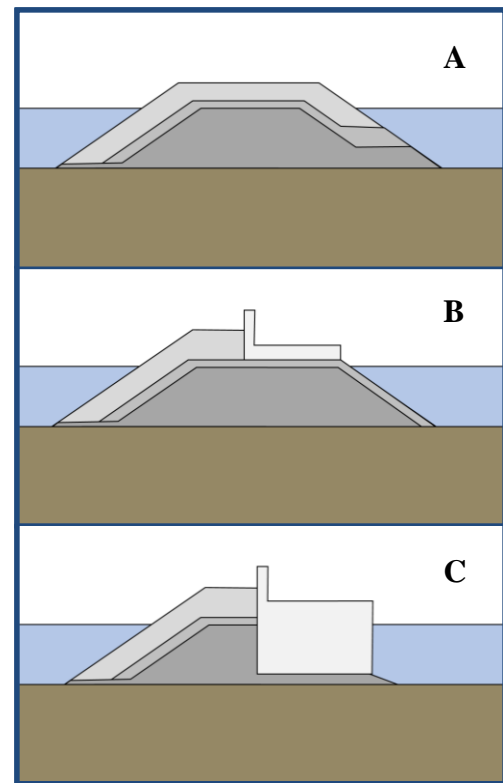


Figure 6-1: Breakwater Types – A) Rubble Mound Breakwater, B) Rubble Mound Breakwater with Concrete Walkway, C) Composite Rubble Mound/Concrete Vertical Wall Breakwater

and data taken during storm events and provided by marina staff. The results of this wave diffraction modeling demonstrate why the outermost fingers of Dock A and the last segment of Dock B often sustain the heaviest damage during extreme weather events.

These results can be improved through realigning and repositioning the breakwater structure. The structure's angle of incidence with the waves has a great affect on the strength and path of diffracted waves within the harbour. Also, increasing the distance between a point in the harbour and the edge of the breakwater will decrease the size and strength of the waves. Another consideration is that if a new breakwater structure were built to the east of the existing armour stone wall, it could be extended northward to provide additional protection to other exposed regions of the marina, such as the lighthouse base, the beach, and the parking area south of the marina buildings.

