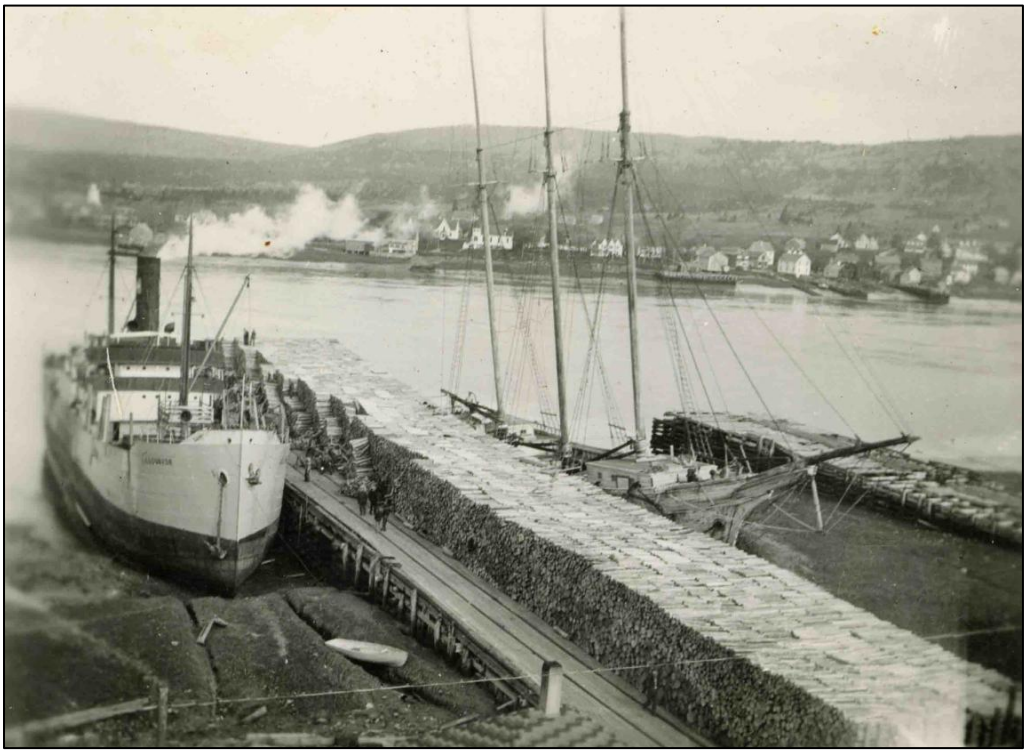
Annapolis Royal
Nova Scotia

Annapolis Royal Wharf
Adaptive Re-Use of Wharf Structure



Prepared by

JOST+ ARCHITECTS
PUTTING THE PIECES TOGETHER

240 St. George Street

Annapolis Royal, NS B0S 1A0
902.532.2395
info@jost.ca

May 2026

Consultants :
Able Engineering Limited

Our Project JPN2025092

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Photo Credit Annapolis Heritage Society

1. EXECUTIVE SUMMARY

The Town of Annapolis Royal is in a difficult position with regards to the future of the Town Wharf.

The extant structure in its current configuration is at the end of its useful life span. Economic uses for the wharf are minimal or non-existent.

In addressing its adaptive re-use, we felt it is important to identify problems and potential costs if nothing is done. The report identifies that “No Action” could be costly.

The budgets provided ranges from $2,200,000.00 - $5,600,000.00. These were prepared in concert with the engineering team and an experienced Marine Contractor. Of note is that these are construction estimates, is that design fees, permit fees and contingency need to be added, raising the costs by 30%. The presence of contaminated material will significantly increase costs. Approval for alteration may be difficult as we understand that the Department of Fisheries and Oceans are not in support of its existence. This is undocumented but may result in additional time and expense in permitting. Our understanding is that any increase in footprint size will require a permit.

The possibility of adding a unique tidal viewing experience may encourage some interest from visitor focused funding, but the cost is significantly higher than other identified options.

The least costly identified solution is to reduce the structure to a breakwater which would eliminate any public use.

There are several unknowns in determining the way forward. A major question is the possible presence of contaminated materials in the existing structure and the condition of the tie rods installed during the last renovations.

Test pits and further physical investigation is required to assess these. Testing was not a part of this report.

The Town should determine its preferred option and then focus on the elements which will most affect the preferred approach, including hazardous material testing, detailed existing infrastructure, investigation and development of concept budgets based on findings.

2. BACKGROUND

Annapolis Royal is marine focused community. Prior to the arrival of the Europeans, the Mi'kmaq used the site because of its location bridging the navigable Annapolis River and the start of the Bay of Fundy in the Annapolis Basin.

In the early 1700's French explorers were taken by the easily protected waters of the Annapolis Basin and the abundance surrounding. The tidal flats provided areas for agriculture using techniques similar to those delivered on the homeland.

Through the "Age of Sail" vessels were constructed on the tidal shores including Annapolis Royal as late as the early 1900's. A vibrant marine trade continued into the middle of the 20th century.

Export markets of wood and agricultural products from the Annapolis Valley and Hinterland were exported through Annapolis Royal. Import and export material moved over wharfs lining the basin shores of Annapolis Royal. Shipping continued until the early 1980's. The remnants of these can be seen today.

Fort Anne had its own requirements for shipping, both under French and English control. The remnants of the Queens Wharf remain today.

In the late 1800's the Windsor and Annapolis Railway was constructed. This link terminated on what is now the Annapolis Wharf. The railway further increased and supported the export and import of goods.

Photo's (Appendix A) show a very active wharf with dual rails and a "tee" with ramp at end.

The Annapolis wharf in its current configuration (steel sheet piling with filled interior) was completed in the 1980's.

We understand that it was a project done by the Department of Fisheries and Oceans (or Small Craft Harbours) more as a political requirement than an economic one, maintaining for a limited future, a structure with decreasing usage.

Recent upgrades including the addition of a floating access dock and ramp installed by the Annapolis Wharf Association in 2013 were completed to encourage recreation and commercial access.

Adjacent the existing structure to the north is a marine railway originally installed as a community-based facility, is now owned and operated by a private company with an additional facility in Digby.

We have received mixed messages as to the need and impact of the wharf on the existence of the haul-up. Owner's have proposed that the wharf's existence is vitally important to the haul up whereas the Town reports that their inquiries drew a blank and no interest from the haul-up operators.

Prior to limiting access, the wharf also served as additional parking for the adjacent Theatre and Farmers and Traders Market functions. It provided a wonderful viewing point both looking back at the Town and out at the Annapolis Basin and Grandville Ferry across the water.

A Tai-Chi group met regularly at the end of the wharf year-round. Visitors were able to see the scale of the tides (approximately 10 metres).

The Town of Annapolis Royal has commissioned studies as part of it's Climate Adaption Strategy. These include a report, approval of funding, and detailed construction documents for a living shoreline from the edge of the Parks Canada property to property south if the wharf. This work is slated to be constructed in the fall of 2026 and spring of 2027.

A further report from CIMA, dated January 2026 recommends the continuation of this approach moving north and including the wharf.



Photo Credit Annapolis Heritage Society

3. CURRENT USE

The wharf is now limited to any access. Pedestrian use is limited to areas identified by barriers to restrict access to the edge because of fall risk at low tide.

The Annapolis and District Volunteer Fire Department have a launch ramp for marine work emergencies to the north between the existing wharf and the haul-up.

4. METHODOLOGY

The report commenced with a search of existing drawings, reports or other background material to try to determine the details of construction and implementation of the current structure.

No records have been located from the Town records or from contact with the Department of Fisheries and Oceans.

Local archives (Annapolis Heritage Society) provided a wealth of photos (Appendix A) from various times leading up to but not including the construction of the current iteration.

It appears from these photos that the current wharf faced with steel sheet piling was installed over a rock filed wood crib and wood piling construction.

Without further destructive testing (not a part of the scope of this report) it is not possible to determine if any contaminated (pressure treated, creosoted, etc.) materials are present in the existing wharf structure. This makes it very difficult to provide costing. Disposal costs of contaminated materials can be very significantly greater than those of uncontaminated materials and managing material onsite can become more difficult.

Initial, informal discussions with DFO indicate that furthering the “Living Shoreline” approach already approved for the Town to the south of the wharf may receive a positive response.

Depending on the nature of work undertaken, review by Fisheries and Oceans Canada may be required. Their regulatory input and requirements depend on the impact of the proposed work on the surrounding fish habitat.

A site visit was conducted on January 28th. The visit was impaired by heavy snow. The visit which took place art low tide confirmed deterioration of the steel piling and emphasized the scale of the exposed structure. The wharf surface was not visible.

5. RECOMMENDATIONS

The current situation leaves the Town of Annapolis Royal in a quandary. There is no current economic purpose or use for what remains of the wharf, other than as an attraction. The Town's insurers consider it a hazard and have put restrictions on its further use.

There is strong community support for its retention and use but we speculate that would diminish quickly if any work on the wharf or upkeep were to raise the tax rate.

The authors have concluded six (6) possibilities for its future as follows. The report is to focus on the adaptive re-use of the wharf but it is important to articulate the consequences of other action.

1. **Abandonment**

   If the wharf were abandoned, it is our understanding that as it deteriorates further and potentially spreads its current footprint that the Town can be subject to fines under the Navigable Waters Act, Department of Fisheries and Oceans.

   This fine (theirs) can be a million dollars ($1,000.000.00) or greater. Therefore, if no future use or purpose is identified, the Town may be fined and required to remove what is there.

   If the Town of Annapolis Royal decides abandons the wharf in its current condition, it may become subject to fines and legal liability as the structure continues to deteriorate, becoming a hazard to navigation, the environment, or the public with no maintenance or repair.

   Under the Canadian Navigable Waters Act, it is the owner's duty to report if a structure is likely to cause danger to navigation and to take all reasonable prevention measures. The Town may be ordered to repair or remove the wharf under this act. If the Act is violated, the Canadian Navigable Waters Act can fine up to $500,000 on the first offense, and up to $1,000,000 on the second.

   If the abandoned wharf were to collapse, it could become a risk to public safety and the environment. The Town of Annapolis Royal risks being held liable for personal injury, damage to property, and damage to the environment. The Fisheries Act can hold the Town liable for the costs and expenses incurred due to unauthorized deposit or danger of deleterious substances in water.

   Maintenance Requirements: None.
   Service Life: Unknown.

   Estimated Cost: No immediate cost, but significant risk. If the Town is fined, it will be additional to the required removal / cleanup costs.

2. Removal

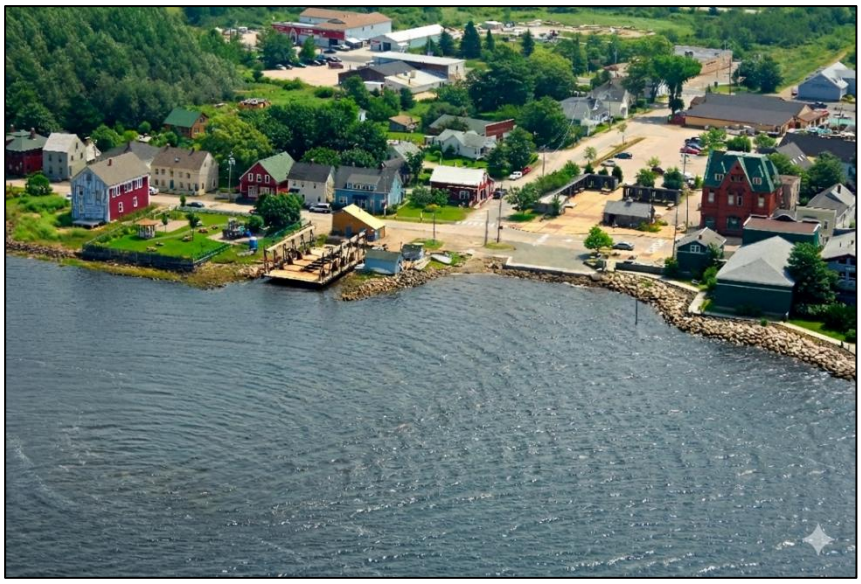
Pros - Eliminates ongoing operation and maintenance costs.

Cons - No public access or potential future development.

Maintenance Requirements: Nil

Service Life: N/A

Estimated Cost: $4 M





3. Partial Demolition-Seawall

This would be accomplished by reducing the height of the sheet piling to almost sea bottom and removing the unsupported material to create a sloped breakwater, stable within the current footprint. Armour stone will be required to protect and stabilize the slopes.

This approach would limit the amount of removals necessary compared to complete demolition. An unknown caveat is the possible presence of contaminated material.

The presence of contaminated material may be determined with a series of test pits.

Pros
- Least costly solution.
- Reduces Town liability.

Cons
- No public access.
- Loss of visual identity as wharf.
- Loss of marine heritage.

Maintenance Requirements: Minimal to none.

Service Life: Infinite.

Estimated Cost: $3.5M (Assuming clean materials)



4. Rehabilitation / Re-Encapsulation

This approach would maintain the existing wharf and its current configuration. This would require new poured concrete or steel sheet pilings and concrete slabs to encapsulate the existing wharf. The condition of existing tie rods must be confirmed via exploratory digging. These may be reused but are likely not suitable.

This would maintain the existing and with the new supports providing a base for any future use such as solar farm, wind turbines, interpretation displays, the addition of guardrails, retail outlets or future buildings.

Pros
- Maintains public access.
- Base for future developments (Possible revenue from builders or retailers).
- Base for climate change adaption and carbon reduction.
- Solar desalination for drinking water and salt production, tidal gravity power generation, solar farm for internet and cell communications.

Cons
- Difficult to fund.

Service Life: 25-50 years

Inspection and Maintenance: Annual inspection for the first few years.

Estimated Cost: $2.2M (Assume existing tie rods are intact)





5. Rehabilitation with Living Shore

This approach would take on some of the demolition approach but retain a surface which could be developed for other uses.

In general, the top surface of the existing wharf would be reduced to ± 6 metres from 15 metres in width. The south (down river side) steel piling would be removed and a living shoreline shore protection system installed similar to the system approved for the harbour front already.

The reduction of the surface width reduces the extent of the terraced living shoreline beyond the existing footprint of the wharf. This approach and reduction may be easier to get approvals.

The reduction of the top surface reduces long term maintenance for the Town.

The north (upriver side) would be stabilized with a new retaining system likely a poured concrete wall out boarded of the existing steel sheet piling.

Initial observations indicate that the end of the wharf will require new construction, also concrete. The steep drop-off channel at the end of the wharf will define the extents of the terraced living shoreline base construction.

Pros
- Maintains public access.
- Surface suitable for uses, shanty's. sea cans marine related displays, possible commercial use, and Duguay displays.
- Base for climate resiliency opportunities; solar farm, tidal generator.

Cons
- Ongoing maintenance for Town.
- Continuing safety hazards as defined by the Town's insurers to be ameliorated with guardrails and structures.
- Cost.

Service Life: 25-50 years

Inspection and Maintenance: Annual inspection for the first few years. Maintenance expected later in service life.

Estimated Cost: $4M (Assumes clean material)

5. Rehabilitation with Living Shore

This approach would take on some of the demolition approach but retain a surface which could be developed for other uses.

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Initial observations indicate that the end of the wharf will require new construction, also concrete. The steep drop-off channel at the end of the wharf will define the extents of the terraced living shoreline base construction.

Pros
- Maintains public access.
- Surface suitable for uses, shanty's. sea cans marine related displays, possible commercial use, and Duguay displays.
- Cost.

Cons
- Ongoing maintenance for Town.
- Continuing safety hazards as defined by the Town's insurers to be ameliorated with guardrails and structures.

Service Life: 25-50 years

Inspection and Maintenance: Annual inspection for the first few years. Maintenance expected later in service life.

Estimated Cost: $4M (Assumes clean material)







6. Unique Event

It is difficult to imagine that funds for option 1, 2, 3, or 4 from other public sources are likely. There is no justification of the wharf's rehabilitation other than public access and the possibility of limited seasonal activity.

A unique experience might gain traction from funding sources focused on visitor development.

Many residents and visitors are attracted by and fascinated by the tides. There are limited chances to "experience" it. Events such as on the Dining on the Oceans Floor take advantage of the tides but do not directly display them.

A sixth option for the wharf would be to take option 5 and further develop it. New construction is required for the end of the wharf if it is to be rehabilitated.

This could be constructed as a marine experience. The new construction (within the current footprint) be made as a watertight tidal viewing area. A series of vision panels would be installed in the new construction. The shore end of the "Auditorium" be terraced to allow visitors to sit with a view of the rising or falling tides which move at a rate of almost a metre every half hour. This auditorium space could have displays (AV or static) depicting the marine history of the area and the larger story of the Bay of Fundy.

It might even allow visitors to see fish and marine life through the vision panels.

Such an approach could be unique enough to attract funding from sources outside the Town.

Pros
- Unique and additional attraction to the Town.
- Possible funding assist
- No operation costs.

