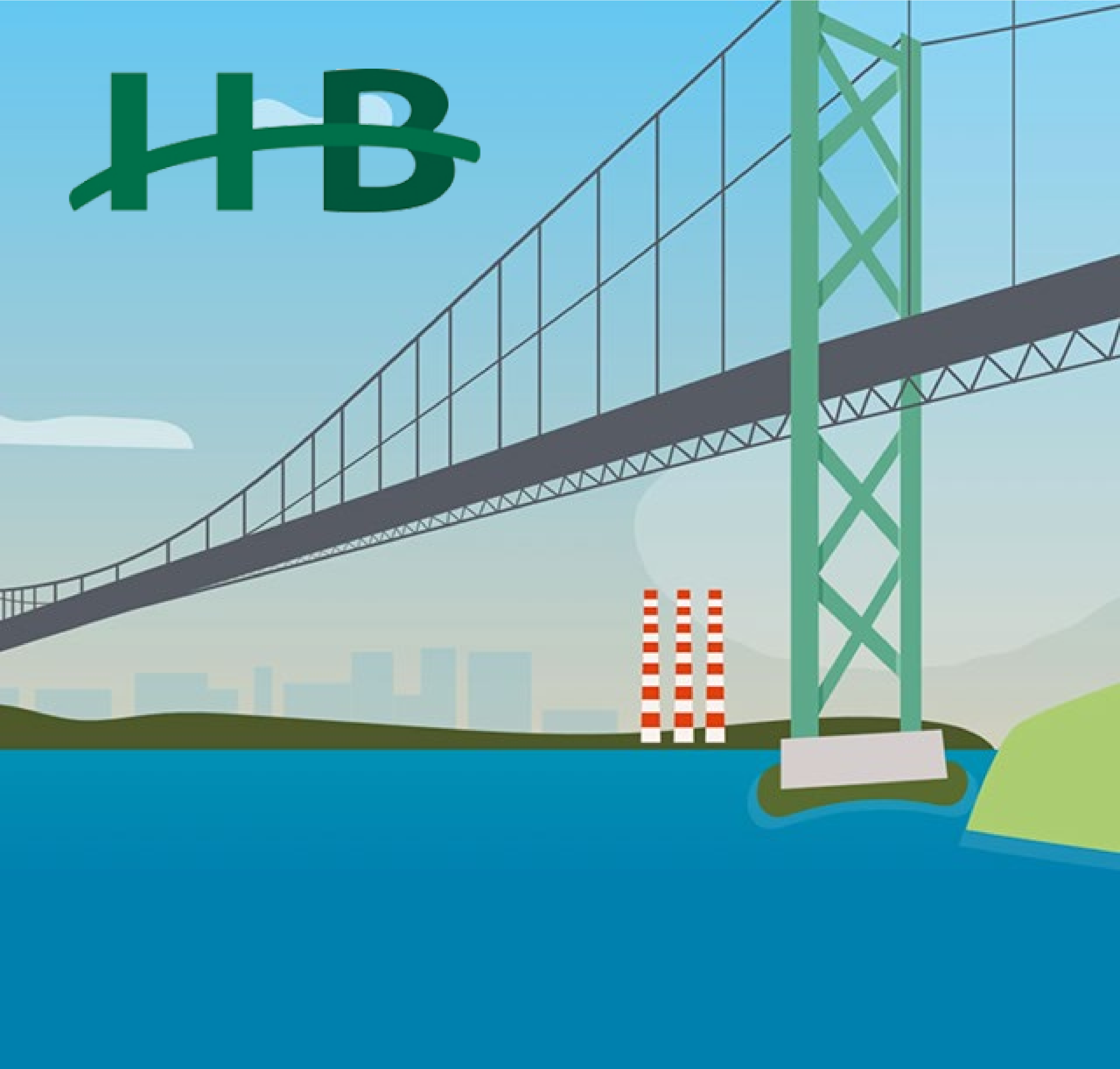


2021 TEN YEAR PLAN

HALIFAX HARBOUR BRIDGES

TABLE OF CONTENTS

INTRODUCTION

Halifax Harbour Bridges (HHB) owns, operates, and maintains multiple bridges/structures in the Halifax area. These are critical infrastructure links for Nova Scotia's transportation network with over 100,000 crossings each weekday (pre-pandemic). The inventory includes the A. Murray MacKay suspension bridge, the Angus L. Macdonald suspension bridge, ancillary structures, and the approach roadways adjacent to the suspension bridges. Figure 1 provides a map of the location of each of HHB's structures.

The NSURB approves toll rates proposed by HHB. In late 2021, it approved a toll increase that has allowed the organization to embark on an aggressive 10-year $285 million capital, maintenance and rehabilitation plan.

Figure 1 Map showing the locations of all HHB Structures

1	Mackay Bridge	6	Canadian National Railway Overpass
2	Macdonald bridge	7	Windmill Road Overpass
3	Halifax Approach Retaining Wall	8	Victoria Road Overpass
4	Baffin Boulevard Retaining Wall	9	Barrington Street Ramp
5	Princess Margaret Overpass		

HISTORY

Halifax Harbour Bridges (HHB) manages and maintains the critical cross Harbour infrastructure that allows Halifax to be the preeminent economic centre in Atlantic Canada.

Created by provincial statute in 1950, HHB is a dynamic self-supporting entity that operates two toll bridges, the 1.3-kilometre Angus L Macdonald Bridge and the 1.2-kilometre A. Murray MacKay Bridge. Together these critical pieces of infrastructure facilitate 105,000 vehicle crossing each weekday.

On April 2, 1955, the Angus L. Macdonald Bridge opened and the communities of Halifax and Dartmouth were united for the first time with an efficient transportation link that provided 24/7 access across the Halifax harbour.

The Macdonald Bridge was named after former Nova Scotia Premier Mr. Angus Lewis Macdonald. He served as the Liberal premier of Nova Scotia from 1933 to 1940 when he became the federal minister of defense for naval services. The Macdonald Bridge was converted from a two-lane to a three-lane structure with a pedestrian walkway and bicycle lane in 1999. In 2005, the Halifax Harbour Bridges (HHB) celebrated the 50th Anniversary of the Macdonald Bridge. There are approximately 48,000 crossings on the Macdonald Bridge on an average workday. The Macdonald Bridge has a reversible centre lane. In the morning, there are two lanes to Halifax. At noon, it switches and there are two lanes to Dartmouth and one to Halifax.

The opening of the A. Murray MacKay Bridge on July 10, 1970 was another historic event for Halifax Dartmouth Bridge Commission. The opening of the MacKay Bridge drew international interest due to its design and the engineering techniques that were applied to its construction for the first time in North America.

HHB has 50-full time employees, and contracts with Commissionaires Nova Scotia for another 50 workers who provide bridge patrol, emergency service, and toll booth operations.

The safety of employees and bridge users is at the heart of HHB's operation. It is the first consideration in all planning, maintenance and repair efforts.

A future-focused organization, HHB is committed to looking both globally and locally to find innovative and sustainable solutions to engineering and service delivery challenges. It is similarly committed to offering world-class customer service to bridge users.

AUTHORITY COMPOSITION

As a commission of the provincial government, HHB is governed by a board of nine commissioners and reports to the provincial Minister of Public Works.

The governing board is composed of five commissioners appointed by the Province of Nova Scotia, and four by Halifax Regional Municipality.

10-YEAR RENEWAL AND REPLACEMENT PLAN

Halifax Harbour Bridges (HHB) originally developed a 10-year plan for the Nova Scotia Utility and Review Board to support its proposed increase in tolls from $1.00 to $1.25 (cash) and a $0.20 increase for MACPASS transponder users. Since then the ten-year plan has played a vital part in the long-term management of the physical assets owned by HHB. The report details planned capital improvements with associated estimates of construction, engineering, maintenance, and inspection costs. The items found in this report have been derived using historical inspection data and on-going discussions with HHB's engineering consulting firms.