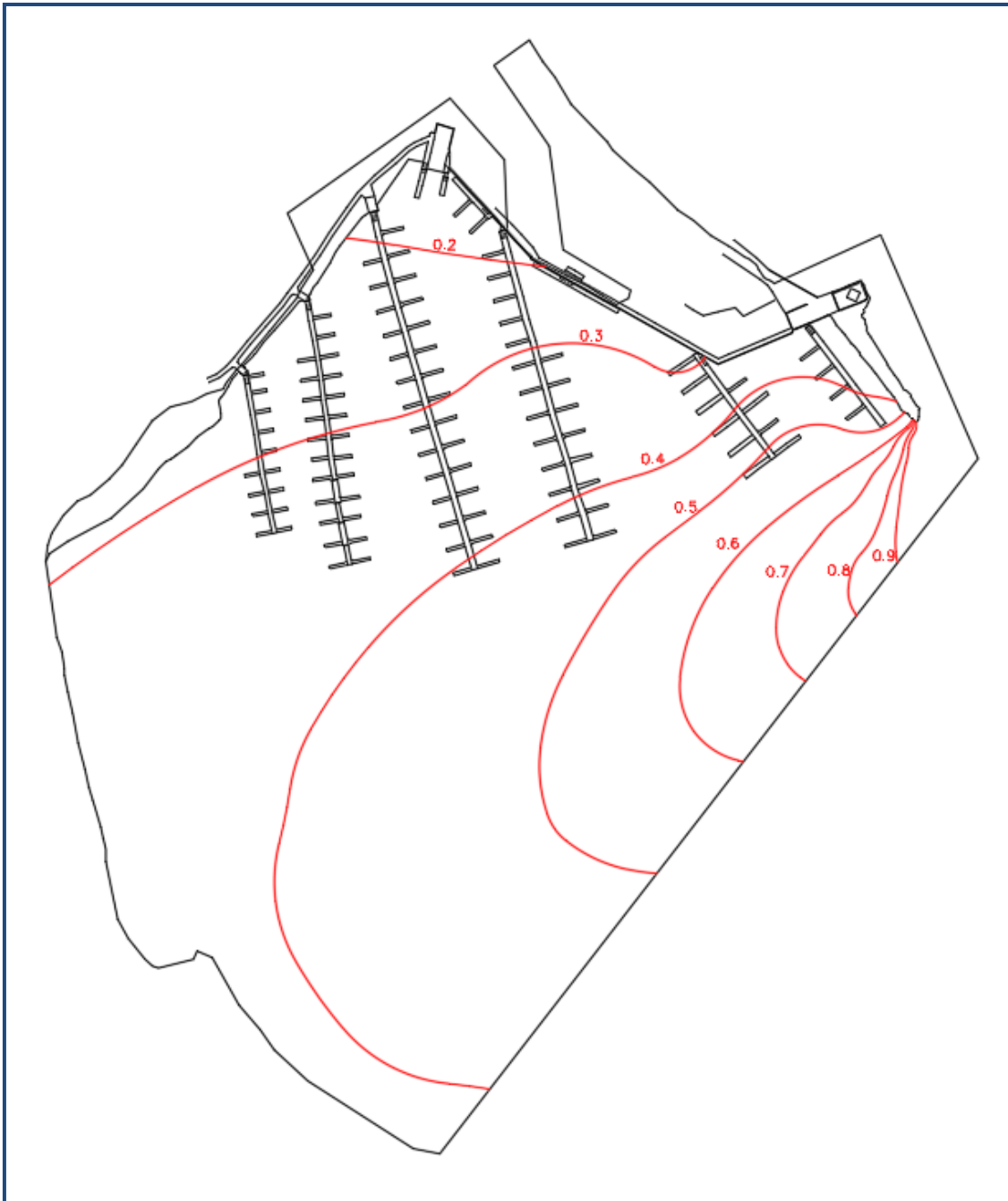


Figure 6-2: Contour Map of Wave Heights During Typical Storm Events

6.3. Summary and Recommendations

We recommend that the existing breakwater structure be removed, and, where possible, salvaged and rebuilt into a new armour stone breakwater structure. This new structure would be taller than the existing structure to more adequately shelter the marina from Lion's Head's strong winds, and would be longer to provide more protection from diffracted waves. The new structure would be built to the east of the existing structure to provide more useable space within the marina.

We also recommend that the Municipality give consideration toward the implementation of a concrete walkway along the lee-side of the new wall. While this will not have a significant structural effect on the wall, it will provide a safer environment for marina visitors wishing to capture photos with the site's iconic lighthouse and vistas.

7.0. LIGHTHOUSE FOUNDATION CONDITION ASSESSMENT

7.1. Existing Condition of the Concrete Lighthouse Foundation

At the site meeting, we observed an elevation gap that had developed between the marina pier and walkway and the concrete slab supporting the Lion's Head Lighthouse (see Figure 7-1 for top and side view of separation). The lighthouse base has risen when compared to the concrete wharf, and has also shifted to the east, away from the wharf. Water is visible in the gap produced between the two concrete structures, and waves coming in from Georgian Bay can be seen to continue through this gap, toward the armour stone breakwater structure on the south side. The slab's other edges are protected by armour stone. This stone barrier has deteriorated slightly, to a similar degree as the neighbouring breakwater structure. The lighthouse base was originally poured onto rocks and fill material, which has washed out, creating a void underneath. This has caused the slab to rotate and slant to the east.

7.2. Lighthouse Foundation Improvement Alternatives

7.2.1. Option 1: Cementitious Grout

This option involves boring holes through the slab, through which cementitious grout would be injected. This would fill the voids under the slab that have caused it to displace, and would help prevent further deterioration.