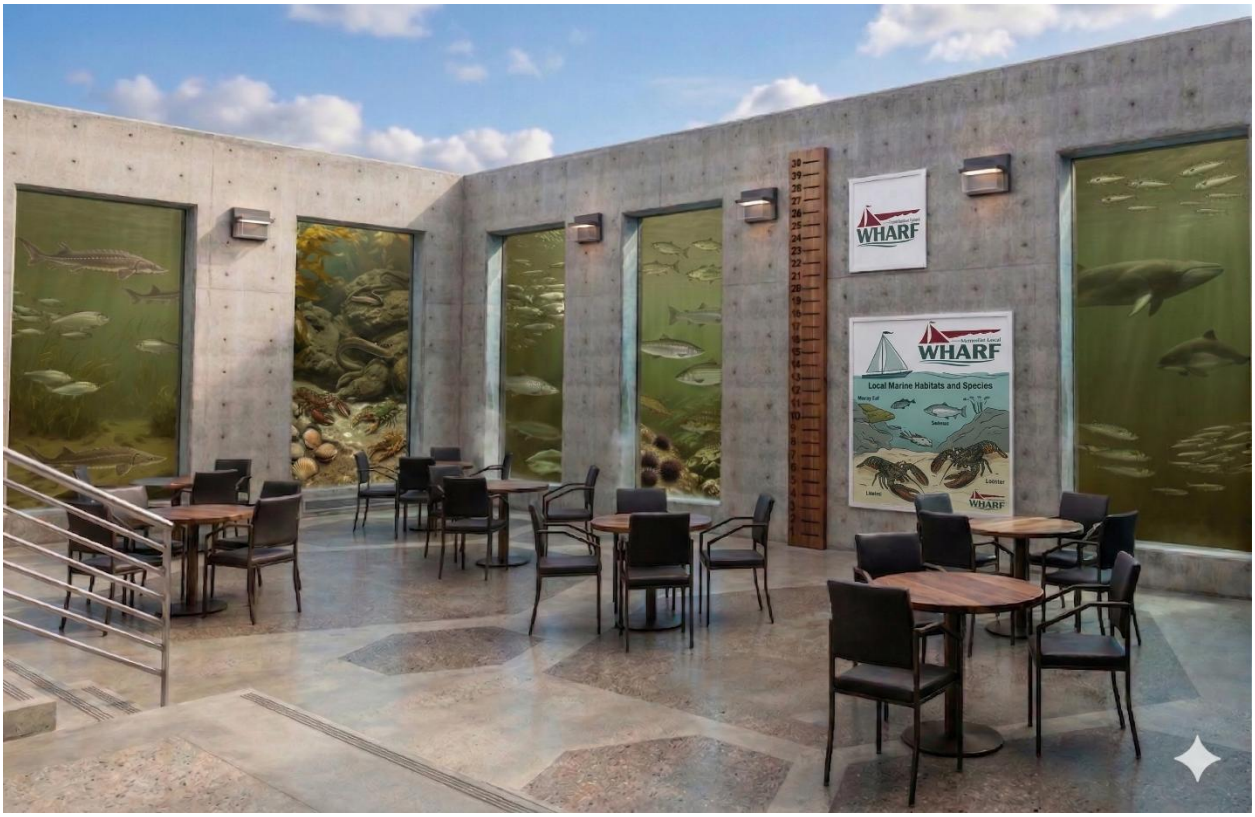
Cons
- Technically challenging
- Cost.

Service Life: 25-50 years

Inspection and Maintenance: Annual inspection for the first few years. Maintenance expected later in service life.

Estimated Cost: $5.6M (Assumes clean material)




WHARF
WHARF
Local Marine Habitats and Species

6. REGULATORY REVIEW

The selected solution will require review by Fisheries and Oceans Canada under the Fisheries Act. Preliminary concepts were submitted for initial feedback, and the Department emphasized minimizing the project footprint wherever possible, with a preference for less intrusive design approaches.

Approval timeliness from the Department can vary significantly depending on the scope of the project and its potential impact on fish habitat. Projects with minimal additional footprint and limited impact may be approved through a letter of advice, typically issued within a few months. However, if the project is determined to cause harmful alteration, disruption, or destruction (HADD) to fish habitat, a full authorization may be required. An authorization would require comprehensive consultation, the development of habitat offsetting measures, and formal regulatory approval.

Rehabilitation projects involving habitat creation, such as the proposed construction of terraced living shorelines, are subject to the same regulatory review process as other project types. However, preliminary feedback from the department indicates that this approach will be viewed favorably when assessing habitat offsetting requirements.



Photo Credit Annapolis Heritage Society

APPENDIX A – PHOTOS

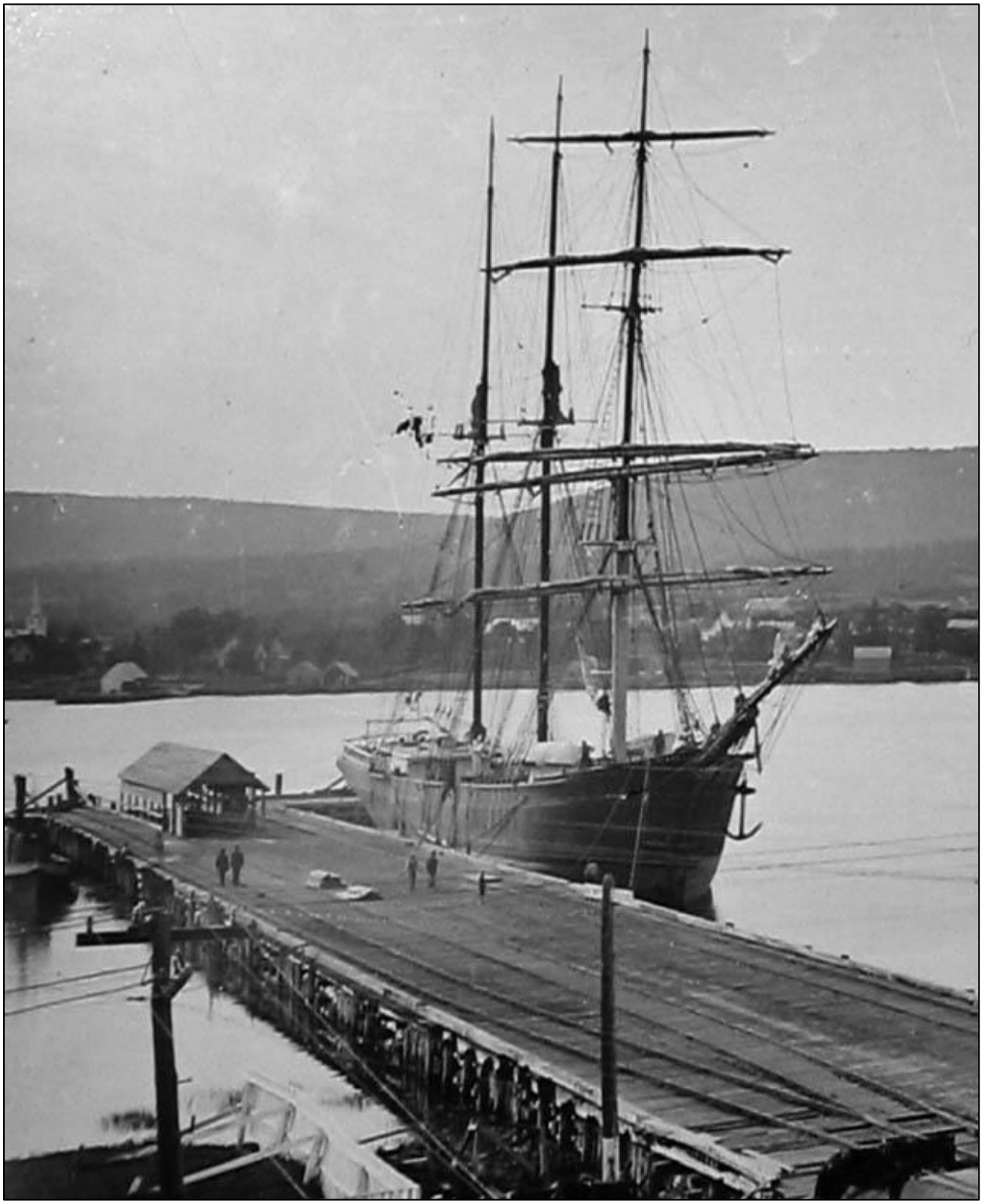


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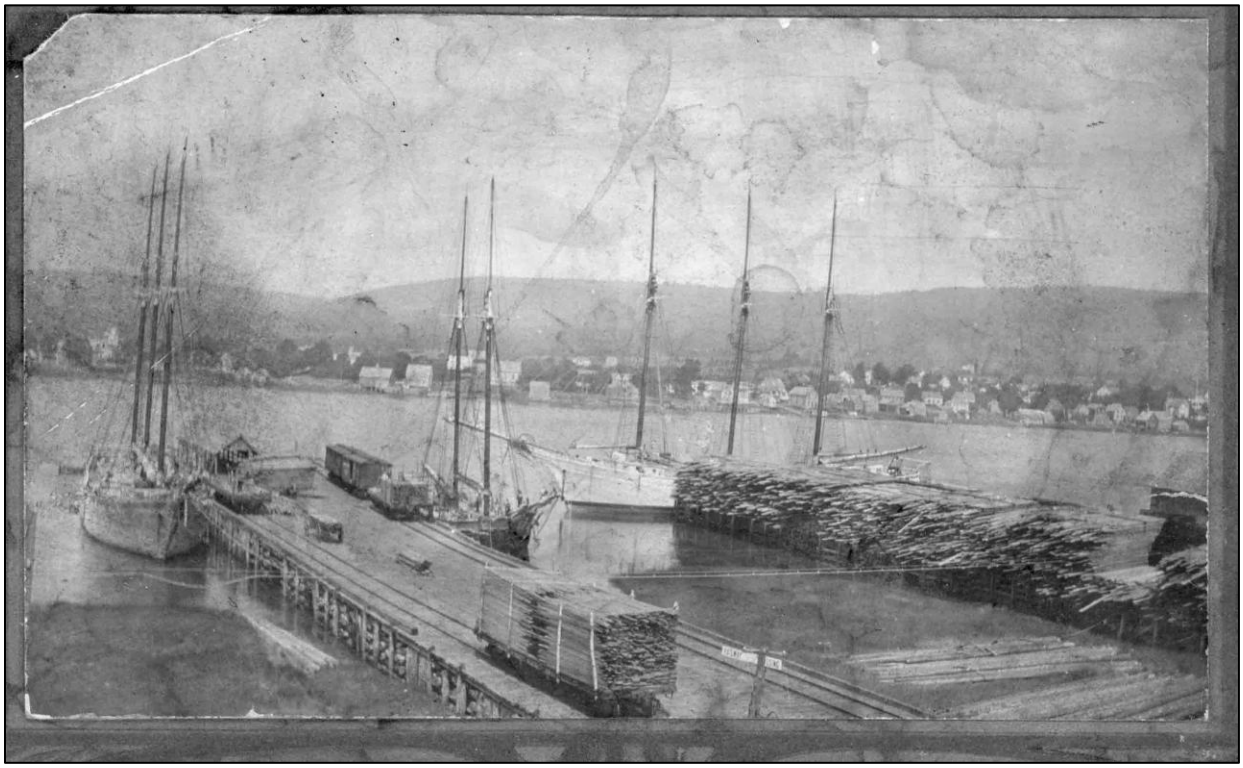


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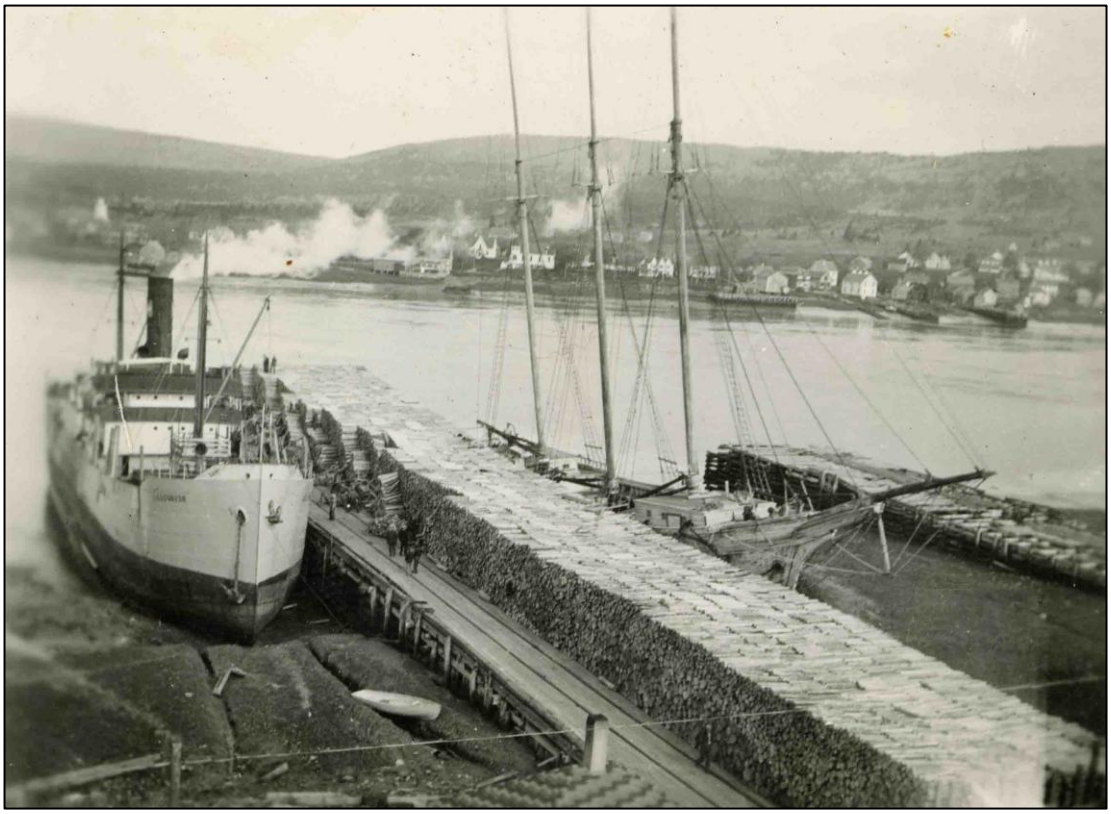


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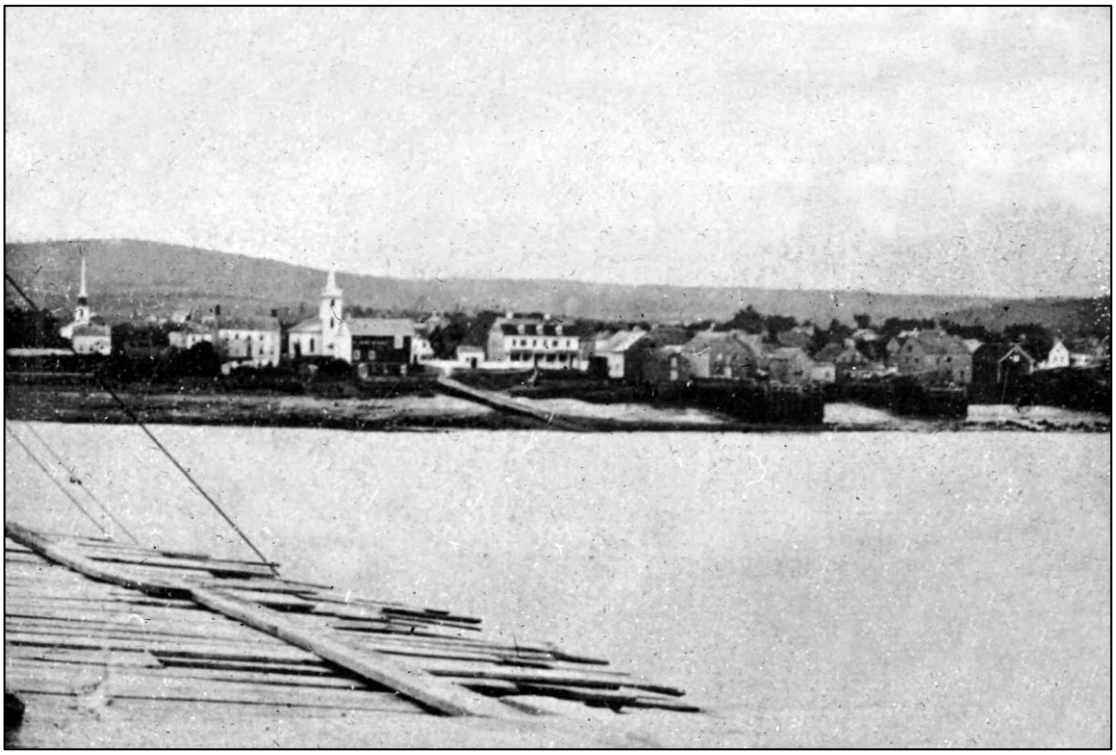