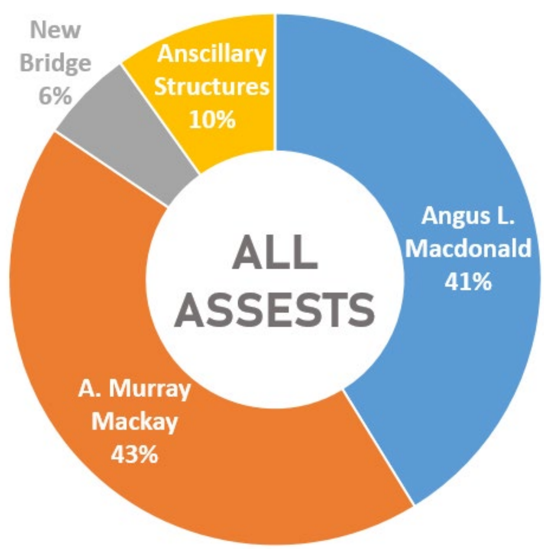
As explained further in the report, a majority of the focus within the next 10 years is placed on the Macdonald Bridge. In 2017, a major works project now referred to as "The Big Lift" replaced the entire Suspended Deck of the Macdonald. This extended the life span of the suspended span super structure by 75 years. The focus now over the next 10 years will be to revitalize everything else on the bridge in order to extend the total life-span of the entire bridge by 75 years. At that point, HHB's focus can shift to the Mackay rehabilitation. As the Mackay approaches 52 years of service the conversation has begun to decide how to move forward. Once the Macdonald is in a state requiring less maintenance and lower inspection frequencies, HHB will be able to shift its resources to outlining a path forward for the Mackay crossing – be it total rehabilitation or a new bridge altogether.

SUMMARY OF PLANNED WORK

HHB's 10-year plan will require a total investment of $238 million spread over 10 years. This investment is crucial to HHB's goal of extending the life span of the Macdonald Bridge by 75 years, and shifting focus to the Mackay Bridge rehabilitation.

A breakdown of how the total investment is spread amongst HHB's assets. A further breakdown for each project is provided throughout the document.

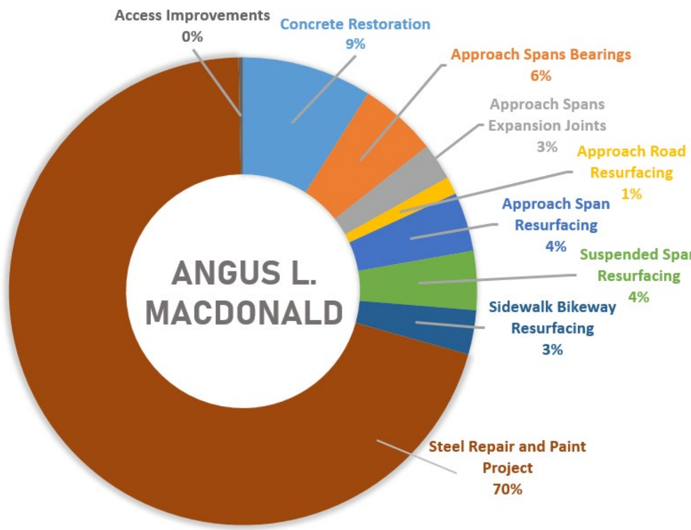
Angus L. Macdonald:	$ 98.1M
A. Murray Mackay:	$ 102.95M
New Bridge:	$ 13.48M
Ancillary Structures:	$ 23.47M



As expected, the majority of the spending over the next ten years will be on the two large suspension bridges, accounting for 84% of the budget– with the Macdonald requiring $98.1M and Mackay requiring slightly more with $102.95M. This can be explained by the size, complexity, and age of the structures. Although the Macdonald is receiving the major rehabilitation, the MacKay is approaching it's end-of-life and will require signifigant engineering effort to maintain safe crossing until a replacement option is in place.

The next largest budget item is the Ancillary structures which will require 10% of the budget over 10 years for standard maintenance, inspections, and in some cases rehabilitation. HHB is still in early phase of the New Bridge discussion and will not require significant investment until the later half of the next decade.

ANGUS L. MACDONALD BRIDGE



The Macdonald opened to traffic in 1955 and carries three lanes of traffic over the Halifax Harbour, and one lane each for Sidewalk and Bikeway on either side of the bridge. The suspended spans comprise two side spans and a centre span measuring approximately 160.5 m and 441.1 m, respectively. The suspended spans' deck system is a below-deck stiffening truss supporting transverse floorbeams, OSPD and paving. Both the Halifax Main Tower and Dartmouth Main Tower are approximately 91.6 m tall.

The bridge's approach spans were replaced with OSPD as part of the Third Lane project circa 1999 and are supported by trusses/girders and concrete piers. The Dartmouth (truss and girder arrangements) and Halifax approach (truss arrangement only) spans are approximately 436.6 m and 148.2 m long, respectively.

There are approximately 48,000 crossings on the Macdonald Bridge on an average workday. The Macdonald Bridge has a reversible centre lane. In the morning, there are two lanes to Halifax. At noon, it switches and there are two lanes to Dartmouth and one to Halifax.

As shown in the above chart, Steel Repair and Painting consume the majority of the budget at 70% of the allotted funds for the Macdonald Bridge over this ten-year period. These repairs are required due to the age of the structure itself and the deterioration of the steel. This is a key investment in the overall structural stability and durability of the bridge – intended to extend the life span of the remaining steel on the structure after the replacement of the entire suspended span deck in 2017. Once completed in conjunction with the concrete sub-structure rehabilitation, the Macdonald Bridge’s life span will be extended by 75 years.

ITEM C.1 Concrete Restoration

The Macdonald Bridge's concrete foundations are per their original design from the 1950s where concrete strengths were of low strength and quality compared to today's standards. Over the past decade, HHB has been rehabilitating the concrete surfaces to address deficiencies and cracking to enhance service life.

In 2012, HHB consulted W.S. Langley P.Eng. to perform a detailed condition assessment of the Macdonald substructure and foundations. This assessment identified the majority of the concrete was experiencing alkali-aggregate reactivity coupled with cycling freezing and thawing damage. Additionally, the evaluation categorized each pier and abutment with a priority level. HHB targets to rehabilitate High & Medium priority piers by 2024 and remaining piers by 2028.

Since 2012, HHB rehabilitated 14 piers along with portions of the Halifax and Dartmouth Abutments. The remaining work includes rehabilitation of the main tower and cable bent foundations, five piers and the remaining portions of the Halifax and Dartmouth abutments.

Concrete restoration projects are a highly complex process, and in the case of the piers on Macdonald and Mackay Bridges, the scope changes based on the location of the respective pier/abutment. A typical project may consist of (but not limited to) the following:

i. Site mobilization/demobilization
   - Mobilization occurs at the beginning of the project. The contractor will begin moving their equipment to site, installing their site offices, safety stations, etc.
   - Demobilization occurs once the project has been completed and the site completely reinstated. This will consist of the removal of all equipment, debris, and the complete reinstatement of all landscaping, utilities, etc. on their exit.

ii. Traffic Control
   - Controlling all pedestrian, cyclist, and vehicular traffic, which may be affected by the ongoing work on site.

iii. Site survey and measurement
   - Surveying and measuring the pier/abutment before issueing any drawings is key to the success of the project. Design drawings issued to the contractor by HHB are simply suggestions and are not a completely accurate representation of the work to be done on site. It is the responsibility of the contractor to visit the site and take the measurements they will require to complete the work depicted in the scope of the project.

iv. Submissions – Including shop drawings, schedules, erection methods, etc.
   - Prior to beginning work, the contractor is required to prepare various submittals regarding safety, erection methods for scaffolding, scheduling, etc.

v. Environmental/Community Controls
   - Environmental Controls are a strict part of every tender issued by HHB. For concrete restoration, an extremely prevalent control is the erect of dust control enclosures. This is not only for the environment, but for the community surrounding many of the piers/abutments.
   - Strict time restrictions for noise levels during inappropriate hours.

vi. Site Safety and Security
   - Site safety and security is an on-going discussion for the contractor and all parties involved.

- This involves installing fencing surrounding the entire site (laydown area included) as to prevent from any external interference with the project. Also to prevent any untrained individuals to be placed into a potentially hazardous environment.
- Contractor should adhere to the safety precautions that were submitted to and approved by HHB.
- Contractor should provide all employees and sub-contractors with all required safety training and PPE.

vii. Site preparation

- Removing, temporary storage, relocation, and reinstatement of all existing utilities that interfere with the scope of the project.
- Potential excavation, shoring, backfill, and compaction necessary for the site at hand.
- Securing sources for all utilities required to complete the scope of work.

viii. Removal and disposal of old concrete

- Chipping and blasting of concrete skin on Pier, and proper disposal as per Municipal guidelines.

ix. Removal and disposal of existing skin reinforcing steel.