This is the cheapest option for the improvement of the slab. It would provide the required additional stability, and would last for decades. However, this option would not provide any remedy to the current displacement, only prevent further deterioration.

To prevent further erosion of the foundation materials which would cause new voids to develop, replenishment of the armour stone protection would be required as part of this option.

7.2.2. Option 2: Slab Replacement

This option involves the removal and replacement of the existing slab. After demolishing the existing slab, granular fill materials would be added to the



Figure 7-1: Separation of Concrete Lighthouse Base Slab from Concrete Wharf

base to replenish the fill that has been washed away. Once the granular base is refilled and compacted, the new concrete slab would be poured directly onto it. Similarly to Option 1, the armour stone protection would need repair as part of this work in order to prevent future deterioration.

This work would be provide more strength and durability than Option 1. However, it would be much costlier, and would take longer to implement. Another factor to consider is that the lighthouse currently serves as a major tourist destination in Lion's Head. If this option is chosen, Planmac recommends that work be done outside of the busy summer months if possible to mitigate this, as well as to mitigate adverse effects to marina operations. A temporary beacon should be installed during construction to help boats navigate until the lighthouse is reinstated.

In order to remove the slab, the lighthouse would first have to be relocated from the site. We understand from our site meeting on June 19, 2017 that the existing lighthouse was originally a replica, that was relocated to the harbour when the real lighthouse was destroyed. It should therefore be quite feasible to relocate it once more.

7.2.3. Option 3: Foundation Protection Improvements

This option is similar to Option 2 in that it involves the demolition of the existing slab and temporary relocation of the lighthouse. However, in this option, a sheet pile wall would be built around the new slab to better protect the fill material in its foundation from future deterioration.

This would be costlier than Option 2, but would provide more durability and strength against the extreme weather conditions present at this site. The existing armour stone could be salvaged and used to repair/replace the existing breakwater.

7.3. Summary and Recommendations

The existing concrete slab supporting the Lion's Head Lighthouse has rotated and shifted due to erosion of fill materials. To remedy this, Planmac recommends the existing slab be demolished and replaced, with the addition of a protective sheet pile wall (as per Section 7.2.3.). This will provide long-term durability and strength to the lighthouse foundation.

8.0. ADEQUACY OF VEHICLE PARKING RESOURCES

8.1. Existing Parking Facilities

The marina's parking lot currently consist of 70 parking spots. One of these spots, located immediately south of the marina building, is a 'Type A' van-accessible parking spot, which is about 3.4 m wide. An additional two of these spots, located just north of the marina building, are 'Type B' accessible parking spots. These are regular-sized spots, but are designated to people with accessible parking permits. This is consistent with the accessible parking requirements for a lot of this size. In addition to these vehicle parking spots, there are 10 truck-trailer parking spaces, which are longer to accommodate vehicles towing boat trailers for the public boat launch. The trailer parking spots are located near the marina's boat launch to avoid unnecessary maneuvering through the facility. Increases in parking demand from marina visitors who do not own or use boats moored in the marinas slips, such as sightseers, trail hikers and stargazers, have put strain on the marina's existing parking facilities. As a result, some paying seasonal and transient recreational boaters are not able to find parking.

8.2. Demand for Parking Facilities

There are many variables that affect the demand for parking facilities in the Lion's Head Marina. These can be broken down into: private slips, commercial slips, marina staff, boat launches and tourism/public interest.

People using an average private slip will usually require 1-2 parking spaces, depending on the size. However, it is unlikely that, at any given time, they will all simultaneously be in use. On busy days, such as public holidays or celebrations, harbours typically require 3 spaces for every 5 slips in use. There are currently 208 slips, and at the time of this report, 164 of these are in use, not including slips occupied by transient or overnight visitors. All of these slips are currently occupied by privately owned vessels, so the demand for parking from private slips is about 99 parking spots. If all the marina's slips were occupied by privately owned vessels, the demand for parking from private slips would be about 125 parking spots.