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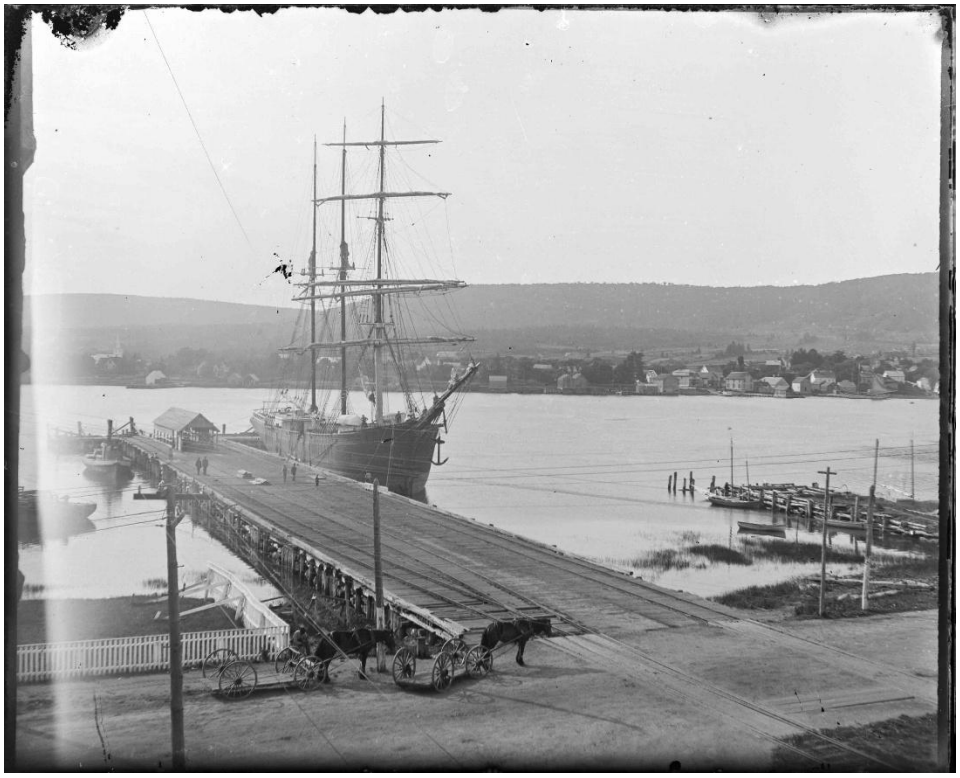


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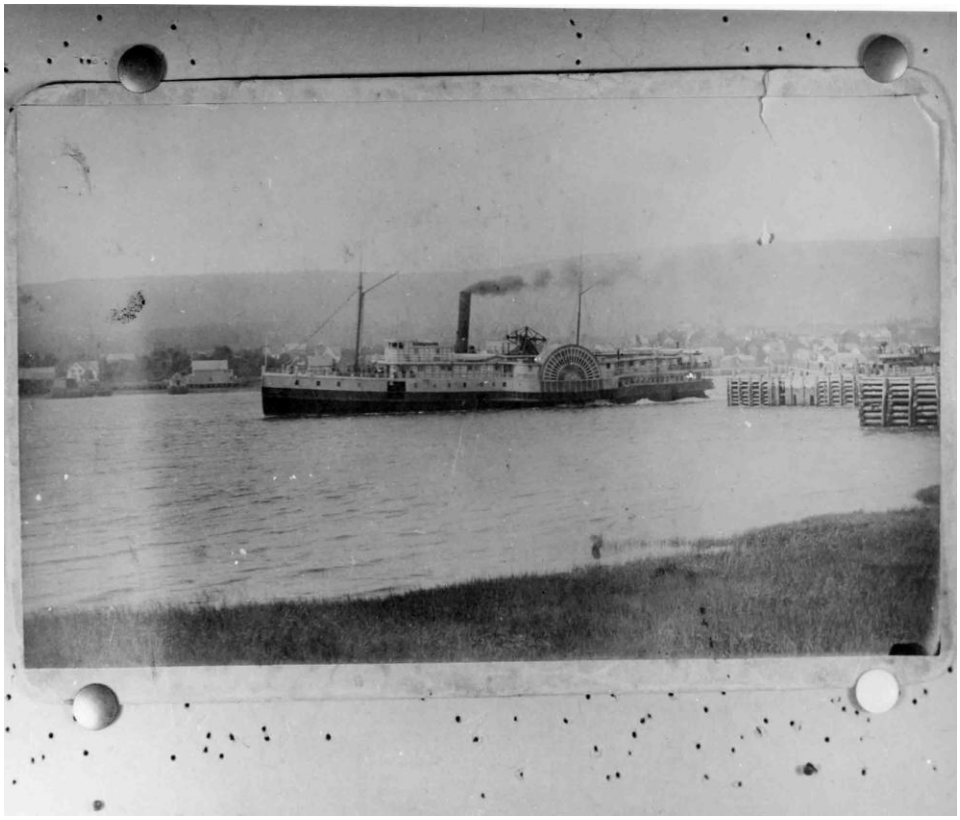


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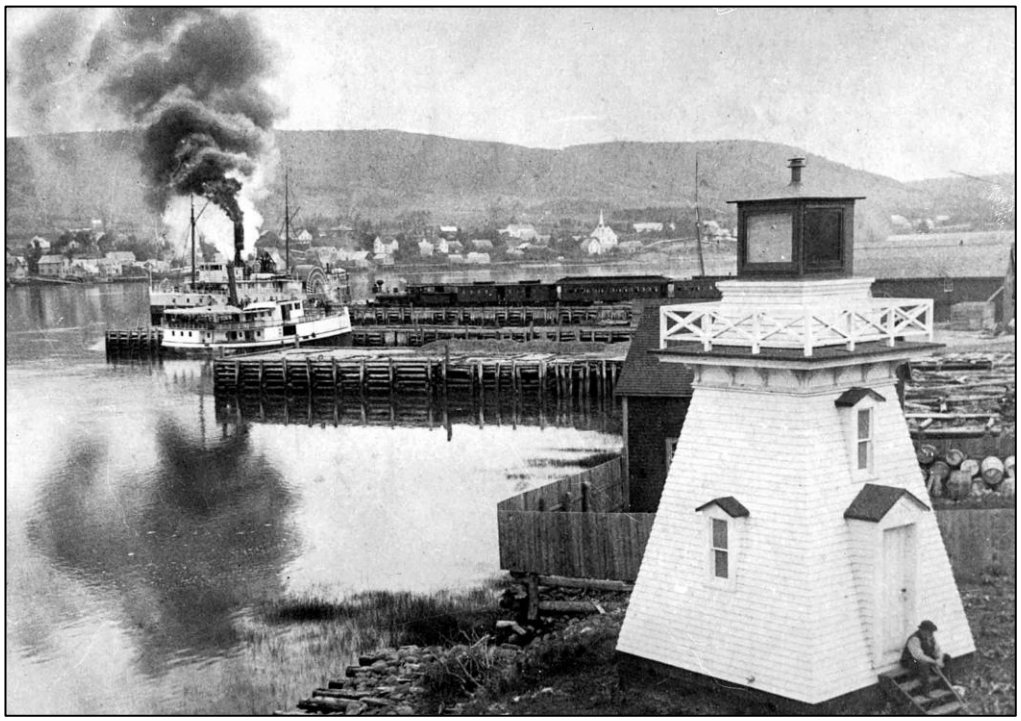


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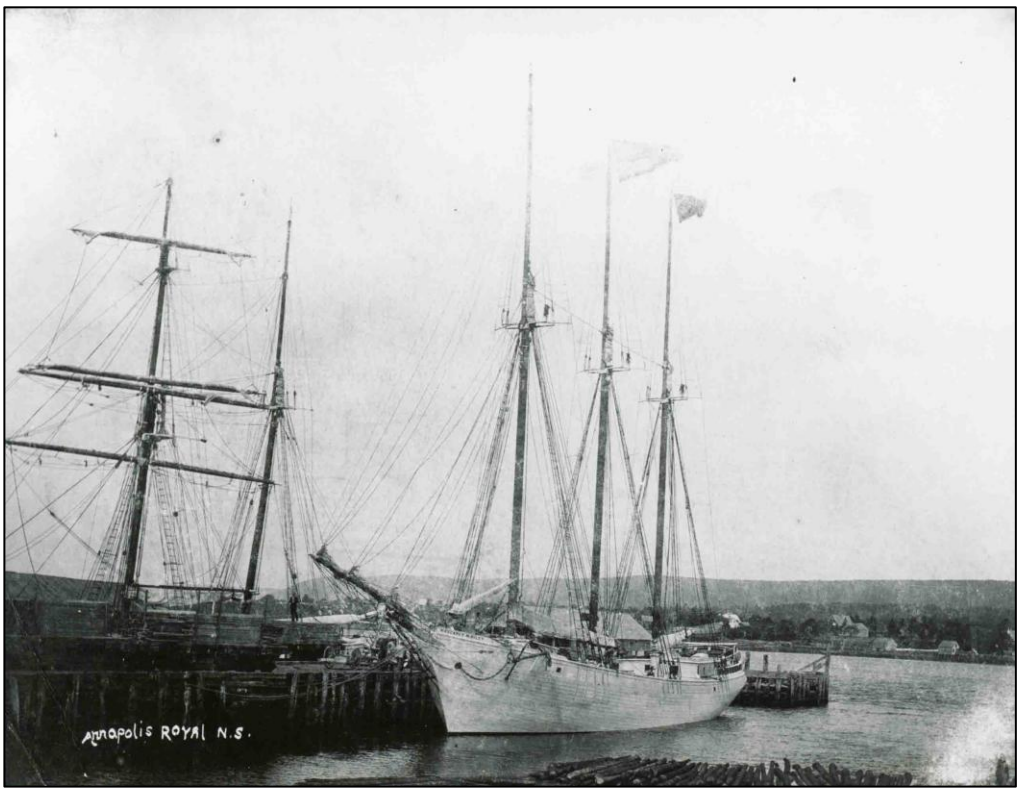


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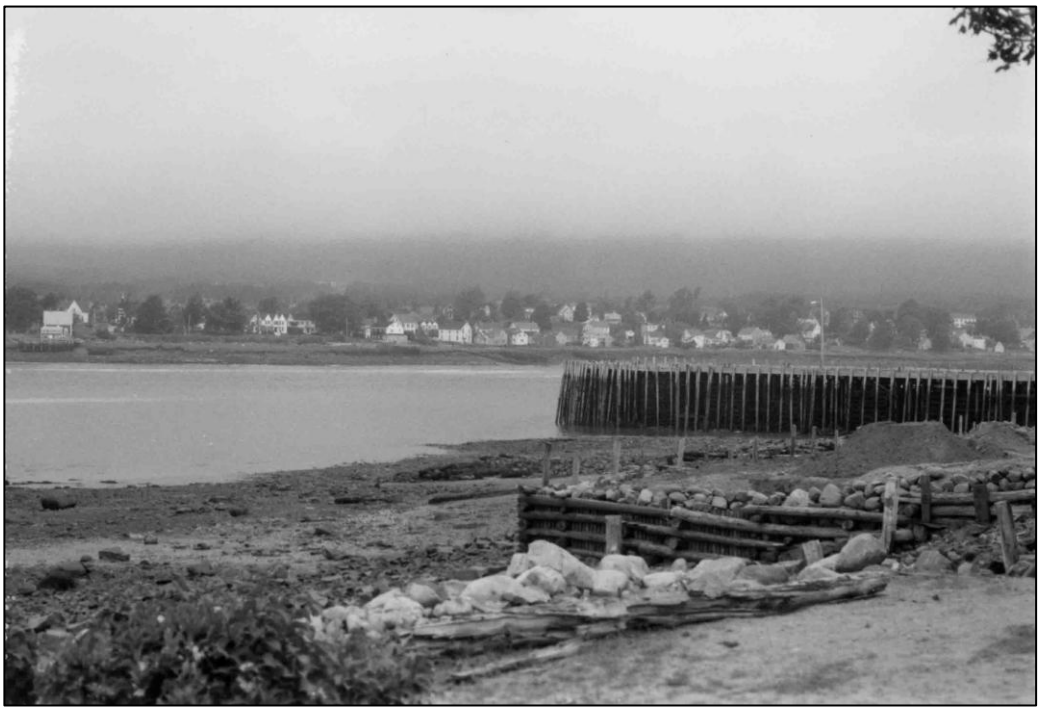


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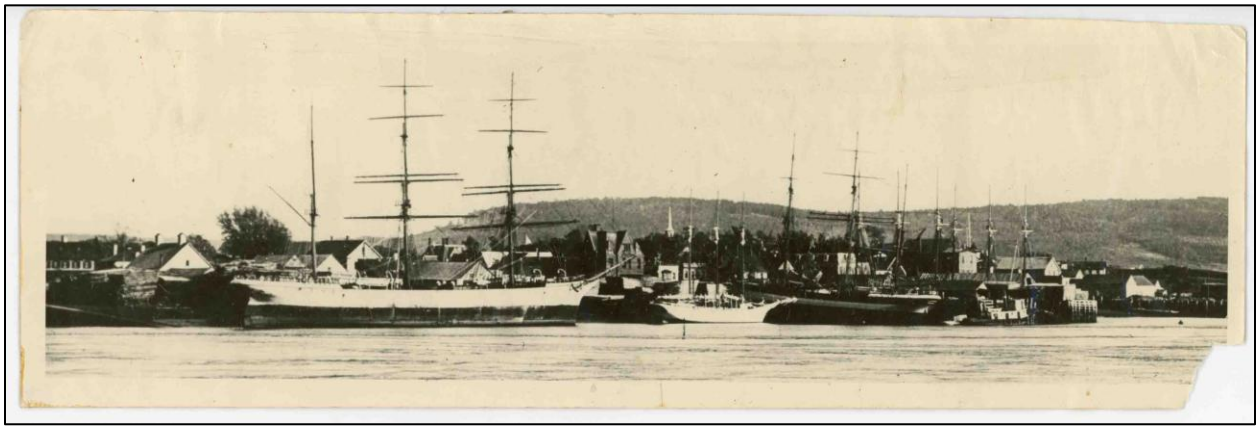


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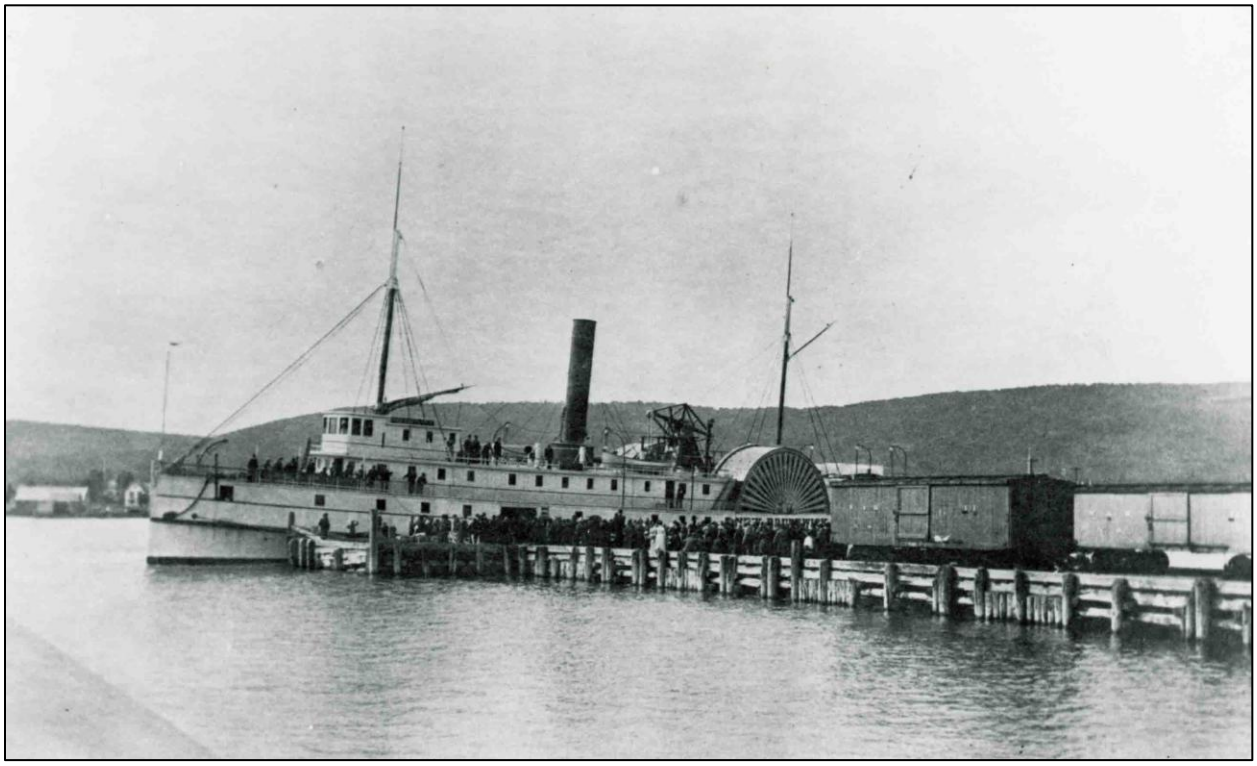