- Removing the existing steel reinforcing skin and properly disposing the material in a timely manner in accordance with the given contract and municipal guidelines.

x. Design, Supply, and installation of new reinforcing steel

- The contractor is responsible for sourcing a supplier, generating/providing shop drawings built off of HHB's Issued for Tender (IFT) drawings, and installation as per approved shop drawings.

xi. Design, supply, placement, and finishing of new concrete encapsulation.

- The first stage is designing the formwork and temporary works for the project, sourcing the required materials, and installing said temporary works in accordance with CSA requirements and as per stamped drawings from contractors engineers.
- The contractor is responsible to source concrete from a supplier which meets HHB's requirements, design the concrete encapsulation structure, place the concrete as per design, and finish concrete surfaces as to improve aesthetics.

xii. Defect Control

- Defect control is a large portion of the contractor's job. This occurs in the form of Quality Control (QC), and any remediation needed from QC reports.
- Remediation tactics consist of the installation of epoxy grout into drill injection holes, and patch work to combat deficiencies like honeycombing.

Figure 2 Honeycombing present on Pier D4 from T2021-Q

xiii. External Coordination

- There are a number of third-party utilities on the bridge, which are typically required to stay operational throughout the project. The contractor is responsible for communication with these parties to discuss the proper relocation/temporary storage/reinstatement of these utilities.
- During the construction season there are multiple ongoing projects at all time on both Bridges. It is important and required for all contractors working with HHB to communicate with HHB Operations, and each other to ensure no interference.
- Liaison with and obtain permits from HRM, HRWC, NSPE, CNC, and other authorities having jurisdiction, utilities, and others as necessary.

ITEM C.2 Approach Spans Bearings

During the 2012 annual inspection, bearing observations were made regarding concrete cracks on top of the pier at bearing seats, deformed anchor bolts, and evidence of the bearings' potential to be resisting longitudinal bridge movements.

As a follow-up to the 2012 annual inspection findings, HHB installed movement monitoring devices at 12 out of the 26 sliding bearings to quantify the observations from the inspection. Field measurements, including calculations and evaluations, revealed that various bearings were seized and restricting movement. The existing bearings are original from construction (65 years old), which is well beyond their expected service life of 35-40 years.

HHB started the bearing replacement program in 2015 with a target to replace all original bearings to be replaced by 2024. To date, bearings at 12 of the 18 pier or abutment locations have been replaced.

Replacing the bearings is an incredibly complex process as these are the main points of contact for the bridge to the foundations. This requires jacking the bridge by 35mm, which is accompanied by several risks. Jacking the bridge also requires a bridge closure, so these already complex processes are subjected to unforgiving timelines.

ITEM C.3 Approach Spans Expansion Joints

Beyond the suspended spans, there are two and four strip seal expansion joints in the Halifax and Dartmouth approach spans, respectively. Within the past few years, HHB replaced the Halifax Abutment, Pier H1, and Dartmouth Abutment expansion joints. These joints were installed during the 1999 Third Lane Project and have reasonably outlived their useful life (30 years). The glands have required replacement over the joints' life, with the replacement of the steel armouring and adjacent concrete blockouts now being necessary due to deterioration and damage to components.

Replacing the strip seal expansion joints is not technically challenging work, but requires full roadway closures to remove the joint, install temporary traffic plates, and install the new joint. HHB makes every effort to ensure that minimal bridge closures are needed when planning the maintenance work to be done over the construction season. This requires close coordination with all parties involved (contractors, consultants, HHB personnel, etc.) and strict adherence to schedules.

ITEM C.4 Approach Road Resurfacing

The approach road is comprised of the area between the Dartmouth abutment and Wyse Road near the Dartmouth Toll Plaza and between Halifax Abutment and the first pedestrian crossing on North Street and its connecting off-ramp west of the Halifax Approach span.

These elements are non-structural but represent the asphalt roadway surface as part of the approach roadway to the Macdonald. The condition of the asphalt is maintained in alignment with criteria as per HHB standards and based on prior project execution / successes. It is anticipated that, by 2025, the condition will no longer meet the HHB standards and will require resurfacing.

ITEM C.5 Approach Span Resurfacing

The Halifax and Dartmouth approach spans support three lanes of traffic (two in one direction and one in the other that alternate) are approximately 148.2 m and 436.6 m long, respectively. During the 1999 “Third Lane Project”, the Sidewalk and Bikeway (SW/BW), the approach span deck was replaced with an orthotropic steel deck, including the SW/BW. During this work, traditional hot mix asphalt was applied as the roadway wearing surface.

During 2015-2017 “The Big Lift” suspended spans re-decking of the Bridge, the approach spans were not significantly impacted or modified, including the roadway wearing surface.

These elements are non-structural, but the applied asphalt is approximately 20 years old. Longitudinal cracking is present near the wheel paths, and HHB performed sizeable patch repairs where asphalt bond failure has occurred.

Historically – paving projects on the approach spans for the Macdonald and Mackay have consisted of the following scope:

i. Mobilization;
   - Installation of site-trailer and lay down area. For paving projects which occur on the bridge, the lay down area and site trailer may be a bit further from the work-site than in typical projects due to limited area on the bridge.
   - Locating or providing any needed utilities on site.

ii. Submissions;
   - Before beginning work the contractor has several submittals they need to provide to HHB. These are related to fire prevention, occupational health and safety, insurance, schedules, etc.

iii. Site Safety
   - Traffic control is a key part of site safety. This includes proper planning and coordination with HHB. For Approach span resurfacing where space is incredibly limited, especially on the Macdonald with only 3 lanes, a paving schedule must be determined to properly close sections of the bridge. Most of these projects would occur on either a weekend closure or overnight if the paving projects scope permits such a small time frame.

iv. Design, Supply, Erection, and Removal of all Temporary works;
   - Paving Dam supply and installation along barriers of wearing surface.

v. Protection of Existing Structures;
   - The contractor is responsible to ensure there is no damage to existing structures outside of the scope of the project, before, during, or after the work has been completed.

vi. Curb Rail Removal and Reinstatement;
   - In order to properly compact the asphalt along the paving dam, the bottom rail of the traffic barrier needs to be removed, temporarily stored, and reinstated to initial conditions.

vii. Surface Preparation and primer
   - This item includes the blasting of the steel surface as to ensure proper cohesion between the membrane and the surface.

viii. Eliminator membrane barrier supply and installation
   - The contractor is responsible for applying the defined membrane to the steel deck and to ensure it has comprehensive coverage.

- The contractor is also responsible to engage a representative of the membrane manufacturer to be present on site during installation as to ensure proper application and suitability of the product.

ix. Asphalt Removal, Supply, and Installation

- This includes milling the existing pavement to expose the steel below, supplying new asphalt, and installing in a ~50mm thick lift to the bridge deck.

x. Pavement Markings

- Any and all pavement markings need to be reinstated to their exact location once the new wearing surface has been installed.

xi. Making good all defects, including damage to existing facilities;

- Ensure no damage to newly installed material, or existing material remains after demobilization.

xii. Clean up

- General housekeeping in area – return area to the state it was found in.

xiii. Demobilization

- Total and complete removal of the contractor’s presence from the work-site.
- Removal of site-trailer, laydown area, temporary utilities, etc.

ITEM C.6 Suspended Span Resurfacing

During 2015-2017 “The Big Lift” suspended spans re-decking of the Bridge, the side and centre spans were replaced with new orthotropic steel deck, including new paving. The paving system is a proprietary epoxy asphalt supplied by ChemCo systems with a nominal thickness of 45 mm.

Paving of orthotropic steel panel decks has never been easy, and there have been almost as many failures as successes. Paving of orthotropic deck panels that must carry traffic practically as soon as they are placed adds further challenges. A fundamental decision in the development of Macdonald's deck replacement is that "thin" paving layers of about 10 mm thickness are unreliable and should not be considered. Paving thickness must therefore be in the range of at least 37 to 50 mm.

When the suspended spans of the Lions' Gate Bridge were replaced, the system was changed. Aggregate chips were broadcast and rolled into an epoxy bond coat, which was well cured in the shop, and traffic ran over this "prepaving" for up to a year before a final lift of "final" paving was placed over the entire bridge, thus producing a smooth and durable running surface. The resulting road surface has been so much better than the system with paving stops that it is recommended for the Macdonald.