Figure 8-1: Parking Facilities at the Lion's Head Marina.
**Please note that this satellite image is out of date and the marina parking layout has since been rearranged slightly.*

Commercial slips can be more complicated, as the demand for parking spaces depends greatly on the use and size of the boat. For charter boats, 1 parking space is recommended for every 3 persons of the charter boat's capacity. There are currently no commercial vessels moored in the Lion's Head Marina, so there is no demand for parking from commercial slips. However, should slips 1, 3, 5 and 7 of Dock C be assigned to commercial vessels in future years, as discussed in Section 4 of this report, and should they be occupied by charter boats with an average capacity of 12 people, the demand for parking from commercial slips is about 16 parking spots. Commercial slips have a higher parking demand than private slips, so any increases commercial activities would increase the existing strain on the marina's parking facilities.

Marina staff members typically require 1 parking space per 2 employees. The Lion's Head Marina employs about 8 people, so the demand for parking from staff is currently about 4 parking spots.

To get the most use out of a public self-launch boat ramp, a minimum of 20 spots is required per launching lane. Of these, 15 should be designed to accommodate boat trailers. The public self-launch ramp at the Lion's Head Marina has 2 lanes, so the demand for parking from the boat launch is 40 parking spots, including 10 regular parking spots and 30 large parking spots designed to accommodate boat trailers.

The Lion's Head Marina and the neighbouring Beach Park host a number of events open to the public. On top of this, the marina has become a popular tourist destination, and many people visit the marina solely to take a dip in Georgian Bay, do some fishing off the end of the wharf, stargaze from the beach, go for a hike, enjoy a relaxing trip in a kayak, or to appreciate the sights such as the Lion's Head Lighthouse and the surrounding scenery. The affect of tourism and public interest on the parking facilities has increased significantly over the years since the parking facilities were initially designed. As a result, the marina's parking spaces can be filled before marina customers using the harbour's slips even arrive for the boating season. This group would increase the demand for parking at the marina by at least 20 parking spots.

8.3. Adequacy of Existing Parking Facilities

The existing parking facilities at the Lion's Head Marina provide 80 parking spots, including:

- 67 regular parking spots;
- 1 Type A accessible spot;
- 2 Type B accessible spots;

- 10 large spots designed to accommodate cars with boat trailers.

Currently, 164 of the marina's slips are in use, and all are occupied by private vessels. Therefore, the demand for parking in the marina is 163 parking spots, including:

- 128 regular parking spots (+61);
- 2 Type A accessible spot (+1);
- 3 Type B accessible spots (+1);
- 30 large spots designed to accommodate cars with boat trailers (+20).

If the marina intends to occupy all 208 of its slips, and 4 of these slips were used commercially, as discussed in Section 8.2 of this report, the demand for parking in the marina is 203 parking spots, including:

- 167 regular parking spots (+100);
- 3 Type A accessible spot (+2);
- 3 Type B accessible spots (+1);
- 30 large spots designed to accommodate cars with boat trailers (+20).

Therefore, the existing parking facilities at the Lion's Head Marina are inadequate. Note that should a larger portion of the slips be used commercially, the demand for parking will increase.

9.0. SUMMARY AND RECOMMENDATIONS

In this report, Planmac has addressed operational issues associated with the Lion's Head Marina in Lion's Head, Ontario. These include:

1. Undertake an operational assessment of the existing floating dock system in Lion's Head Marina at 1 Bruin St to determine if future commercial boats could be incorporated and if non-commercial boats could be better accommodated while maintaining appropriate boating maneuverability;

Planmac recommends actions be taken to better shelter the marina's floating dock system from the weather conditions that currently result in a great deal of damage to these docks. Changes should be made to the breakwater system to expand the sheltered area of the harbour to at least reduce the impact of existing issues. If these measures are put in place, it will address the cause of the majority of the operational issues associated with the current floating dock system.