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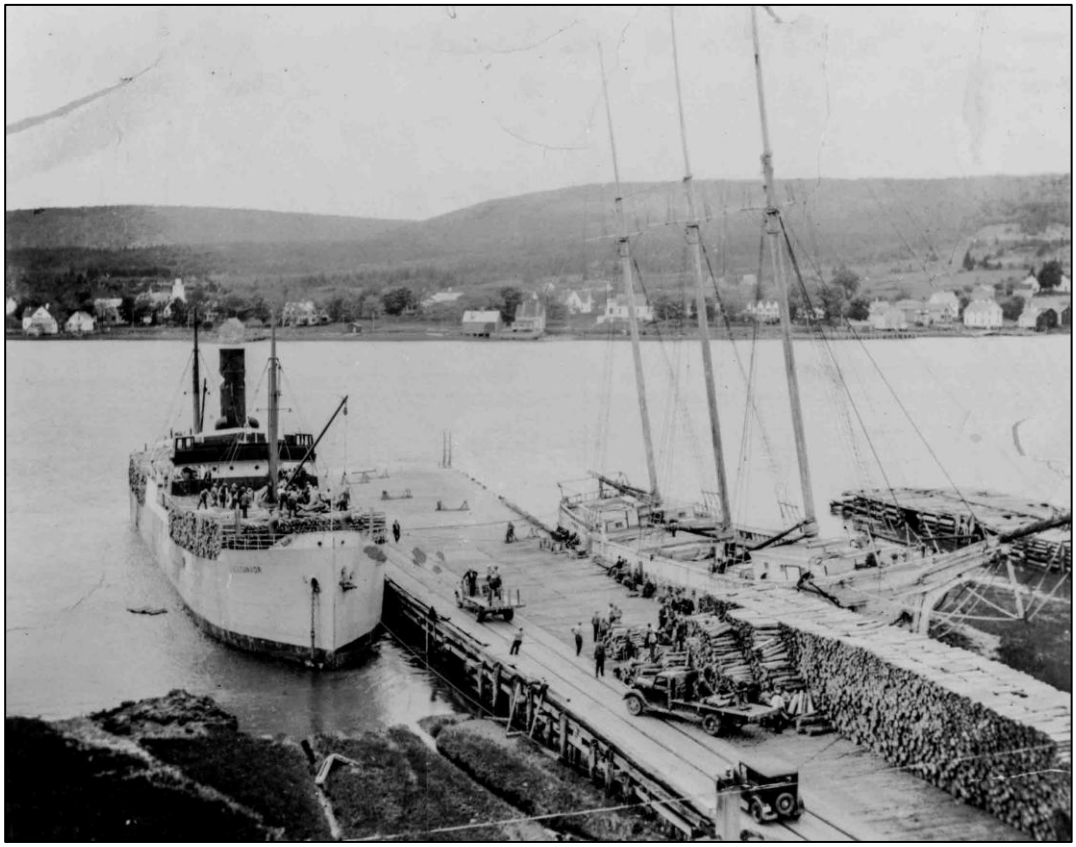


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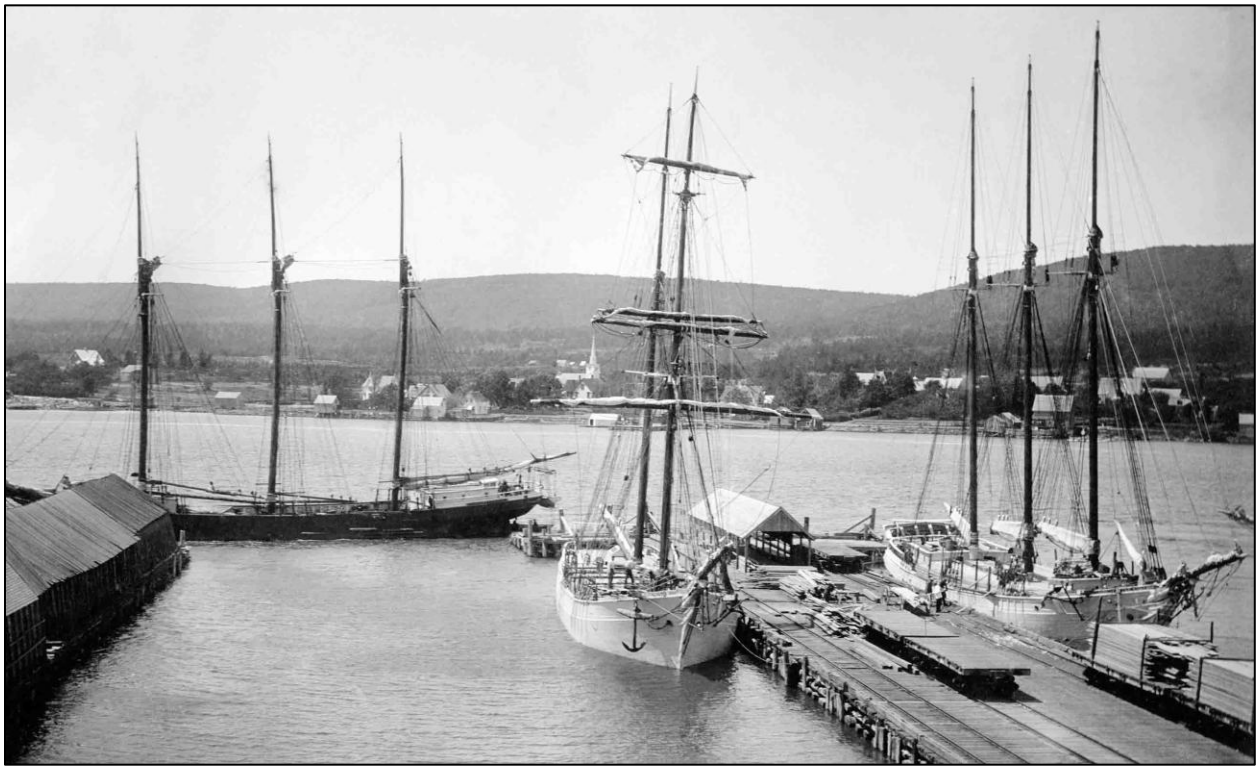


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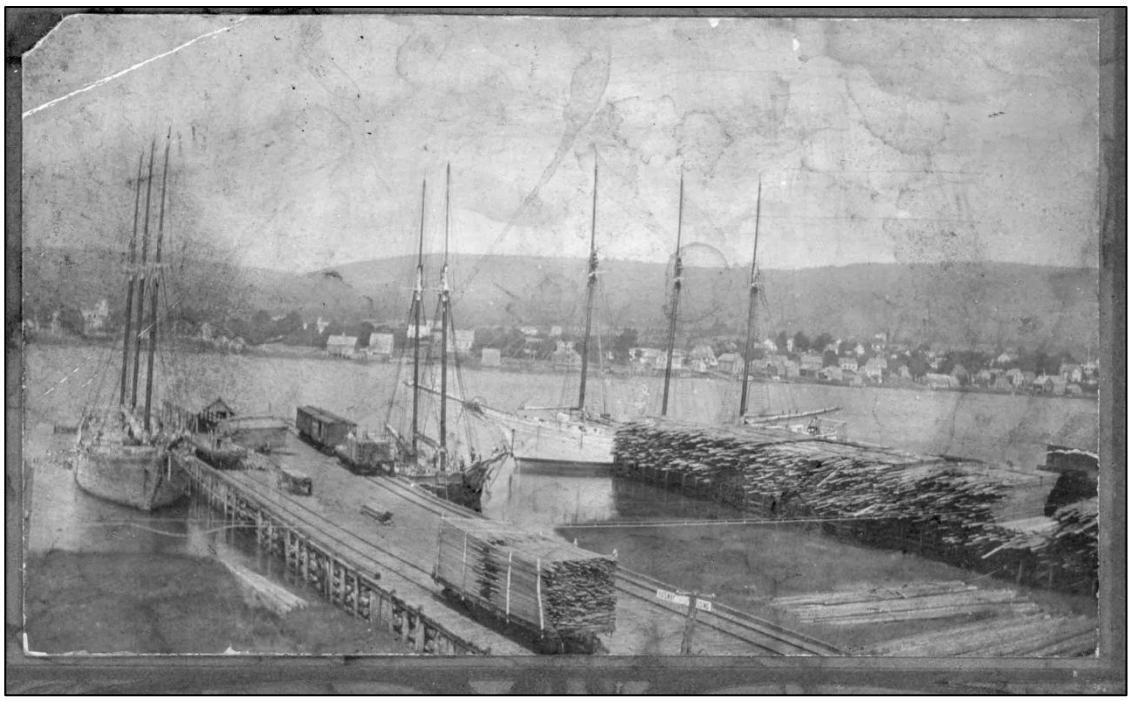


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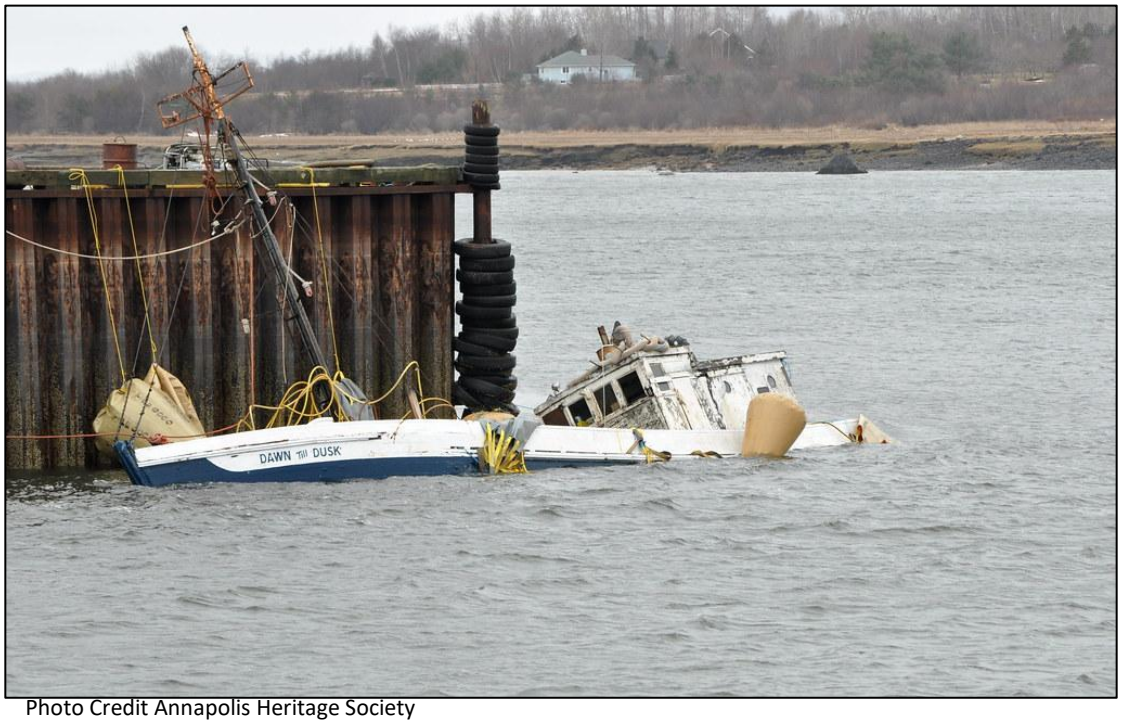


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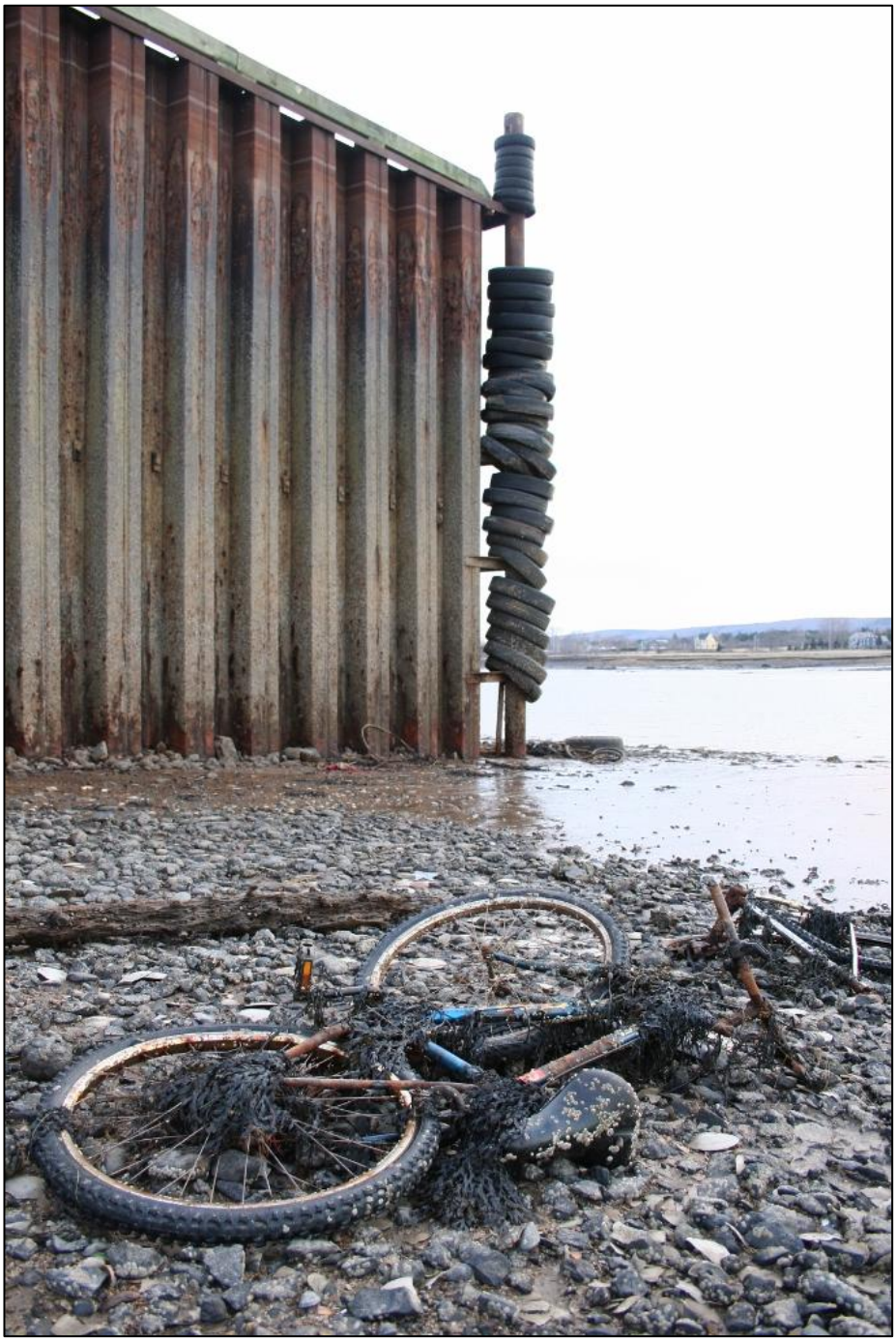


Photo Credit Annapolis Heritage Society

APPENDIX B – ABLE ENGINEERING WHARF ASSESSMENT AND PHOTOS 28 PAGES



2025

ANNAPOLIS ROYAL WHARF

STRUCTURAL ASSESSMENT AND CONDITION REPORT

Prepared For

Annapolis Royal
Nova Scotia

Town of Annapolis Royal
285 St. George Street
Annapolis Royal, Nova Scotia

Prepared By

ABLE
ENGINEERING | LAND SURVEYING

ABLE Engineering Services Inc.
9153 Commercial Street
New Minas, Nova Scotia

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- Additional Wharf Pictures

1 INTRODUCTION

In 2022, the Town of Annapolis Royal approached ABLE Engineering Services Inc., “ABLE”, to complete an annual structural assessment of the town wharf. The following report will represent the fourth annual structural assessment performed by ABLE.

The existing wharf was constructed in the 1980’s by D.J Lowe Contracting. At that time, sheet piles were installed around an existing wooden structure, filled with rock and the surface then paved.

Presently, the Town of Annapolis Royal has only one wharf left, which is no longer used by local fisherman and recreational boaters as there is no mooring allowed to the wharf. The portion of wharf closest to shore is still used as parking for the downtown area. Nearly a century ago, there were a dozen wharfs on the Annapolis side of the Annapolis Basin, and 8 to 10 on the Granville Ferry side. An image of the wharfs in Annapolis Royal in July 1931 can be seen in Figure 1.

In 2022, the wharf was found to be nearing the end of its useful life. At that time, the remaining service life was estimated at five years, meaning the wharf would need to be replaced or rebuilt by 2027. The recommendations below have been put forth to maximize the service life remaining of the wharf:

- Parking to be reduced to the inner two-thirds of the wharf’s surface
- Sacrificial anodes be installed on the sheet piling
- Fallen tire fenders be repaired or replaced
- Ladders be repaired or replaced
- Timbers be repaired or replaced
- General hole patching of sheet piling, where possible.

Continued maintenance will be required until the structure is eventually replaced. Unfortunately, funding has not been found to do any of the above noted repairs in the past year. A decision has not been made on whether the Town will try and save it for as long as possible or to upgrade it. The use of the wharf is being restricted by the Town by posting signs indicating that ships were prohibited to tie up to the wharf.



Figure 1 - Annapolis Royal in July 1931

2 STRUCTURAL ASSESSMENT AND CONDITION REPORT

2.1 INVESTIGATION

On June 19th, 2025, ABLE conducted a visual inspection of the wharf during low tide to ensure the sheet piling was exposed.