Because the wearing surface that is being reinstated sits on a bridge span, extra caution must be taken. These extra considerations may consist of the following:

- The depth of asphalt you mill from the existing wearing surface is important as there is a risk of damaging the steel deck below.
- The water-proof membrane needs to be installed properly on an ideal surface, and needs to provide comprehensive coverage of the entire steel deck below the wearing surface.
- With regulations preventing dynamic compaction rollers on bridge decks, what modifications are needed for the process to be done with a standard compaction roller.

ITEM C.7 Sidewalk Bikeway Resurfacing

During the 1999 “Third Lane Project”, the sidewalk and bikeway approach span deck was replaced with an orthotropic steel deck. The applied wearing surface was the Stonehard Epoplex, comprised of a primer, base coat, and finish coat. After approximately 6-7 years, failure of the wearing surface was observed. In 2013, HHB trailed seven repair products in various areas in order to select a preferred repair in two years based on their in-situ performance.

The 20-year old surface had been experiencing local failures for the past fourteen years, at increasing extents. To address the deterioration and continue to protect the deck top surface, HHB planned a resurfacing project. The project was budgeted to be performed in 2015-2017, but with the "The Big Lift" suspended spans re-decking occurring at the same time, HHB delayed its start until 2020.

ITEM C.8 Steel and Paint Project

The original Macdonald Bridge was painted with a lead-based oil alkyd three-coat paint system. Around 1993, HHB transitioned to a zinc hydroxy phosphite paint system in place of the lead-based paints for painting repairs. Maintenance painting is conducted annually using needle scalers for surface preparation and recoating with a three-coat oil alkyd paint. In general, touch-up painting only is done, except on the main towers where a single finish coat was applied for colour uniformity and aesthetic floodlighting.

During the 1999 "Third Lane Project", the Macdonald approach span deck was replaced with prefabricated (shop coated) orthotropic steel deck segments, which are painted Ameron 68HS and PSX700.

During the 2015-2017 "The Big Lift" suspended spans re-decking project, the entire deck and truss was replaced in prefabricated deck segments, which were coated in a three-coat Organic Zinc/Epoxy/Polyurethane (OZ/EP/PU) system.

In 2013 and 2015 HHB retained two paint/coating consultants; Trans Canada Coatings and KTA-TATOR Inc., to examine the existing coating systems on both bridges and provide recommendations for the most cost-effective system that would best protect the bridges and minimize future maintenance.

Based on condition assessments for the integrity of the existing coating systems and degree of rusting, steel section losses, the coatings consultants independently stated the current coating system was no longer effective and recommended that it be replaced on the approach spans, cable bents and towers. This involved the paint system being removed by grit blasting to bare steel and coating with a new three-coat corrosion protection system.

A multicomponent zinc/epoxy/polyurethane system was recommended as the best candidate for long term maintenance-free corrosion protection. The coating works typically require the following:

i. Full Site Containment
   - For on-going works at the Dartmouth Cable Bent, the entire work-zone has been enclosed in tents, and sealed to the outside (As seen in Fig to the right)

ii. Special Access
   - These enclosures require special permissions to access.
   - You require proper training, and appropriate PPE. (Respirator, enclosed suit, etc.)

iii. Environmental Controls
   - Considering the environment is a key principal to this project. When blasting the existing coatings, the

lead contained in the paint can become airborne. There are air quality monitoring procedures in place as to mitigate the air pollution, and to ensure the enclosures are working appropriately.

iv. Abrasive Blasting to Remove Old Materials to Bare Metal

- Once the existing coating has been removed, the real scope of the project can be determined. At this point – it is much easier to understand to extend of the steel deterioration, and what needs to be replaced.

v. Spraying of New Coatings

- Once the newly exposed deteriorated steel has been replaced, the new coating system can be applied.

A tentative steel repair and corrosion protection program was developed in 2017. HHB started the program with a pilot project on the Halifax Approach span in 2018, which included steel repairs and replacement of approximately 54,000 ft2 of existing coatings and associated steel repairs. Following the 2017 work, HHB and COWI revised the coating program; accounting for increased section loss and strengthening requirements than initially anticipated. This increase was primarily due to the difference between estimating the extent of work before grit blasting the structure and the actual results observed during the pilot project (this was the intent of performing a pilot project).

In 2019, work on the Halifax Cable Bent was undertaken with similar scope, steel repairs and approximately 14,400 ft2 of existing coatings. In 2020, the Halifax Cable Bent work was completed, along with interim strengthening measures to areas of the Dartmouth Cable Bent (selected based on the condition and findings during the Halifax Cable Bent work).

ITEM C.9 Access Improvements

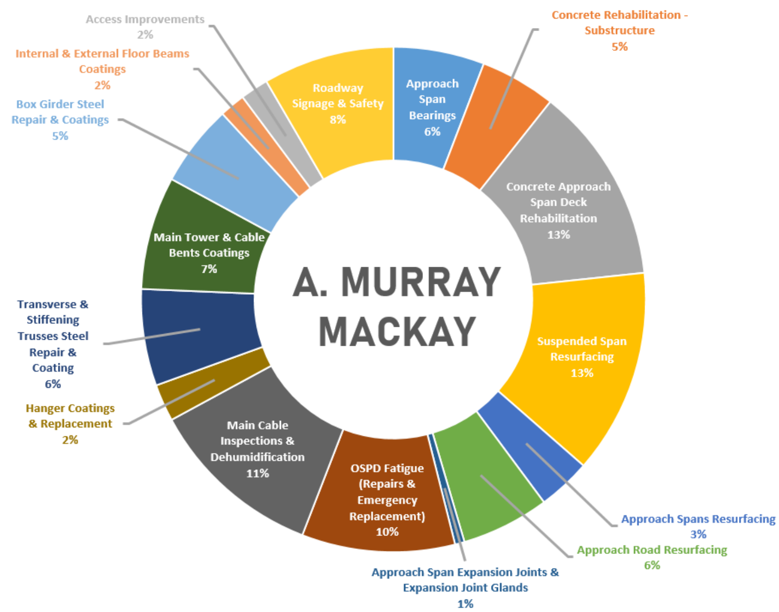
This item represents an all-encompassing item for HHB to improve and/or repair existing access systems (i.e. ladders, catwalks, lifelines, stairs, etc.), which can be required based on recent inspections or by a desire to improve access to new or existing locations of the bridge.

The scope of these items was based on annual inspection findings and rehabilitation programs implemented by HHB. In general, this work includes repair of ladder rungs (in-kind), new vertical lifelines inside cable bent legs, horizontal lifelines at the main towers and general access improvements.

For engineered safety systems, typically an inspection is required (intervals vary as required by the designer/supplier). It is assumed these specific inspections are separate from the annual inspections. Once inspected, repairs can be specified, or in other cases, a new system would need to be designed, fabricated, supplied and installed.

A. MURRAY MACKAY BRIDGE

The MacKay opened to traffic in 1970 and carries four lanes of traffic over the Halifax Harbour. There are no lanes for pedestrians or cyclists. The suspended spans are comprised of two side spans and a centre span measuring approximately 156.6 m and 426.7 m, respectively. The deck system of the suspended spans consists of a stiffening under-deck truss supporting transverse trusses. The floor beams, in turn, support an Orthotropic Steel Plate Deck (OSPD) and paving. Both the Halifax Main Tower and Dartmouth Main Tower are approximately 87.2 m tall.



The approach spans of the bridge have a concrete bridge deck supported on twin box girders and concrete piers. The Dartmouth and Halifax approach spans are approximately 114.3 m and 381.9 m long, respectively.