Should the marina staff wish to assign an area of the existing floating docks to commercial vessels, we recommend slips 1, 3, 5 and 7 of Dock C. Should commercial activity in the marina grow beyond the berthing area provided by these four 30 ft slips, this commercial zone could be extended to the odd-numbered slips from 9 to 27 on Dock C. See Figure 4-1 on page 4 for a diagram showing the location of these slips.

2. Provide input and recommendations on stabilization of floating dock systems adjacent to large vessels with the intent to determine and provide input on a maximum vessel size that may be docked beside the Municipality's standard dock size while still ensuring dock stability and adequate maneuverability. We note that based on our site review, there are recurring dock breakages that are present due to wave action;

Planmac recommends that vessel size in the Lion's Head Marina is limited to the length of its slip's finger dock. This will improve maneuverability and avoid excess strain on docks. Until measures are taken to provide more sheltering from the extreme wind, waves and currents subjected to the marina during severe weather events, Planmac does not recommend the use of longer finger docks to accommodate larger boats. Larger vessels will exert stronger and more hazardous forces on the floating dock system, which already suffers heavy damage under existing conditions.

We also recommend that the existing floating dock system configuration be maintained until measures are taken to improve sheltering in the harbour. The weather conditions experienced in parts of this marina, such as Docks A and B, are very extreme, and will damage the floating docks regardless of their configuration unless improvements are made to the marina's breakwater.

3. Complete a condition assessment and loading review of the armour stone breakwater wall to determine alternative methods for the prevention of further deterioration, and (if necessary) improvements to its existing condition;

We recommend that the existing breakwater structure be removed, and, where possible, salvaged and rebuilt into a new armour stone breakwater structure. This new structure would be taller than the existing structure to more adequately shelter the marina from Lion's Head's strong winds, and would be longer to provide more protection from diffracted waves. The new structure would be built to the east of the existing structure to provide more useable space within the marina.

We also recommend that the Municipality give consideration toward the implementation of a concrete walkway along the lee-side of the new wall. While this will not have a significant structural effect on the wall, it will provide a safer environment for marina visitors wishing to capture photos with the site's iconic lighthouse and vistas.

4. Complete a visual condition assessment and theoretical structural loading review of the supporting slab and foundations under the Lion's Head Lighthouse. Provide recommendations on follow up works as necessary, and prepare a conceptual design for the repair and/or rebuilding of the lighthouse and its supporting slab;

The existing concrete slab supporting the Lion's Head Lighthouse has rotated and shifted due to erosion of fill materials. To remedy this, Planmac recommends the existing slab be demolished and replaced, with the addition of a protective sheet pile wall (as per Section 7.2.3.). This will provide long-term durability and strength to the lighthouse foundation.

5. Provide input on the existing capacity for parking at 1 Bruin St, and whether more parking spaces are required to accommodate the needs of individuals using the vessels moored in Lion's Head Marina.

The existing parking facilities at the Lion's Head Marina provide 80 parking spots, including 10 large spots designed to accommodate cars with boat trailers. Currently, since 164 of the marina's slips are in use by privately owned vessels, the demand for parking requires 163 spots, including 30 longer spots for boat trailers. Should all the marina's slips be put to use, a total of 203 parking spots are needed, including 30 longer spots for boat trailers. Therefore, the existing parking facilities at the Lion's Head Marina are inadequate.

We trust that the information presented within this report is sufficient for the purpose of this Operational Assessment Report. If you have any questions concerning this report, please feel free to contact the undersigned.

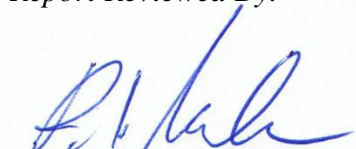
Yours Truly,

PLANMAC ENGINEERING

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