Wharf Measurements

Each year, the top width of the wharf was measured at 5-metre intervals for its full length to document irregularities and to be used for comparison of sheet piling displacement over time. ABLE took its first set of wharf measurements on June 7, 2022, then again in 2023 and 2024. Comparative measurements to the inside edge of the timber curb can be found in Figure 2 on the following page.

When returning to site in June of 2023, it was observed the curb was displaced to facilitate the addition of a new sign. Measurements for 2023 were again taken to the timber curb, see Figure 2, but a second set of measurements to steel angle iron were also taken. Measurements from 2024, and 2025 have been added to Figure 2 showing measurements from the angle iron have been stable over time.

Readings this year were stable compared to last year with most stations having only a centimeter or two of change. The measurements taken in 2025 indicate the width of the wharf has shown little change in the past year.

Sheet Piling

It is important to mention that holes on the northeast end of the wharf at the bottom of the sheet piles have continued to expand as the steel continues to rust away. Some of these sheet piles have rusted more than halfway off. Complicating this is that a lack of funding has resulted in no cathode protection being added to the steel to protect and extend the life of the wharf, and no repairs or patches to the steel piling have been completed in the last year. As the steel piling continues to rust away it may not be possible to weld patches on in many places as the steel is too thin and rusted to hold the patches. Unfortunately, no maintenance or repair work is yet scheduled for this year on the sheet piling or to attach the anodes to slow the rusting, which is happening from the inside and outside of the piling.

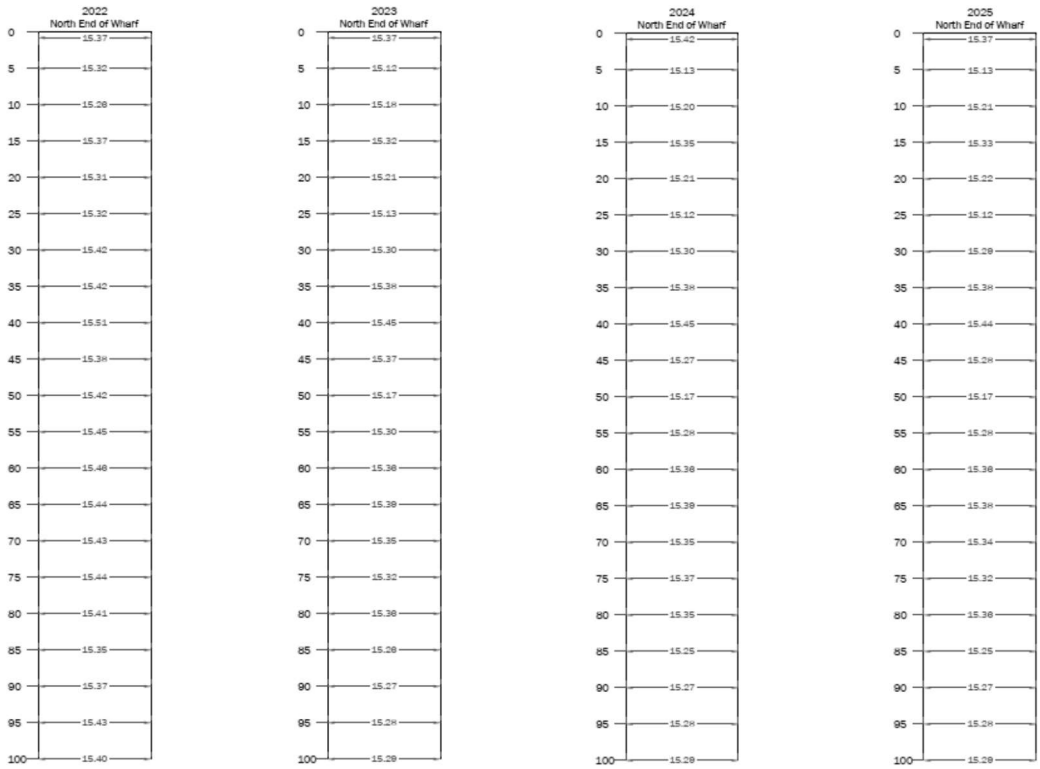


Figure 2 – Annual Wharf Measurements (2022 to 2025, inclusive)

Further deterioration and holes left unpatched from the 2023 assessment were also noted during the May 2024 inspection, particularly on the east side of the wharf. There were several large holes completely through the sheet piles which will allow the rock to wash out if not patched.



Figure 3 – East Side of Wharf

The sheet pile deterioration was most pronounced on the lower sections of the east side near the north end (see Figures 4 and 5). It was noted that there are six large holes near the bottom of the wharf where the floating ramp sits at low tide.

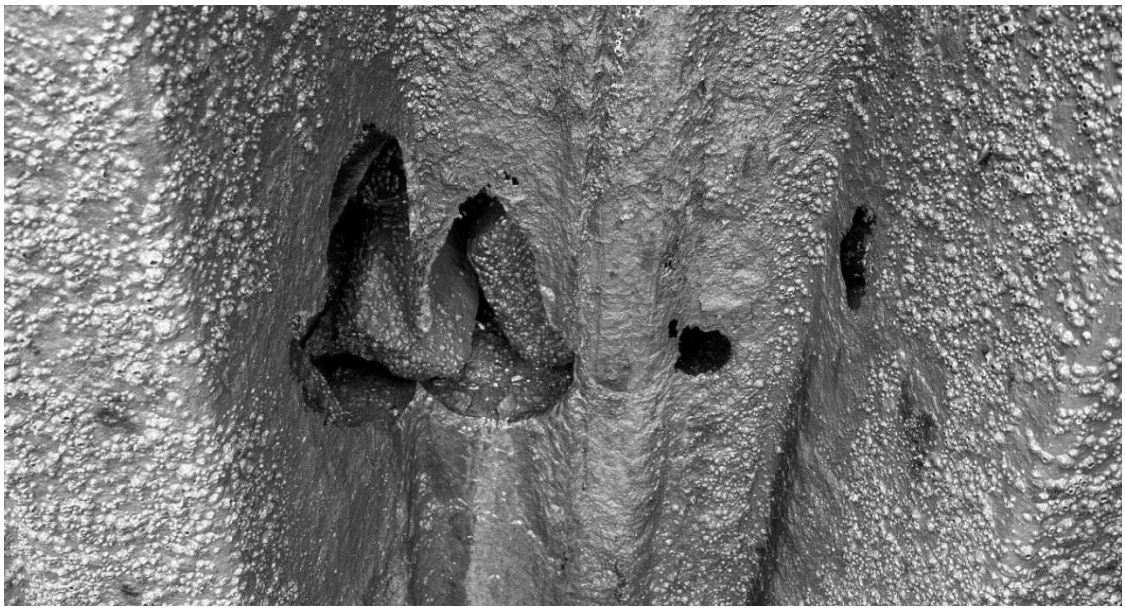


Figure 4 – Rust Deterioration on Lower East Side of Wharf 2025. Notice the new holes and the larger size since last year.

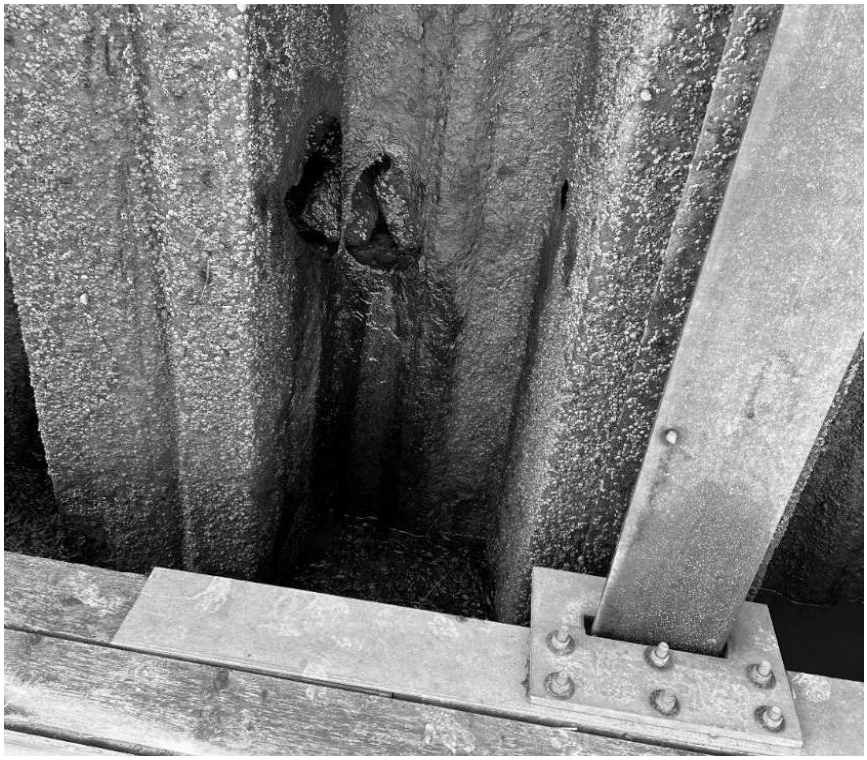


Figure 5 - Sheet Pile Deterioration at Drainage System Level, East Side of Wharf Near North End 2024

The area of rust deterioration at the bottom of the structure is of greatest concern as the sheet piles continue to rust away. The piles will eventually rust off and the rocks and filling the structure, will spill out. As mentioned previously, the weight of the structure rests on these piles. Further deterioration and rusting will result in interior rock spilling out and structure collapse.

During the 2025 inspection, it was noted that on the west side the rusting is more pronounced on the top 10 feet of the steel sheet piling. However, rusting around the drains near the bottom is also expanding. (see Figure 6 and 7).



Figure 6 – *West Side of Wharf*



Figure 7 – West Side of Wharf (Middle Section)

Ladders

During the 2025 inspection, it was noted the existing ladders are no longer in use but are available in case of an emergency for someone in the event of a fall. It was noted that warnings are posted that mooring of boats is no longer permitted.



Figure 8 – Floating dock with aluminum ramp/stairs.



Figure 9 – Ladder on East Side with rungs removed.



Figure 10 – Portable aluminum ladder in good condition (West Side).

Bollards

The steel bollards themselves appear to be in good condition; however, they are supported on top of rusting and deteriorating sheet piling. This infers they are only going to hold as much as the sheet piling beneath them can support the lateral loads. The bollards can be seen in Figure 10. With no ships or boats tying up anymore, they will no longer be used for their intended purpose.



Figure 11 - Steel Bollards Anchored in Concrete

Timber Curbs and Tire Fenders

The wharf's surface has an 8" x 8" timber curb running along the perimeter. The condition of the curbs has deteriorated and are considered of poor condition. Some of the timbers were seen to be rotting (Figure 13) with a notable difference in the timber on the east side of the wharf compared to the west (in better condition). The steel that the timbers are fastened to is deteriorating. Large rocks and caution tape have been placed on the east side of the wharf warning of the timbers that have deteriorated to the point that they would no longer stop a vehicle from going over the side. Therefore, the rocks have been placed along the edge to keep vehicles back.



Figure 12 – Timber Curb with Fallen Tires



Figure 13 – Rotten Timber Curbs on East Side of Wharf

The tire fenders that used to hang on the sides of the wharf to prevent vessels from damaging the wharf (and themselves) have all rusted off. The steel cables holding them in place rusted away, and the tires have fallen to the bottom of the wharf (Figure 12). No tire fenders remain on the wharf and they are no longer needed as boats can no longer dock here.

Floating Adjustable Dock

Small boats would likely use the floating adjustable height dock at the east side of the wharf at the north end if they were allowed, but this is no longer allowed, and it is roped off. This is much newer and was not part of the original construction. It appears to be in much better condition (Figure 15).

Asphalt Deck

The asphalt deck is still in fair condition, but has some signs of settlement and longitudinal cracking 12 to 24" from the side of the wharf.

In addition, some grasses and vegetation are starting to grow in the cracks in the asphalt. There does not appear to have been any substantial loss of materials from inside the rusting piles and the depressions that exist along the sides do not appear to be any worse when compared to 2022.

The asphalt should be observed closely and inspected frequently for any signs of further settlement. An example of asphalt settling along the sides of the wharf can be seen in Figure 16.

Sheet piling repairs, as previously mentioned, should be carried out this year to prevent the condition of the asphalt deck and wharf from further deterioration. Particular attention should be given to the lower section of the east side.

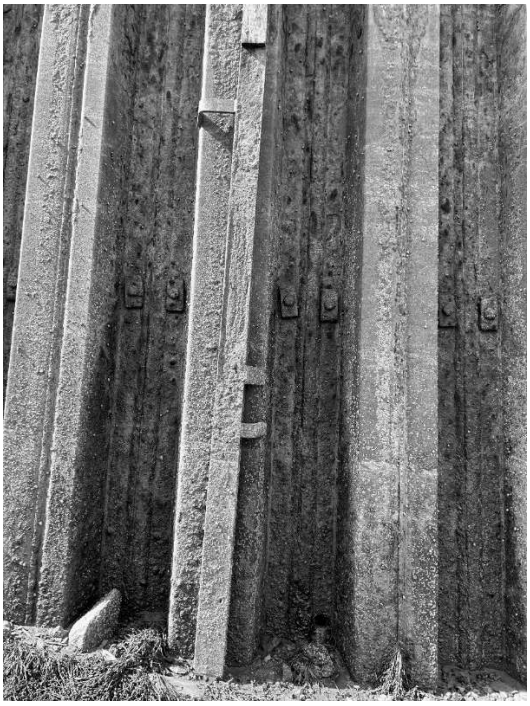


Figure 14 - Wooden Fenders on Side of Wharf Missing



Figure 15 - Floating Dock for Recreational Boaters



Figure 16 –Settling Along Sides of Asphalt Deck

Benches & Telescope

Park benches have been installed on the north end of the wharf. These also act as traffic barriers to keep vehicle traffic from driving out to the end of the wharf. In addition, a telescope was installed in this area to allow users to view the water and marine life along the Basin.



Figure 17 - New Bench Seats

2.2 STRUCTURAL ANALYSIS

The wharf working surfaces are supported by rocks and gravel in crib work inside the sheet metal pile walls on three sides. Loads from trucks and vehicles are exerted in a downward direction supported by the underlying stone fill, however, there is a lateral component of this which is resisted by the sheet piling and the steel rods running under the wharf into the cribwork. The condition of these rods, which would highly likely be deteriorating due to the twice daily saltwater flow, is ultimately unknown.

Previous measurements of the sheet metal pile thickness by Hatch Engineering in 2018 (6 years ago) showed that it was rusted away by as much as half of the original material thickness in some places.

It is recommended the 12 metric tonne weight limit and restrictions on parking, be maintained. No parking should be allowed on the outer 30 metres of the wharf. The addition of the new heavy bench seats on the wharf, and a couple of large rocks, has effectively blocked traffic from the end of the wharf and made it more attractive for pedestrian use.

It is recommended that immediate repairs be made to patch any holes in the sheet piling with ½" steel plate welded in place to solid steel materials around the hole. This will help prevent the loss of rock and fill from inside the structure which would further weaken it, and to help maintain the structural integrity of the sheet piling.

The northeast end of the wharf on the east side has several rather large holes (6) that need immediate repair near the low tide level. These are accessible at low tide from the floating ramp on that side. These appear to have been missed the last two years when repairs were being made, and these are the sheet piles that when they fail will cause the most damage to the wharf.

The wharf should be inspected regularly at low tide to see if any larger holes develop in the sheet piling, and for the loss of any fill from inside. Should this happen, the repairs should be made as soon as possible, and vehicles restricted from parking nearby until the repairs are completed.

A cathode protection system using zinc anodes was recommended starting in 2022 to help protect and slow the loss of the steel to corrosion. This should be installed as soon as possible. If funds are limited, they should first be installed on the outer or north end of the wharf first near the low tide level.

3 EXISTING AND FUTURE USE OF WHARF

As mentioned earlier, the wharf is the only remaining wharf structure in the Town. It has had its use severely restricted and no longer supports the three main uses, which helps to attract people into the Town (tourists, locals, etc.):

- Parking for access to the downtown core
- Access for recreational boaters to dock and access the town
- Use by local fisherman to dock, complete vessel repairs, etc.

The future use of the wharf is up in the air as the funding has not been available to do major repairs. Now the wharf no longer supports boat traffic or is available for tying up to for visiting boats. It is clear, based on this report and those previous, that the wharf is quickly approaching the end of its useful life. Without significant repairs and maintenance, continued use could pose a significant safety risk. Unfortunately, regular maintenance will not prolong the useful life for much longer, the wharf will need to be rebuilt or dismantled, and both options are expensive.

4 REQUIRED MAINTENANCE AND INSPECTIONS

Below is a list of maintenance and inspections recommended to be completed this year. These are the same as last year as not much maintenance was done on the wharf.