The distribution of spending on the Mackay is much more diverse than the Macdonald – this is largely due to the difference in long-term strategy for the two bridges. The Macdonald, as stated earlier, is under-going complete rehabilitation to extend the bridges life span by 75 years. The MacKay on the other hand is being considered for replacement or major rehabilitation in the next couple of decades. Keeping this in mind – until a decision is made, the Mackay is undergoing a series of rigorous maintenance programs to each of it's major components. The aim being to extend the life span of the MacKay long enough to develop a plan while maintaining safe crossings. The major works (accounting for 47% of budget) for the Mackay over the next ten years are listed below:

ITEM D.3	Concrete Approach Span Deck Rehabilitation	$ 13.0M
ITEM D.4	Suspended Span Resurfacing	$ 13.5M
ITEM D.8	OSPD Fatigue (Repairs & Emergency Replacement)	$ 10.1M
ITEM D.9	Main Cable Inspections & Dehumidification	$ 11.55M

A significant portion the investment is focused on the Suspended Span itself. This includes the repair and some replacement of the OSPD, and the resurfacing of the entire suspended span. The resurfacing and repair of a Suspended Span Deck is an incredibly complex process, and with that high costs are expected. Similar to the Cable Dehumidification project conducted on the Macdonald Bridge, one will be designed and constructed for the MacKay. The main cable is the most vital component of the bridge, and this project will extend its life significantly.

ITEM D.1 Approach Spans Bearings

During recent detailed inspections by COWI, the elastomeric bearings in the approach span between the abutments and cable bents were observed to be in fair condition and performing as intended. At the abutments, the bearings are skewed and feature minor cracks. Elsewhere in the approach spans, there is light bulging and cracking of the bearings.

Observations about the skewed abutment bearings and minor cracking of existing bearings are known, as noted in previous annual inspection reports. In 2016, COWI performed a detailed assessment of the bearings following the findings from the annual report where the inspecting engineers had recommended to replace the bearings in 1-3 years. COWI summarized a 2008 assessment of the same bearings, which concluded the distortion was likely predominantly due to concrete placement during construction, and displacement or rotation of the abutment toward the approach spans. As such, no work is considered necessary until 2025 or later (dependent on bearing performance).

ITEM D.2 Concrete Rehabilitation – Substructure

The concrete approach span substructure is generally performing well, with routine inspections and assessments conducted in a 3 – 5-year cycle. Deterioration to date has been shown to be primarily cracking and local delaminations. HHB is currently undertaking an underwater investigation for the main tower foundations.

In 2013, HHB engaged a concrete expert, W.S. Langley, P. Eng., to perform a detailed concrete assessment of the Mackay substructures and foundations. The evaluation noted that the concrete has suffered from alkali-aggregate reactivity, cyclic freezing and thawing damage, cracking, corrosion of reinforcing steel, and leaching. Encapsulation was recommended as the bridge foundation repair option.

In 2016, HHB performed concrete removal and rehabilitation by encapsulating the Halifax Cable Bent, and partial repairs of the Halifax Main Tower foundation. In 2019, HHB consulted W.S. Langley P.Eng. to assess the bridge substructure and foundations. The evaluation identified most of the concrete was experiencing some cracking, with no significant changes in the overall condition since a 2012 inspection. Additionally, the assessment categorized each pier and abutment with a priority with the highest priority locations being repaired soonest.

ITEM D.3 Concrete Approach Spans Deck Rehabilitation

The cast in place concrete approach span deck has been observed to have increasing amounts of deterioration, including spalling concrete, exposed reinforcement, cracking and difficulty to maintain the paving bond. These are all indications of a concrete deck where there are areas experiencing active corrosion of the steel reinforcing.

To maintain the concrete deck, it is anticipated that significant repairs will be required to address the areas of active corrosion. A testing program is also planned for 2021 to quantify the extent and severity of the deterioration presently occurring.

Based on the visual inspection results to date, HHB anticipates significant concrete removals, particularly in the vicinity of cold joints and expansion joints along the deck. This work will require construction staging to keep traffic moving and engineering assistance throughout construction to determine the appropriate measures for repair following concrete removals.

ITEM D.4 Suspended Spans Resurfacing

HHB performed various levels of asphalt milling, local repairs, full lane replacements to the suspended spans throughout the structure's life. The 2019 suspended span south lane resurfacing experienced some failures in 2020 and HHB is currently undergoing QA/QC to determine the root cause before proceeding with the two north lanes' resurfacing.

The wearing surface on the MacKay has a short life due to the relatively flexible steel deck on the suspended spans, which results in cracking of the asphalt and eventual deterioration. The deck remains safe, but the asphalt deteriorates more quickly than typical and requires frequent repairs/replacement.

Throughout the years, HHB experimented with and investigated various asphalt mixes appropriate for the suspended spans orthotropic steel deck and the concrete approach deck with varying levels of success. Due to the thin top plate design of the orthotropic steel plate deck for the suspended spans, typical asphalt paving systems have difficulty remaining in place. To protect the steel deck, HHB maintains the paving system on approximately a seven-year cycle.

ITEM D.5 Approach Spans Resurfacing

HHB performed various asphalt milling, local repairs, full lane replacements, and the suspended spans, approach spans, and approach roadway throughout the past 10-15 years. HHB milled and replaced the paving on all lanes of the Halifax Approach in the Summer of 2020. The Dartmouth Approach span was last repaved in 2001.

The approach spans of the MacKay are cast in place concrete supported by steel box girders. As the concrete deck deteriorates (known from inspection findings), the asphalt system on the approach spans is anticipated to be more challenging to maintain.

To suit the anticipated concrete deck major rehabilitation (planned for 2026 and 2028), COWI has noted a mill and replace methodology to maintain the existing paving until full replacement following the concrete deck repairs. This technique involves a reduced timeline between work packages (four-year cycle rather than seven) but reduces overall cost as HHB prepares for significant repairs to the concrete deck beneath. A full-depth asphalt replacement is planned to coincide with the concrete deck repairs. This approach will also limit traffic interruptions and is developed based on the priority sequence of repairs to the suspended span deck.

ITEM D.6 Approach Road Resurfacing

The approach span road extends approximately 2 km from the Dartmouth abutment and 1 km from the Halifax abutment. The approach road was last resurfaced in 2001.

These elements are non-structural but represent the asphalt roadway surface as part of the approach roadway to the Macdonald. The asphalt condition is maintained in alignment with criteria as per HHB standards and based on prior project execution / successes.

ITEM D.7 Approach Span Expansion Joints & Expansion Joint Glands

There are three expansion joints associated with the approach spans. In 2020, HHB replaced the Halifax Abutment and Pier D5 expansion joints due to failure of the surrounding concrete and steel armouring. In 2021, HHB plans to replace the Dartmouth Abutment expansion joint (also due to steel armouring failures), thus replacing all approach span expansion joints.

HHB also anticipates, as an interim measure prior to replacing these expansion joints again, the replacement of the glands prior to 2030.

The approach span expansion joints are less complicated than the Cable Bent and Main Tower expansion joints in the suspended spans. Replacement of the approach span expansion joints is often required due to a deterioration of the adjacent concrete deck, and excessive wearing of the steel armouring. For example, recently, a section of the Dartmouth abutment steel armouring was removed due to deformation and damage from snowplows. Subsequently, this joint is now planned to be replaced with design underway with COWI.

ITEM D.8 Orthotropic Steel Plate Deck Fatigue (Repairs) & OSDP Replacement (Emergency)

The Bridge was designed when less was known regarding the fatigue life of Orthotropic Steel Plate Decks (OSPDs). The deck top plate is 9.5 mm thick compared to the minimum 14 mm, which is currently specified by the Canadian Highway Bridge Design Code (CHBDC). The thin plate leads to the deck's increased flexibility, often resulting in a shorter fatigue life that can not be corrected. This deck's flexibility has led to increased deterioration and cracking of the wearing surface, allowing water and de-icing salts to penetrate through to the steel and cause corrosion. COWI hypothesises that where cracks are present, water will collect and corrosion will probably occur in the longitudinal troughs.

In 2009, HHB requested that COWI estimate the remaining life of the deck of the Bridge. COWI concluded that the OSPD would continue to perform, in conjunction with increasing maintenance, until about 2024. It was noted that the Bridge has several deficiencies and that as far as practical, the deficiencies have been remedied, but that a complete "cure" would not be possible due to the inherent nature of the original design. It was concluded there was no evidence of significant cracking of the OSPD in 2010, and that fatigue loading would not likely cause widespread cracking of the OSPD until 2028 to 2038 (15-25 years from 2013) and maybe longer. It was noted that it was possible that there would be intermittent cracking before that time.

In 2019, COWI performed a detailed inspection of the deck plate's top surface in both southbound lanes of the Bridge, covering half of the overall deck width. In general, most panels were in fair condition, although a significant degree of pitting corrosion was typical in the wheel paths. Four new cracks were identified in the top plate, suggesting a change in the behaviour of the OSPD into a period of increasing cracking due to fatigue damage, as projected in the 2010 study. While not yet considered widespread cracking, the condition of the OSPD may be shifting into a time of increasing rate of deterioration.