- Patching of the rusted holes along the lower section of the sheet piles at the north end of the wharf.
    - These holes are getting larger. Since they are at the bottom, further pile deterioration could result in rock material from the interior spilling out and the collapse of the north end of the wharf.
    - Potential spillage of rock and materials from inside the wharf on this side, could also damage the floating dock and block the use of the slipway beside the wharf on the east side.
- The useful life of sheet piling can likely be extended, in some areas, with a cathodic protection system using sacrificial anodes, such as zinc bars fastened to the sheet piling. This should be done as soon as possible to slow the rate of corrosion, especially around the lower northeast corner of the wharf by the floating dock.
- Continue patching holes as they appear in the sheet piling to stop the loss of rock from inside the wharf structure. **Note: do not weld patches completely over the drain holes near the bottom of the sheet piling as these are needed to allow water pressure to equalize or be minimized from rising and falling tides.** Repairs of further wharf elements are recommended as follows:
- Replace timbers around top of deck, where needed.
    - This can be done with locally obtained rough sawn timbers. Hemlock and cedar are good for this purpose as they do not need preservatives added to protect.
- Replace wooden fenders along the sides of the wharf.
- Repair ladders up the side of the wharf, these provide a closer place for people to swim to if they fall over the side.
- Patch holes in asphalt where weeds are growing, and as more holes develop.
- Regular inspections are still recommended.
    - In addition, it is recommended that town staff assess the structure to identify any of the above changes monthly and after any major storm. Should damage, movement or settling of the structure be detected they should request the services of a professional engineer for inspection as soon as possible. The Town may wish to consider a twice-annual inspection as the end of the useful life of the wharf approaches.
- As mentioned previously, measurements of the width of the wharf were taken at 5-metre intervals along the length of the wharf. The results shown within this report show it has been relatively stable over the past year. These measurements should also be checked and compared at a minimum once per year to determine if the sheet piles are moving outward. This will most likely provide a good indication or early warning of failure of the steel tie backs that are not accessible to inspect inside the wharf rock fill.
- Pictures of the wharf and any areas damaged should also be taken each year so visual comparison of the change can be noted over time.

5 RECOMMENDATIONS AND CONCLUSIONS

The wharf is nearing the end of its useful life. The steel piling holding it in place is rusting away and there is no way of stopping this; only slowing its progress. Realistically, the wharf can only be expected to last another few years, and by then its use will be severely limited. It is noted that the wharf is no longer used for tying up ships and boats, and parking is restricted to the inner part of the wharf.

The repairs that were made 2 years ago appear to be holding up and have helped to reinforce the sheet piling. This work was mostly done on the west side. Our 2025 inspection revealed that there were several large holes where the sheet piling had rusted all the way through, which appear to have been missed (not patched with steel plates) on the east side near the low water level. These expanding holes should be patched as soon as possible. These are most likely to cause an early collapse of the wharf and need to be prioritized.

It is recommended that the above inspections and maintenance be carried out annually, at a minimum, to assess the continued capabilities and safety of this structure.

- The weight limit of 12 tonnes should be maintained on the wharf and vehicle parking can still be allowed on the inner two-thirds of the wharf.
- No parking should be allowed on the outer section of the wharf. If the rock and materials are contained in the structure, the weight of vehicles is being carried by the underlying rock so parking can still be allowed on the inner section.
- Should any buckling, deflection of the sheet piles, or large holes appear in the sheet piling allowing the loss of rock from inside the structure, then use of the wharf should be further restricted in that area and beyond. Similarly, if holes appear in the asphalt surfaces, parking should be restricted in these areas and beyond.
- Patch remaining large holes in sheet piling.
- Attach zinc anodes to the sheet piling to help slow corrosion.
- Repair or discontinue the use of damaged ladders.
- Replace wooden curb timbers on the top of the wharf.
- Consider signage for areas with uneven asphalt, or patch as needed.

Prepared by:

Robert Rowe, P.Eng., MPH
Project Engineer



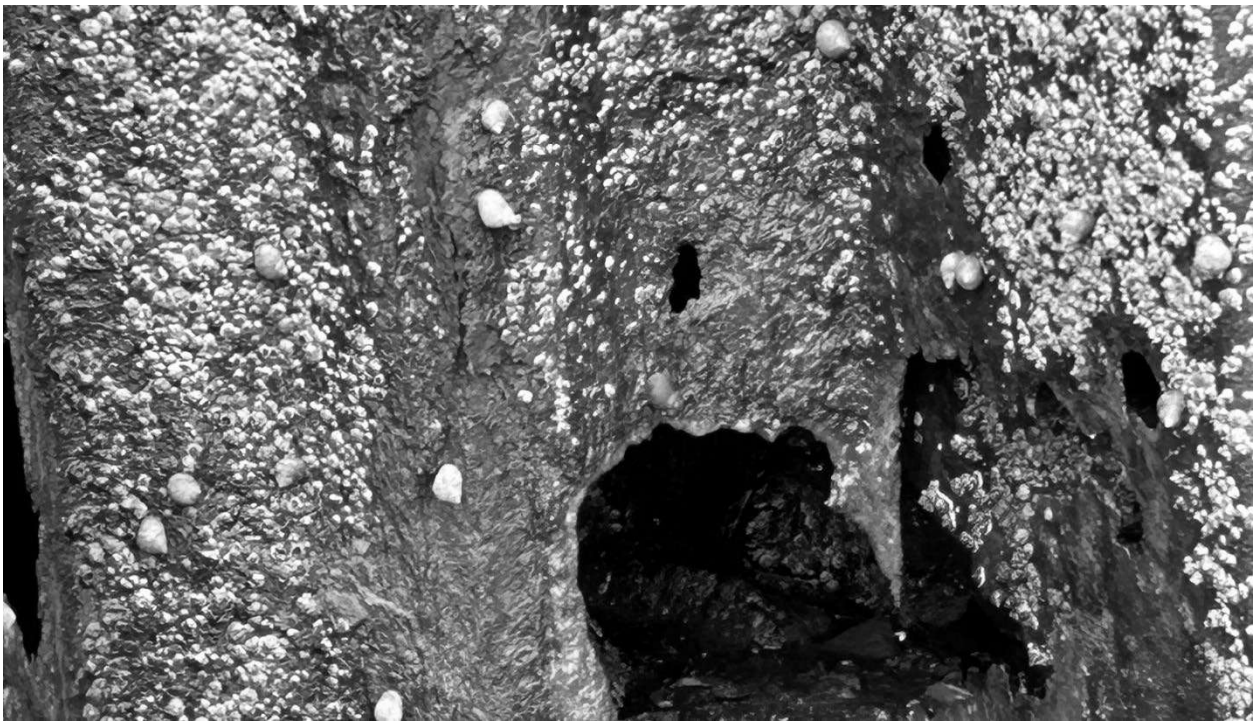
APPENDIX A



East Side of Wharf and Boat Launch



Sheet Pile on Lower East Side Nearly Rusted Through (2024).



Same hole expanded in 2025 from last year shown above.



West side of wharf also rusting away near bottom note some rock ballast gone.



Roped off area on west side of outer wharf to keep people back from edge



East side of outer wharf fenced off closing use of floating dock facility and keeping people away from the side.



Wooden curb rotted away on east side of inner Wharf and large rocks place to keep cars from driving off



Steps cut out of ladder to discourage people climbing on them



Patch on East side of wharf from a couple of years ago rusting through



New signage limiting use and safety throw ring on wharf



Boardwalk approaching Wharf behind Kings Theatre



Existing Parking spots 10 spots.



Approaching Pedestrian Area / View of temporary barriers to Protect against Fall Hazard



Mural painted by local artist and community.



Floating Dock Access from Wharf



Floating Dock at High Tide

APPENDIX C – CIMA REPORT
WHARF REHABILITATION TERRACED FILL EMBARKMENT PROJECT
38 PAGES

Town of Annapolis Royal

Wharf Rehabilitation Terraced Fill Embankment

CONCEPTUAL DESIGN OPTIONS

CIMA+ project number: Z0027061
January 2026 – Version 0A

Town of Annapolis Royal

Wharf Rehabilitation Terraced Fill Embankment

CONCEPTUAL DESIGN OPTIONS

Prepared by:

Raphaël Pouliot, F.Eng., M.Sc.
OIFQ member number: 2022-023
Earth and Environment

Christophe Jenkins, LEED AP BD C, M. Sc.
Associate Partner / Lead Consultant / Strategic Consulting and Advisory Services – Sustainability and Decarbonization

Verified by:

Charles White, Biologist, M.Sc.
Associate Partner / Director
Earth and Environment

CIMA+

300–1145, boul. Lebourgneuf, Québec QC G2K 2K8 CANADA T 418 623-3373 F 418 623-3321

CIMA+ project number: Z0027061
January 2026 – Version 0A

Project Team

Clients

Sandi Millett-Campbell	Chief Administrative Officer - Town of Annapolis Royal
Cassidy Walker	Climate Lead - Clean Foundation
Logan Horrocks	Senior GIS and Adaptation Lead - Clean Foundation

CIMA+ s.e.n.c.

Charles White, biol. M.Sc.	Project Director
Raphaël Pouliot, F.Eng. M.Sc.	Project Manager
François Lambert, tech.	Senior Designer
Gaétan Couture, tech.	Senior CAD Drafter
Christophe Jenkins, M.Sc.	Climate Change Expert and Project Coordinator
Emilie Knight	Administrative Assistant

Version log			
Version no.	**Reviewed by**	**Date**	**Description**
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Appendix B Embankment fill conceptual design

1. Introduction

1.1 Project Description

The town wharf is a picturesque waterfront destination in Annapolis Royal, Nova Scotia (Mindtrip, 2026). It also features a gangway, floating dock and four guest moorings in the middle of the Annapolis Basin (Annapolis Royal, 2026). The wharf was originally constructed using timber, and the existing corrugated sheet piles were subsequently installed as part of its rehabilitation. Unfortunately, following a recent structural report issued by Able Engineering on September 22, 2022, the wharf has been found to require rehabilitation or replacement within the next five years. Since the conclusion of this report, the Town of Annapolis Royal is assessing options to address the structural issues at the town wharf.

The Town of Annapolis Royal subsequently prepared a feasibility study (Town of Annapolis Royal, 2024) addressing flood risk assessment and various adaptation concepts, including options related to the wharf's replacement. The study examined the possibility of constructing a new exterior shell around the existing wharf, rather than rebuilding it entirely, to retain the existing fill as the deteriorating sheet piles continue to corrode and perforate. The proposed shell would also integrate a terraced embankment (the "Terrace") on the south side of the wharf as part of the shoreline restoration efforts, thereby reducing the extent of vertical wall construction required for rehabilitation.

In addition to other shoreline rehabilitation and flood mitigation measures, the feasibility study (Town of Annapolis Royal, 2024) also provided a magnitude cost estimate for the Terrace. Additional work is needed to complete designs for the Terrace and provide a more detailed cost estimate that can be put towards applications for capital funding. The Town is looking for support from a climate change roster expert (CIMA+) to develop design options for the Terrace with a more detailed cost estimate for the options than what was completed in the feasibility study.

1.2 Project Objective

The objective of this assignment is to develop design options for the terrace and to prepare detailed cost estimates for each option, incorporating insights from previous engineering assessments as well as traditional ecological knowledge (TEK). The design options will include:

- Conceptual designs and initial renderings, presenting alternatives with varying terrace elevations and configurations, including differing numbers of terrace levels.
- An expanded cost estimate, building upon the preliminary cost information provided in the flood risk assessment and adaptation concepts report.

1.3 Location of Scope of Work

The Town of Annapolis Royal is located on the banks of the Annapolis River on the northwest coast of Nova Scotia (Figure 1.1).



Figure 1.1: Location of Annapolis Royal wharf

The rehabilitation concept under study consists of a terraced slope on the south side of the wharf. The sheet pile portion of the wharf is excluded from the scope of this report (Figure 1.2).



Source: Town of Annapolis Royal, 2024

Figure 1.2: Initial plan view of the terrace concept (taken from the 2024 feasibility study)

Surrounding the wharf, the existing waterfront has been impacted by over two hundred years of development, which has altered the riverbanks and salt marshes that originally thrived in the intertidal zone. The area between the wharf and King's Theatre has been protected from erosion with a mix of large stones and driven sheet pile walls (Figure 1.3).



Source: Town of Annapolis Royal, 2024

Figure 1.3: Existing conditions at the town wharf (taken from the 2024 feasibility study)

2. Desktop Review and Synthesis of Existing Data and Resources of the Wharf Replacement

Throughout the design process, the Town of Annapolis Royal has made available several reference documents to support the work of CIMA+. The following section summarizes the key documents that provided guidance for this process.

2.1 Climate Change Plan

A climate change survey was conducted at the beginning of June 2022 focusing on getting better insight into how community members in Annapolis Royal understand climate change and the effects of climate change relating to Annapolis Royal. The survey highlighted that the Town has recognized the threats of climate change for decades and continues to seek solutions to protect and safeguard the Town's environmental, economic and social integrity (Town of Annapolis Royal, 2022).

While reducing the production of GHG emissions in the community and corporate sector is a way to mitigate climate change and support alternative solutions to address threats such as global warming, the impacts of climate change are inevitable for the inhabitants of Annapolis Royal:

- Intense heat waves
- Shorter or longer seasons
- Severe weather
- Sea-level rise
- Drought

These impacts will gradually intensify, and future effects must be considered while designing the terrace concept.

The 2022 climate change plan of the Town of Annapolis Royal illustrates four guiding principles, which are:

1. Protect and strengthen natural habitats and biodiversity.
2. Foster stronger collaboration among neighbouring communities to identify shared priorities and opportunities for responding to climate change.
3. Encourage meaningful community involvement by connecting local governments, stakeholders, and residents.
4. Enhance long-term sustainability and multiple benefits of adaptation and mitigation initiatives by aligning them with local economic, social, and environmental goals.

The first guiding principle was an integral part of the thinking and designing behind the terrace's concept decision-making process.

2.1.1 Sea-level rise and Flooding

Climate change, sea-level rise and flooding have accelerated the erosion rate around coastal areas, such as the Town of Annapolis Royal, resulting in faster deterioration of flood protection structures. Sea-level rise will continue to threaten Annapolis Royal in the coming decades, especially in the downtown core (Town of Annapolis Royal, 2022).

Living shorelines were identified as a potential adaptation method to tackle erosion and help the coastline reach a more stable state (Town of Annapolis Royal, 2022). Also known as ecosystem services, living shorelines improve water quality and diversify coastal habitats. In addition, living shoreline approaches, such as coastal forests, salt marshes, as well as vegetated slopes and dunes, protect shores from erosion and provide flood protection. Erosion is a natural process that transpires over time as the water hits the coastline (Town of Annapolis Royal, 2022).

With these preferred approaches, living coastlines and salt marshes were the fundamental elements considered in the conception of the terrace as coastal protection.

2.1.2 Land Acknowledgment and Traditional Ecological Knowledge (TEK)

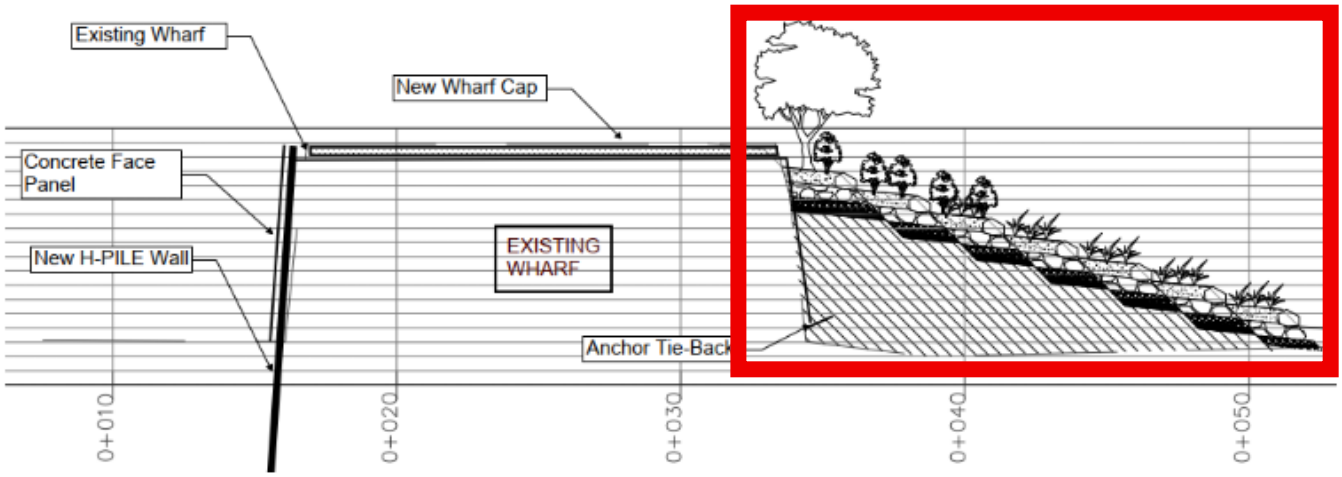
All land in Nova Scotia is considered unceded Mi'kmaq territory. Living in a world affected by climate change, elders, scholars and other Indigenous knowledge holders carry valuable knowledge to help governments and decision-makers address climate change (Town of Annapolis Royal, 2022). In this regard, the terrace concept has great potential for not only consultation, but collaboration on aspects of the project, such as restoring native species' habitat, historical markers, informative signage, or any storytelling through art (Town of Annapolis Royal, 2024).

A research project aiming to recommend climate equity actions to build a partnership with Annapolis Valley First Nation and Bear River First Nation on the project is still in process and no available outcome of municipal engagement with First Nations is currently available. Nevertheless, ecological benefits and native habitats were carefully considered and integrated into the design of the terrace concept options.

It is recommended that the concept developed and presented in this report be shared with the First Nations in order to discuss the proposed approach, explore opportunities for planting native species, establish resilient coastal ecosystems, potentially incorporate historical and informational markers, and ensure that the design option aligns with climate resilience and partnership principles established between the Town of Annapolis Royal, Annapolis Royal First Nation, and Bear River First Nation.

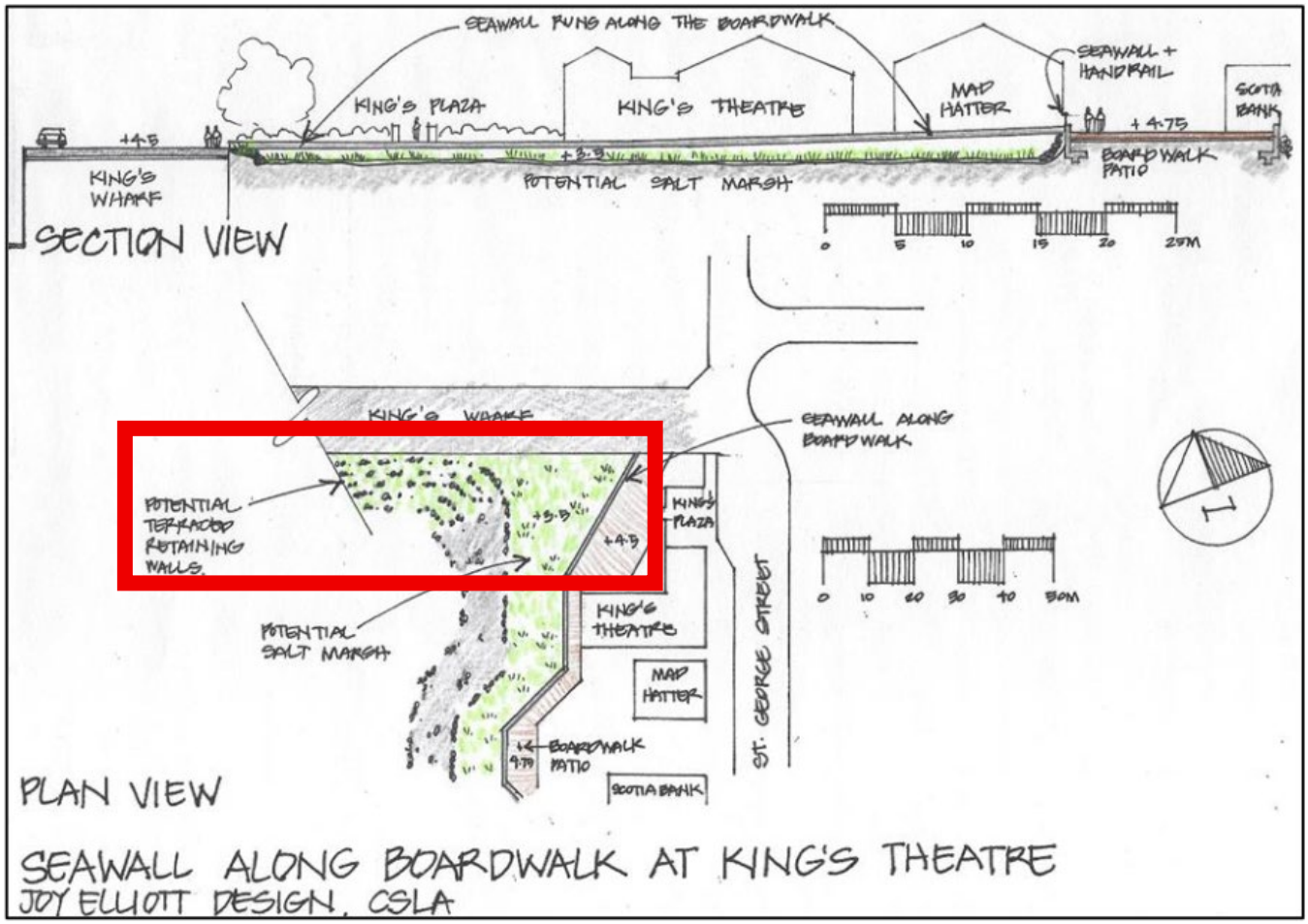
2.2 Shoreline Restoration

The wharf rehabilitation embankment fill constitutes one of the proposed measures to retain and protect the town's wharf but also takes place in a shoreline restoration project as presented in the feasibility study. This restoration project presents an opportunity to reinstate aquatic habitats and biodiversity, such as a rich salt marsh within the intertidal zone. Within the broader shoreline restoration initiative, the Terrace concept entails infilling the area in successive tiers to reflect aquatic environments that support ecological functions and enhance biodiversity. Figure 2.1 and Figure 2.2 show the initial terracing and shoreline restoration concept at King's Theatre.



Source: Town of Annapolis Royal, 2024

Figure 2.1: Wharf rehabilitation concept section A-A (taken from the 2024 feasibility study)



Source: Town of Annapolis Royal, 2024

Figure 2.2: Terracing and shoreline restoration at King's Theatre (taken from the 2024 feasibility study)

3. Designing Criteria

Following the desktop review, it became clear that the design concept needed to prioritize environmental considerations, with a strong emphasis on maximizing ecological function and biodiversity through the integration of living shoreline elements and salt marsh restoration. The design process aimed to incorporate insights and input from First Nations and local communities, but no insights were available from the ongoing engagement project. However, to ensure the development of a resilient and enduring concept, hydraulic preliminary calculations were required to inform and validate the proposed design criteria.

3.1 Armour Stone Sizing

Even with the idea of making a well-vegetated riprap to be able to design a sustainable wharf rehabilitation concept, the appropriate size of the armour stones must be established. No site-specific hydraulic and ice studies, including a hydraulic model of the bay are available. Information was provided on the projected water levels under climate change (including sea-level rise and storm surge).

In the absence of detailed hydraulic and ice data, supplementary calculations were undertaken to estimate wave generation and ice thickness for the design of the stone armour protection. A technical note was prepared to establish the armour stone sizing and to identify the required crest width (appendix A)[1]. Additional details about designing criteria are provided in the technical note.

The recommended stone size for wave stability is 600-800 mm.

The recommended crest elevation is 4.9 m CGVD2013 and the recommended crest width is 2.4 m.

3.2 Tide Characteristics

According to the Digby station (#00325), the tidal range between the Higher High Water Mean Tide (HHWMT) and the Mean Water Level (MWL) is 3.4 m (Table 3.1).

Table 3.1 : Tide characteristics at Digby Station (#00325)

Tide Characteristics	Water Elevation (CD datum)	Water Elevation (CGVD28)	Water Elevation (CGVD2013)
Highest Astronomical Tide	9.38	4.95	4.31
Higher High Water Large Tide	9.17	4.74	4.10
Mean Higher High Water (Higher High Water Mean Tide)	**7.94**	**3.51**	**2.87**
Mean High Water (High Water Mean Tide)	7.8	3.37	2.73
Mean Water Level	**4.54**	**0.11**	**-0.53**
Mean Low Water (Low Water Mean Tide)	1.25	-3.18	-3.82
Mean Lower Low Water (Lower Low Water Mean Tide)	1.12	-3.31	-3.94
Lower Low Water Large Tide	-0.16	-4.59	-5.23
Lowest Astronomical Tide	-0.35	-4.78	-5.42

Source: Government of Canada, 2025

[1] Refer to technical note (appendix A) for more details about flow velocity, ice thickness and wave action criteria.

3.3 Local Plant Biodiversity

The scope of the project did not include a site visit from CIMA+ team. However, Clean Foundation conducted a survey of the shoreline during the summer of 2025 regarding the plant community elevations (Table 3.2). As a result, *Sporobolus alterniflorus* dominate the low marsh, while *Sporobolus pumilis* and *Juncus gerardii* prevail the high marsh. In addition to these species, most often the high marsh, a range of other halophytes typical of the region were also observed in the salt marsh, indicating good biodiversity and the presence of viable seed banks should the project move forward (L. Horrocks, Clean Foundation, personal communication, October 24, 2025):

- *Limonium Carolinum*
- *Suadea spp.*
- *Triglochlin martima*
- *Plantago maritima*
- *Solidago sempervirens*
- *Glaux maritim*
- *Atriplex spp.*
- *Sporobolus michauxiana*
- *Salicornia europea*
- *Carex palacea*

Table 3.2 : Elevation results on the Annapolis Royal survey site

Group	Minimum Elevation (m)	Mean Elevation (m)	Maximum Elevation (m)
Brackish marsh	3.40	3.66	3.88
High marsh	2.70	3.03	3.50
High/low marsh	2.44	2.70	2.99
Low marsh	1.39	2.18	2.91

Source: Clean Foundation, 2025

3.4 Land Registry

Without the land registry, CIMA+ approximated that the initial plan view of the terrace concept had a width of 27 to 28 m as shown on Figure 1.2 in Section 1.3.

The Town of Annapolis Royal confirmed the project must remain within the lot adjacent to the Wharf, as permission to extend beyond the property line is not granted. Figure 3.1 shows the lot boundaries. The measured distance on the drawing is approximately 25 m, which limits the final integrated design option for the terraced embankment fill riprap to this length. For further plan development, accurate surveying is recommended to ensure that no encroachment occurs onto the adjacent property.

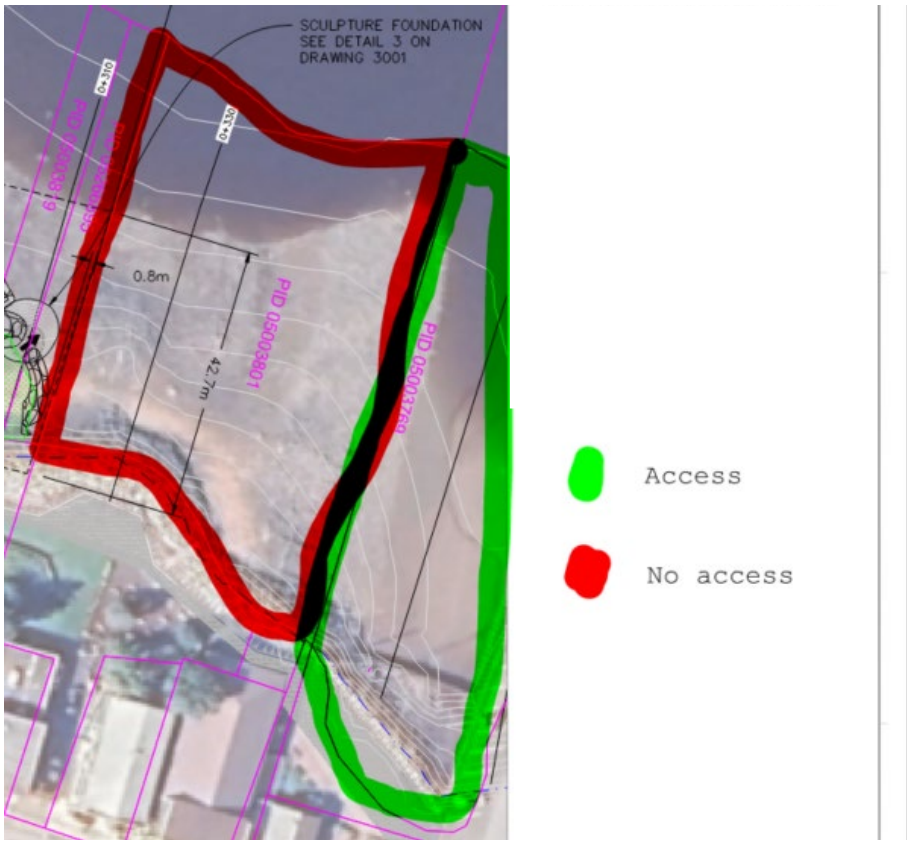


Figure 3.1: Land registry drawing (Town of Annapolis Royal, 2025)

4. Design Options

Considering all designing criteria, two options were developed[2]. The implementation of vegetated terraces was constrained by the stone size of the riprap recommended in hydraulics. A benefit of using such large stone size riprap is that slope stability is less of an issue. To minimize encroachment and optimize planting space, the riprap slope was set to 1.5:1. The crest width of the upper terrace was maintained at 2.4 m in accordance with hydraulic recommendations, although only 1.4 m (equivalent to two stones of 700 mm) was considered for the lower terraces. This allowed for optimized planting space as well. In each option, no matter the elevation, stone paving was added on top of planting soil to keep the material in place under hydraulic stress.

The lower portion of the riprap was not considered even for a lower salt marsh implementation for the following reason: based on field survey results, the lowest elevation of the low marsh is 1.39 m, with an average of 2.18 m. Vegetation integration below this elevation would not survive.

4.1 Option 1

The first option aims to increase the number of salt marsh terraces. A vertical spacing of 1.55 m was maintained between each terrace. This configuration provides three vegetated levels, totalling 11.2 m of salt marsh terrace, with the following widths (Figure 4.1):

- Terrace 1: 5.2 m.
- Terrace 2: 3.0 m.
- Terrace 3: 3.0 m.

However, this option offers limited planting space, and the elevation of the lower terrace remains below the average elevation of the low marsh recorded during the field survey. As a result, the chances of lower salt marsh plants surviving are less likely when considering the existing environmental conditions.

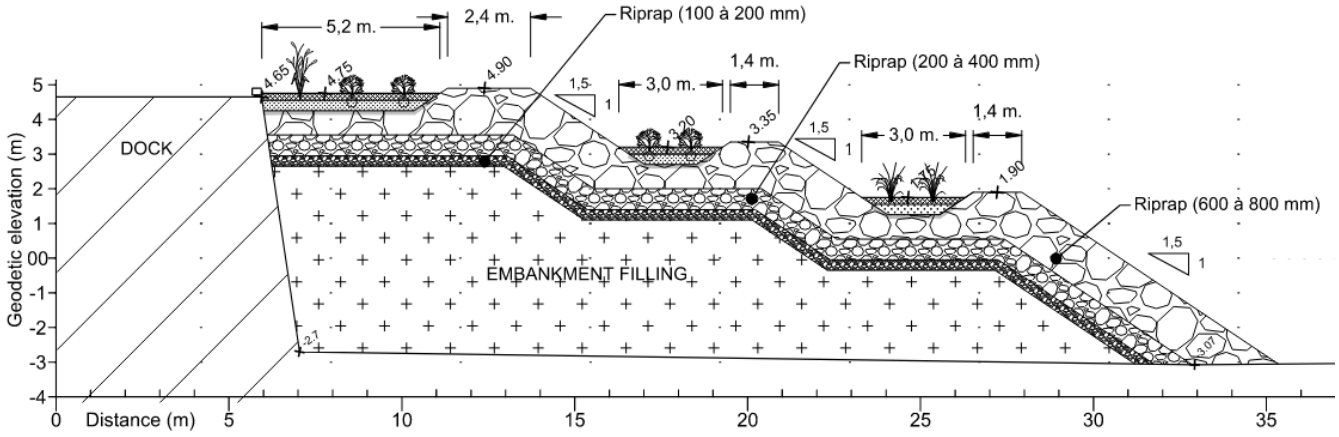


Figure 4.1: Option 1 – terrace concept

[2] The projected width of the Wharf is 28 m, as described in Section 3.4.

4.2 Option 2

The second option aims to increase the salt marsh area instead of the number of terraces. A vertical spacing of 1.9 m was considered between each terrace. This configuration provides two vegetated levels, totalling 13 m of salt marsh terrace, with the following widths (Figure 4.2):

- Terrace 1: 7.0 m.
- Terrace 2: 6.0 m.

This option offers more planting space, and the elevation of the lower terrace is over the average elevation of the high/low marsh recorded during the field survey. As a result, the chances of high and lower marsh plants surviving are more likely when considering the existing environmental conditions.