COWI recommended that the asphalt condition be closely monitored with annual inspections to enable early detection of future cracks and defects. The asphalt condition cross-referenced with the 2019 inspection notes may help predict future crack locations. Cracks must be repaired to slow their growth, and COWI recommends this repair occur as soon as reasonably possible within one year of crack discovery.

Mitigating the risk due to fatigue cracking on an OSPD is undertaken by increased inspections to understand the location and extent of cracking and repair cracks as soon as reasonably possible. In a period of infrequent cracking, repairs may be undertaken by removing the wearing surface, welding the crack closed, and replacing the wearing surface.

If a period exists where cracks reappear consistently in the same locations, or multiple cracks occur within a short distance, replacement of a section of OSPD begins to become a more appropriate action. The need for this approach is likely to occur for one to two years. Based on the complexity of replacing sections of the deck, this is considered a short timeframe for developing designs, installation procedures, and fabricating components. Therefore, HHB will prefabricate sections of OSPD to have on hand for installation as emergency measures.

ITEM D.9 Cable Dehumidification & Main Cable Dehumidification

Installation of a dehumidification system is based on HHB's intention to maintain the existing structure until 2040 or longer, and COWI's recommendation based on their current understanding of the condition of the cable. To date, all areas of the main cable that have been opened show significant amounts of moisture, with corrosion occurring at the low points and some observed broken wires. With the corrosion of the main cable anticipated to continue if no action is undertaken to protect it, the main cable's capacity will continue to decrease. The rate of this deterioration is yet unknown due to only having a limited number of main cable internal inspections performed to date. Still, it is appropriate to preserve as much capacity in the main cable as possible, through the addition of the dehumidification system. While not currently a safety issue, frequent and invasive inspections would be required for HHB to maintain an appropriate level of understanding for the cable's changing condition. Therefore, in addition to preserving the main cable's capacity, the dehumidification system's addition will be good value for money.

Dehumidification has been utilized as corrosion protection over the last 50 years. The main principle is that steel does not corrode when the relative humidity (RH) is below 40%. Between 40% and 60%, corrosion can occur, though at a very low rate. In practice, short periods with a relative humidity of up to about 50% are acceptable. The dehumidification system will comprise: a dehumidification plant in the Halifax anchorage (dry air supply), ducting from the Halifax anchorage to the centre of the bridge where it is injected into the main cable, cable wrapping along the existing cable to ensure an airtight seal, and a control and monitoring system that will record and report critical data of the dehumidification plant.

Prior to wrapping the main cable, HHB will undertake main cable openings during which the condition of the strands may be assessed for corrosion and any additional wire breaks.

ITEM D.10 Hanger Replacements & Hanger Coatings

In 2012, HHB replaced nine suspended span vertical hangers with new galvanized hangers that were field coated to match the existing hangers. Based on recent inspections, the hangers are in fair condition with the volume of coating heavy, especially near deck level. On most hangers, the 3-4 m of length near the deck is continuously affected by splashing from traffic, thus significantly reducing the service life of the corrosion protection (paint).

It is not anticipated that significant hanger replacements will be necessary by 2030 if the painting system's current performance continues. Amounts are budgeted to account for the potential for increasing paint deterioration and a subsequent hanger deterioration. Additionally, HHB continues to perform deck-level hanger repairs in conjunction with their suspended span truss coating work with in-house painters.

HHB replaced hangers in 2012 such that the replacement scheme is already known for future work. The challenge is that the hangers are procured by specific suppliers and need to be fabricated to tension tolerances to achieve its installed length in the field where each hanger has a unique hanger length. Therefore, a supply of hangers cannot be pre-supplied to HHB to have in storage.

ITEM D.11 Stiffener Truss Steel Repair & Stiffening Trusses Coating & Transverse Trusses Coating

Throughout the past ten years or so, the suspended spans have undergone various localized coating repairs by HHB painting crews. Recent inspection reports have identified varying levels of corrosion and coating failure. However, the bulk of it is along the stiffening truss, which receives deck run-off from the roadway above. The transverse trusses and plan bracing are sheltered from the deck and typically free of corrosion but with varying coating quality levels.

During such coating work, is it expected that steel repairs would be required to the stiffening truss where corrosion is heaviest, typically at the gusset plates and at the bottom chords (where debris can collect).

Currently, access to these areas is through HHB moveable access platforms which should permit a dynamic working front independent of traffic.

To protect the steel and maintain the structural integrity of the MacKay for another twenty years, coatings and steel repairs are anticipated.

ITEM D.12 Main Tower Coatings & Tower Steel Repairs (Door and Seal Splices) & Cable Bent Coatings

The Main Tower and Cable Bent coatings are typically in good condition based on the detailed inspection findings. The coating on each interior is in good condition with localized water ingress locations typically at splices where caulking has failed. The Main Tower exterior is in good condition with it being recently painted in 2003-2005. The Cable Bent exterior is in slightly worse condition that the Main Towers but still fair condition. The splices at the cable bent top strut with the legs has corrosion and coating failure due to the deck runoff in these areas. The recoating work's focus would be for full recoating of components that have been identified with coating deficiencies and not a full recoating of the full height of each Main Tower and Cable Bent like the Macdonald painting program. The coatings and steel repairs are recommended to maintain this critical component of the structural system; these are preventative measures to limit the type of deterioration observed on the Macdonald bridge steel substructures.

Multiple door hatches in the Cable Bent and Main Towers are inoperable (jammed or unable to be fully closed), and all of them have deficient sealing systems such that they are a source of water ingress.

Currently, access to these areas is difficult. The Main Tower top strut has a bosun's chair rail, otherwise, temporary access would be required to re-coat these areas.

ITEM D.13 Steel Repairs and Access (Box Girder) & Box Girders Coatings

The approach span concrete deck provides substantial protection from the elements such that the coatings of the approach span box girders are typically in fair condition. At deck construction joints, water is penetrating the deck and rust is visible on the deck soffit at the floorbeams, including the box girders at those locations. Furthermore, recent inspections have identified pinhole corrosion in the box girder top flange, indicating water penetration of the approach deck leading to corrosion. Repairs may be necessary to the box girders; a study is ongoing to confirm this need. Access for these areas is limited due to out of commission travellers and fixed catwalks.

The recoating and repairs timing is intended to be concurrent with the approach span deck rehabilitation work, i.e. when the deck is removed and box girders are accessible, where access may be more feasible if concurrent with traffic control. Additional benefits of this approach include recoating the box girders following deck repairs, during which damage may be incurred due to demolition of the concrete above.

Access to these areas currently is challenging. The approach span catwalk is only wide enough to fit one person to access a limited portion of the interior floorbeams. The cantilevered portions of the floorbeams are only accessible through an aerial work platform or the existing travellers. However, the travellers are not fit for use at this time and require significant repairs or replacement before use.

ITEM D.14 Internal and External Floor Beams Coatings

The approach span concrete deck provides substantial protection from the elements such that the coatings of the approach span floorbeams are typically in fair condition. At deck construction joints, water is penetrating the deck and rust is visible on the deck soffit at the floorbeams, which has been identified in recent inspections. Modifications to the approach span access are assumed within the box girder repairs (D.13).

Based on the observed deterioration and planned concrete deck rehabilitation, it is assumed that a considerable percentage of the floorbeams will require recoating. This recoating is planned to be a local zone approach as section loss, or capacity concerns are not presently anticipated. The recoating is intended to maintain the existing structural capacity for the duration of the foreseeable service life.

ITEM D.15 Access Improvements

The access improvements represent an inclusive item for HHB to improve or repair existing access systems (i.e. ladders, catwalks, lifelines, stairs, etc.), which can be required based on recent inspections or by a desire to improve access to new or existing locations of the bridge.

The scope of these items is based on annual inspection findings and rehabilitation programs implemented by HHB. In general, this work may include catwalk railings, vertical lifelines and access to the main tower foundations.

For engineered safety systems, typically an inspection is required (intervals vary as required by the designer/supplier). It is assumed these specific inspections are separate to the annual inspections. Once inspected, repairs can be specified, or in other cases, a new system needs to be designed, fabricated, supplied and installed.

ITEM D.16 Roadway Signage & Safety

As part of the HHB's Transportation Engineering Services project in 2011, HHB is proceeding with improvements and replacements of existing signage (Guide, Regulatory and Waring signs) and sign structures. This is based on findings from a human factors' assessment, road safety review, a review of signage on the MacKay and Macdonald Bridges and an assessment of speed management on the approaches to the MacKay toll plaza.

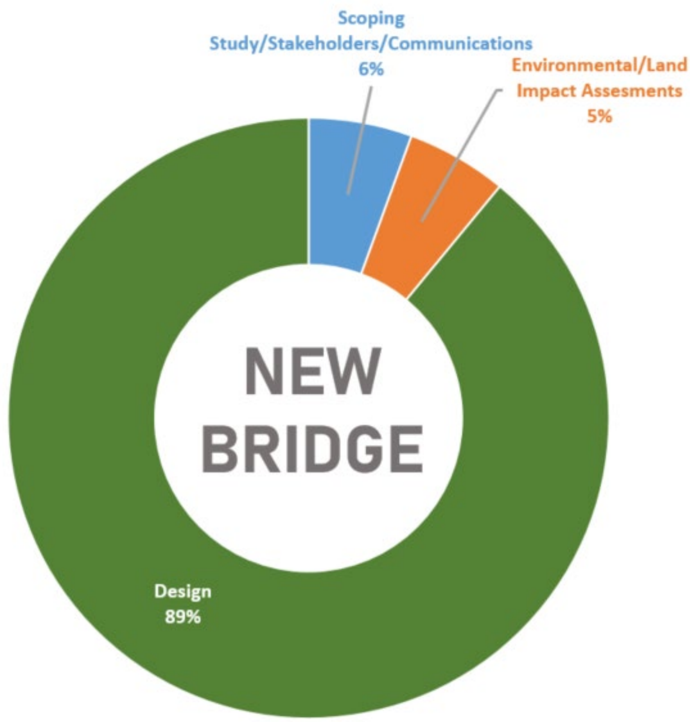
The implementation of a new signage system was put on hold until the completion of Big Lift and All Electronic Tolling projects.

As part of the signage evaluation and design process, the following elements were considered: driver information requirements, driver workload issues related to sign reading, lane changing, and characteristics of traffic operations (including operating speeds, speed differentials, and areas of merging and weaving).

The report recommends HHB to implement an integrated roadway system that includes road safety, speed management and signage with clarity and consistency.

NEW BRIDGE

As part of HHB's plan to replace the existing Bridge by 2040 HHB will begin taking steps within the next several years to determine the scope of work, gather input and facilitate communication with the key stakeholders, and begin to communicate these plans to establish funding and support. COWI provided HHB with a feasibility report for the MacKay replacement options in 2020. This section summarizes the options available for the long-term operation of the crossing, ultimately demonstrates why a replacement bridge is required, and why planning for the new bridge to be in service by 2040 provides the best value to HHB's mandate.



This process would proceed as follows:

- Scoping study for a new bridge;
- Communication with key stakeholders, i.e. nearby property owners (residential, commercial, federal) in the vicinity of the bridge; Federal, Provincial and Municipal Governments; Halifax Port Authority; Department of National Defense; etc.; and
- Assessment of land adjacent to the existing bridge to determine the most appropriate location for a replacement bridge, starting with environmental and land impact assessments. (Note, this work does not include land acquisition, but rather a high-level evaluation of potential acquisition processes and implications.)

Once the scoping study and the environmental and land impact assessments are complete, HHB can proceed with the design and construction of the replacement bridge.

For this capital plan, HHB is proceeding as if the early stages of the planning/design will start between 2025-2030. If the design were to begin in this period, it is assumed that it will extend beyond 2030. Therefore, additional costs are anticipated beyond 2030 for the design and the full construction cost impacts.

ITEM E.1 New Bridge Scoping Study/Stakeholders/Communications

As part of HHB's plan to replace the existing Bridge, HHB is recommended to begin taking steps approximately ten years before construction to determine the scope of work, gather input and facilitate communication with the key stakeholders, as well as begin to communicate these plans to establish funding and support. COWI provided HHB with a draft feasibility report for the MacKay replacement options, finalized to HHB in 2020.

At the stages before the preliminary design of any new bridge, the technical considerations are minimal. The primary focus is on commercial aspects, i.e. securing funding, determining the scope of work, land acquisitions, etc.

ITEM E.2 New Bridge Environmental Assessment/Land Impact Assessments/Land Acquisition

Concurrent with the scoping studying, land adjacent to the existing bridge requires assessment to determine the most appropriate location for a replacement bridge, starting with environmental and land impact assessments. Both activities will help HHB determine if any adjacent sites next to the existing bridge are best suitable to support a replacement structure. However, it is acknowledged that the environmental assessment (suitability of area) and land im pact assessment (suitability of impact of the bridge on an area) are mutually exclusive exercises that may yield different results requiring a compromise to be made.

HHB does not anticipate acquiring any land for the work before 2030.

At the stages before the preliminary design of any new bridge, the technical considerations are minimal as the primary focus is on commercial impacts.

ITEM E.3 New Bridge Design (Partial) & Construction

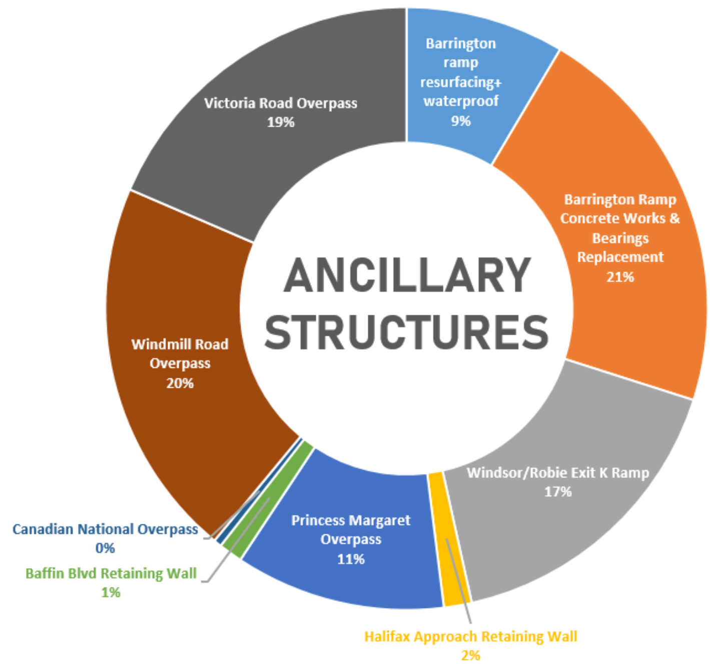
Once the scoping study and the environmental and land impact assessments are complete, HHB can proceed with their selected consultant on the new bridge's design to replace the existing MacKay.

HHB has not yet finalized the timing of this work but, for purposes of the capital plan, is proceeding as if the design will start between 2025-2030 at the earliest. If the design were to begin in this period, it is assumed that it will extend beyond 2030. Therefore, additional costs are anticipated beyond 2030 for the design and the full construction cost impacts.

With the necessary assessments complete and the new bridge location nearly known (i.e., major commercial factors are resolved), HHB's selected consultant can proceed with the new bridge's design. At this stage, without knowing the chosen bridge type, it isn't easy to define or discuss the technical considerations. However, the design team will have to address those challenges as-and-when they occur. It is worth noting that a new bridge will have fewer unknowns to deal with being new construction rather than rehabilitation work.

ANCILLARY STRUCTURES

HHB also owns, operates, and maintains several structures that are not as prominent in the Halifax skyline as our Long Span Suspension Bridges. These are internally referenced as our ancillary structures, consisting of overpasses, ramps, and the Victoria road interchange. These structures are all a part of the more complex infrastructure system that supports HHB's two long span suspension bridges. These ancillary structures help route traffic, and ease access to the bridges – making them a vital part of HHB's operations.



The majority of these structures have undergone significant work in the past 10-15 years, and are in stable condition. Maintenance on these structures is also not nearly as complex as the long span suspended bridges, thus the cost is much lower. Although they are included in HHB's annual inspections, they may not necessarily undergo any maintenance programs in a given year.

ITEM F.1	Barrington Ramp Resurfacing & Waterproofing	$ 2.0M
ITEM F.2	Barrington Ramp Concrete Works & Bearings Replacement	$ 5.02M

As seen in the above table and figure, the Barrington Ramp will require the most service over the next ten-years at 30% of the budget. This will cost roughly $7M to replace the wearing surface, rehabilitate the concrete sub structure, and replace the bearings. The wearing surface is to be replaced within the first few years of the decade, while the rest of the work isn't scheduled to start till 2029.

ITEM F.1 Barrington Ramp Resurfacing/Waterproofing

Located on the south side of the Macdonald Halifax approach span, the Barrington Street Ramp carries one lane of traffic for Dartmouth-bound traffic travelling north on Barrington Street in Halifax. HHB performed periodic inspections and concrete repair work within the past 10-15 years.

Previous inspection reports have noted the wearing surface is in fair to poor condition. There are potholes concentrated near expansion joints, and the wearing surface does not extend the full width of the deck at the turn. There are longitudinal cracks, and there is medium rutting in the wheel paths. However, previously patched areas are in good condition.

For many Halifax to Dartmouth commuters, the Barrington ramp is the first impression they receive of the bridges condition. The wearing surface is progressing from being an aesthetic issue, to a comfort issue. Following HHB's pro-active approach – the entire span of the Barrington ramp will be resurfaced in the next few years. As a bridge owner, it is important not only that your bridge be safe beyond a reasonable doubt – but also that people believe it. Aesthetics and comfort play a huge role in that.

ITEM F.2 Barrington Ramp Concrete Works & Bearing Replacement

Located on the south side of the Macdonald Halifax approach span, the Barrington Street Ramp carries one lane of traffic for Dartmouth-bound traffic travelling north on Barrington Street in Halifax. HHB performed periodic inspections and concrete repair work within the past 10-15 years.

Based on previous inspections, concrete rehabilitation is required before anticipated bearing replacements in 2029. To accommodate the work's staging, the project will take place over a series of four years. Included in this work scope will be an assessment on the most effective manner to strengthen the structure in preparation of bearing replacements as no jacking beam currently exists. The jacking beam is vital to the success of any bearing replacement project as it is the key to lifting the span of the bridge in order to swap out the bearings.

Work to replace the bearings is currently assumed on a preventative maintenance schedule rather than observed deterioration. This will be re-assessed as the schedule progresses.

ITEM F.3 Windsor/Robie Exit K Ramp

Located west of the MacKay Halifax abutment adjacent as part of the NS Highway 111 interchange system, the Windsor/Robie Street Exit structure (New Ramp "K") carries two lanes of traffic (both westbound) as part of NS Highway 111. The structure is a four-span, twin steel box girder bridge with concrete deck and asphalt pavement. HHB performed periodic inspections and concrete repair work within the past 10-15 years.

HHB's recent inspection of the structure revealed that deformation is present along the steel girder webs at diaphragm and bearing stiffener locations. As this condition was previously unknown to COWI and HHB's current personnel, an investigation is planned to assess the influence these deformations have on the structural performance. Additional inspection findings note that the bearings, while currently sufficient for the bridge needs, are likely to require replacement within the next ten years.

There are indications that the abutments or structure have shifted slightly to the south, based on the remaining gaps observed in the expansion joints. This may result in having to address the abutment back wall geometry to allow for adequate joint movement, and fixity of the abutment foundations to limit future movements. HHB has allocated $3.9M to this structure over the next 10 years as to ensure anything that may arise from the investigation can be rehabilitated appropriately.

ITEM F.4 Halifax Approach Retaining Wall

The Halifax Approach Retaining wall is located along the approach road, south of the structure.

During the previous inspection (2012), map cracking and localized spalling were observed. Based on these findings, COWI anticipates some needs for concrete repairs. Total scope to be verified following the next inspection (2021).

A verticality survey was last performed for the wall in 2007. In 2012, recommendations were made to perform a subsequent survey in 4–7 years to capture the wall's possible movement, particularly at the east end where a bulge was noted.

ITEM F.5 Princess Margaret Overpass

Located east of the MacKay Dartmouth Abutment adjacent to the MacKay Dartmouth toll plaza, the Princess Margaret Overpass carries four lanes of traffic (two in either direction) as part of the MacKay Dartmouth roadway approaches. HHB performed periodic inspections and concrete repair work within the past 10-15 years and various concrete repairs and replaced the existing pot bearings with elastomeric bearings in 2010.

The free abutment and pier bearings have some signs of distress, but nothing that would yet warrant a bearing replacement. However, there are signs of potential overloading on the bearing pad material (bulging), which may reduce the assemblies' overall lifespan.

The fixed abutment bearings, initially replaced in 2010, were again replaced in 2011 to address significant distress (tears, bulging and general distortion). This second replacement did not improve the situation as the bearings also have considerable distress. A desktop study was undertaken for HHB by another consultant in 2017 to help understand the situation, with no conclusive findings.

Currently, the impact and influence of the failed fixed abutment bearings are not known. Therefore, HHB is planning for significant bearing replacements within this 10-year capital plan. Following a more detailed assessment of the current bearing conditions and performance, this anticipated work may very well be reduced.

ITEM F.6 Baffin Blvd Retaining Wall

Located between the MacKay Dartmouth Abutment and the Princess Margaret Overpass, Baffin Boulevard Retaining Wall is a cast-in-place concrete retaining wall along the south side of the MacKay roadway approaches. HHB last performed an inspection of the wall in 2012.

During the 2012 inspection, the concrete was in good condition with some vertical cracking and efflorescence. Based on the images provided and details contained in the inspection report, HHB is considering that some localized repairs may be required – to be confirmed following the next inspection.

ITEM F.7 Canadian National Overpass

Located east of the MacKay toll plaza in Dartmouth, the CN Overpass carries six lanes of traffic (three in either direction) as part of NS Highway 111 over the CN Railway below. HHB performed periodic inspections and concrete repair work within the past 10-15 years in addition to various concrete repairs completed in 2008.

During the 2014 inspection, the concrete was in good condition with some vertical cracking and efflorescence. Based on the images provided and details contained in the inspection report, HHB is considering that some localized repairs may be required – to be confirmed following the next inspection.

ITEM F.8 Victoria Road Overpass

Located east of the MacKay toll plaza in Dartmouth, the Windmill Road Overpass is a twinned structure that carries six lanes of traffic as part of NS Highway 111 over Windmill Road. HHB performed periodic inspections and concrete repair work within the past 10-15 years and various concrete repairs and replacing the existing pot bearings with elastomeric bearings in 2010.

The free abutment and pier bearings have some signs of distress, but nothing that would yet warrant a bearing replacement. However, there are signs of potential overloading on the bearing pad material (bulging), which may reduce the assemblies' overall lifespan.

The fixed abutment bearings, initially replaced in 2010, were again replaced in 2011 to address significant distress (tears, bulging and general distortion). This second replacement did not improve the situation as the bearings also have considerable distress. A desktop study was undertaken for HHB by another consultant in 2017 to help understand the situation, with no conclusive findings.

Currently, the impact and influence of the failed fixed abutment bearings are not known. Therefore, HHB is planning for significant bearing replacements within this 10-year capital plan. Following a more detailed assessment of the current bearing conditions and performance, this anticipated work may very well be reduced.

ITEM F.9 Ramp D-Bin

Located east of the MacKay toll plaza and Windmill Road in Dartmouth, the Victoria Road Overpass carries six lanes of traffic (three in either direction on each structure) as part of Victoria Road over NS Highway 111. HHB performed periodic inspections and concrete repair work within the past 10-15 years and various concrete repairs and replaced the existing pot bearings with elastomeric bearings in 2010.

The free abutment and pier bearings have some signs of distress, but nothing that would yet warrant a bearing replacement. However, there are signs of potential overloading on the bearing pad material (bulging), which may reduce the assemblies' overall lifespan.

The fixed abutment bearings, initially replaced in 2010, were again replaced in 2011 to address significant distress (tears, bulging and general distortion). This second replacement did not improve the situation as the bearings also have considerable distress. A desktop study was undertaken for HHB by another consultant in 2017 to help understand the situation, with no conclusive findings.

Currently, the impact and influence of the failed fixed abutment bearings are not known. Therefore, HHB is planning for significant bearing replacements within this 10-year capital plan. Following a more detailed assessment of the current bearing conditions and performance, this anticipated work may very well be reduced.