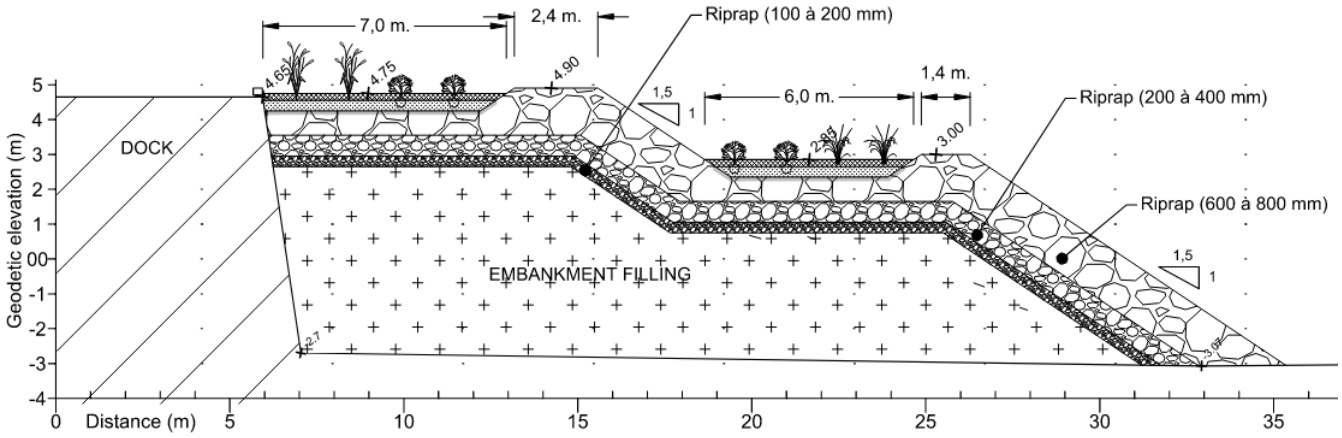


Figure 4.2: Option 2 – terrace concept

5. Integrated Design Option Selected

During a discussion with the Town of Annapolis Royal, the advantages of each design option were evaluated. Following this discussion, option 2 was selected and refined based on the feedback from the Town (Figure 5.1), which emphasized the importance of making the terrace accessible to enhance social acceptability and minimize vegetation trampling. Consequently, the chosen concept was adjusted to integrate natural stone paving along the upper riprap crest (Figure 5.2).

This refined option provides a greater planting space, 10 m[3], and the elevation of the lower terrace exceeds the average high and low marsh elevations recorded during the field survey by the Clean foundation in 2025. Consequently, the likelihood of successful establishment and long-term survival of marsh vegetation is significantly improved based on the existing environmental conditions. Overall, this option could offer superior ecological benefits compared to the alternative, as it maximizes habitat potential and supports the resilience of the restored marsh ecosystem. The geotextile and planting soil used shall comply with applicable standards.

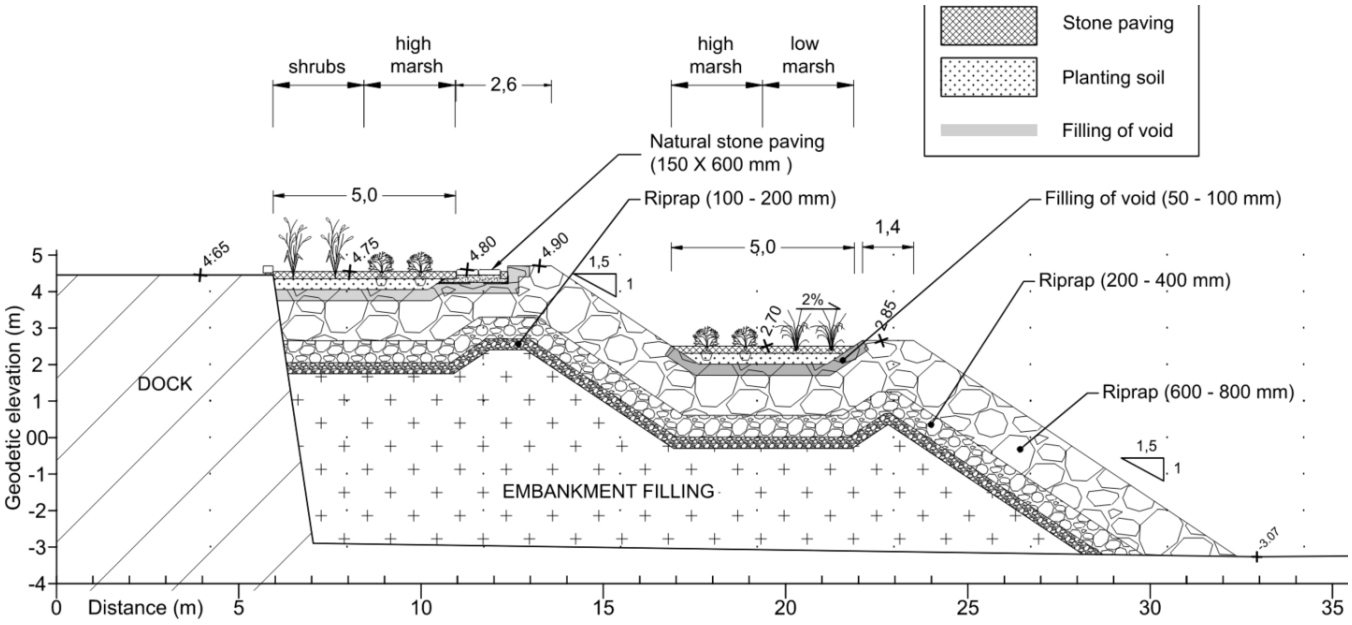


Figure 5.1: Selected terrace concept

[3] The projected width of the Wharf was reduced to 25 m, as described in Section 3.4.

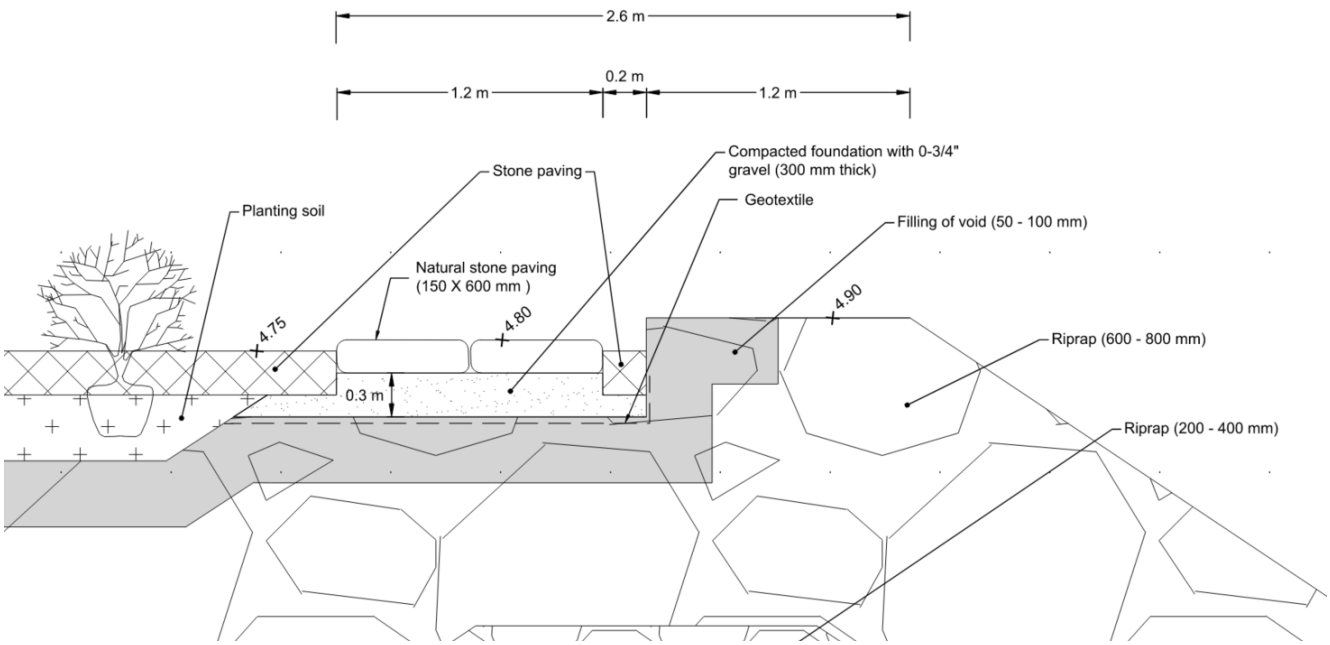


Figure 5.2: Selected terrace concept – enlargement – stone paving footpath

5.1 Terrace Fill Concept Cost Estimate

Upon the preliminary cost information provided, an extended cost estimate was prepared. As shown in Table 3-2 of the flood risk assessment and adaptation concepts report (Table 5.1), the approximate cost of the Embankment fill, rock placement, geotextile, vegetation and planting was $782,200.

Based on the final integrated design option presented in Section 5, an expanded cost estimate was carried out. Additionally, an approximate cost has been added to cover expenses associated with environmental measures, such as performing work at low tide or installing a turbidity curtain.

Considering all the elements presented in Table 5.2, the approximate total amount is estimated at $1,758,347. The main difference explaining the increase compared to the preliminary cost information is the substantial riprap installation required to adapt the embankment fill to the hydraulic constraints. This estimate is based on current assumptions and quantities and should be regarded as preliminary still and subject to change. It is also strongly recommended to verify current prices locally.

Table 5.1: Wharf rehabilitation opinion of probable cost (taken from the 2024 feasibility study)

Element	Approximate Cost (2023$)
Steel Piling and Wall Face	$ 630,000
Structural Steel Work	$ 325,680
Tie-Back System	$ 87,000
Embankment fill, rock placement and geotextile	$ 726,200
Vegetation and Planting	$ 56,000
Concrete capping	$ 140,875
Miscellaneous Staging and Other Elements	$ 38,245
Subtotal	**$ 2,004,000**
Geotechnical Investigation and Detail Design	**$ 162,500**
25% Contingency for unknowns (includes contingency on design)	$ 541,625
Total without architectural panels	**$ 2,708,125**
Architectural Pre-Cast Panels	$ 1,128,000
25% Contingency for unknowns	$ 282,000
Total with architectural panels	**$ 4,118,125**

Source: Town of Annapolis Royal, 2024

Table 5.2: Selected wharf terrace fill concept cost estimate

Art	Code	Designation of Work	Quantity	Unit	Unit price	Product Price
1.0	**Global Measures**					
1.1	01.01.99	Environmental measures	1	Flat Rate	$25,000	$25,000
1.0	**Subtotal – Global Measures**					**$25,000**
2.0	**Embankment Fill, rock placement and geotextile**					
2.1	02.01.99	Embankment fill	7,257	m^3	$90	$653,130
2.2	02.02.99	Riprap 100-200 - 300 mm Thickness	719	m^3	$120	$86,280
2.3	02.03.99	Riprap 200-400 - 600 mm Thickness	1,548	m^3	$140	$216,720
2.4	02.04.99	Riprap 600-800 - 1 400 mm Thickness	3,811	m^3	$160	$609,760
2.5	02.05.99	Filling of void[1]	75	m^3	$110	$8,300
2.6	02.06.99	Planting soil[2]	260	m^3	$85	$22,100
2.7	02.07.99	Pebble paving [3]	165	m^3	$110	$18,150

Art	Code	Designation of Work	Quantity	Unit	Unit price	Product Price
2.8	02.08.99	Natural stone paving	136	m^2	$500	$68,000
1.0		**Subtotal – Embankment Fill**				**$1,682,440**
3.0		**Vegetation and planting**				
3.1	03.01.99	Low marsh – Herbaceous[4]	2 180	ea	$15	$32,693
3.2	03.02.99	High marsh – Herbaceous[5]	759	ea	$15	$11,384
3.3	03.03.99	High marsh – Shrubs[6]	228	ea	$30	$6,830
3.0		**Subtotal - Vegetation**				**$50,907**
Total Cost Estimate for the Wharf Terrace Fill Concept						**$1,758,347**

[1] 25% of the surface area of the salt marshes
[2] 90% of the surface area of the salt marshes
[3] 90% of the surface area of the salt marshes
[4] Density considered of 5 plants/m^2 over the low marsh
[5] Covers 40% of the surface area of the high marsh
[6] Covers 60% of the surface area of the high marsh

6. Conclusions and Recommendations

The report presents an initial draft of an integrated design option for the terraced fill embankment concept, developed as part of a broader shoreline restoration project. By expanding the planted area in the selected design, this would promote healthier marsh vegetation, enhancing soil stability, biodiversity, resilience to sea-level rise, and natural coastal protection for the town wharf. This broader vegetated zone would also help the marsh keep pace with rising sea levels while contributing to the mitigation of storm impacts and flooding affecting the wharf and its surrounding areas.

The cost estimate ($1,758,347) differs significantly from the preliminary cost provided ($782,200), primarily due to the quantity of material required and the larger riprap rock sizes recommended to ensure the long-term stability of the structure. In contrast, the integration of vegetation for salt marsh implementation represents only a small portion of the overall cost. One potential solution not considered in the cost estimate is the reuse of existing riprap material. Assessing this option could help reduce overall costs by reusing material already available onsite, while also minimizing expenses associated with material disposal. In addition to the economic benefits, this approach would contribute to reducing the project's environmental footprint by limiting the need for new material extraction and transportation.

Further work recommended:

- Validate prices locally.
- Share the initial draft concept with the First Nations to discuss the proposed approach.
- Identify native species for planting and establishing resilient coastal ecosystems.
- Evaluate the opportunity to integrate historical and informational markers within the project.
- Evaluate overtopping using a numerical model such as XBeach to refine crest elevation.
- Consult residents to confirm winter ice conditions.
- Validate flow conditions through field inquiry or a 2D hydrodynamic model, although velocities are expected to be low due to shelter from the main channel.
- Validate the feasibility of the terrace fill concept by assessing the condition of the wharf and the structural elements that must be deployed on the opposite side to ensure adequate reinforcement.

7. References

Horrocks, Logan. 2025. Clean Foundation. Personal communication. October 24, 2025

MindTrip. n.d. *Annapolis Royal Wharf*. Retrieved January 8, 2026, from: https://mindtrip.ai/attraction/annapolis-royal-nova-scotia/annapolis-royal-wharf/at-FWMGmYME

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A

Appendix A
Technical note for the design of riprap stone size, crest elevation and crest width

TECHNICAL NOTE

Project:	Wharf Rehabilitation Terraced Fill Embankment
Version:	Rev. B - Preliminary
Date:	2025-09-22
Ref.:	Z0027061
Object:	Technical Note for the Design of Riprap Stone Size, Crest Elevation and Crest Width

1. Context

As part of the rehabilitation of the Annapolis Royal Wharf using a terraced slope, the appropriate size of the armour stones must be established. The 2024 Flood Risk Assessment and Adaptation Concepts report was reviewed for this study. At the outset, it was anticipated that site-specific hydraulic and ice studies, including a hydraulic model of the bay, would be available. In practice, the only information provided concerned projected water levels under climate change (including sea level rise and storm surge).

In the absence of detailed hydraulic and ice data, supplementary calculations were undertaken to estimate wave generation and ice thickness for the design of the stone armour protection. This technical note presents the resulting armour stone sizing together with the determination of the required crest width.

2. Location and Concept

The Town of Annapolis Royal is located in Nova Scotia, on the eastern shore of a tidal inlet of the Bay of Fundy (Figure 2-1).



Figure 2-1: Location of Annapolis Wharf

The rehabilitation concept under study consists of a terraced slope on the south side of the wharf (Figure 2-2). The sheet pile portion of the wharf is excluded from this technical note.

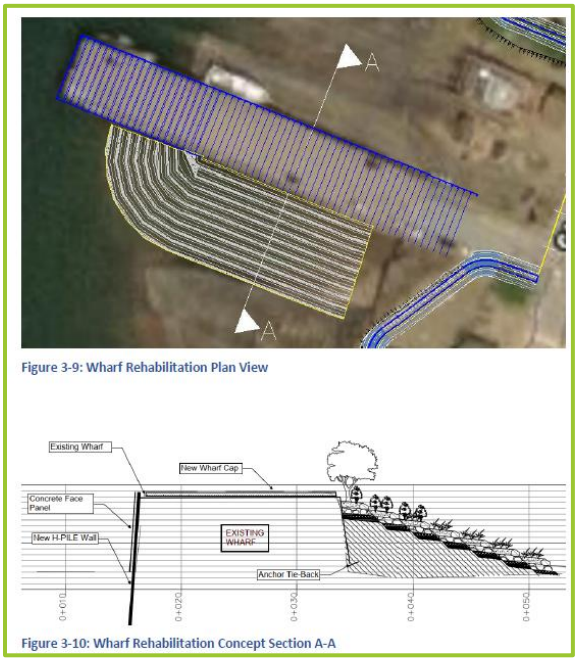


Figure 2-2: Terrace Concept (Taken from the 2024 Flood Risk Assessment)

3. Armour Stone Sizing Criteria

The armour stone size is generally determined based on the most critical of the following three phenomena:

1. Flow velocity;
2. Ice thickness;
3. Wave action.

Flow velocities can be estimated using a hydraulic model. However, no model or hydraulic study was available to CIMA+ for this project. Velocities are therefore neglected in this sizing exercise. However, it is not expected that flow velocities will be the governing factor for stone size in this case.

Ice conditions are discussed in Section 4, and wave conditions in Section 5.

4. Ice Conditions

Based on aerial imagery from the last 10 years (Google Earth and USGS Earth Explorer), ice does not appear to be a significant issue at the wharf site. No ice was observed in the 11 January–February images examined. The upstream dam retains ice and limits the probability of ice runs during thaws.

No information from local residents has yet been obtained to confirm ice conditions.

For reference, ice thickness was simulated using the Stefan equation and freezing degree-days recorded at the Environment Canada Greenwood A station (54 km from the site) for the years 1916 to 2006. Years with missing freeze-up data (1960, 1961, 1987, 1999, 2000, 2002, and 2006) were excluded. Based on site conditions, the Ice Engineering Manual, and previous projects, a regional coefficient of 2.3 was applied. Return periods for ice thickness were then computed using HYFRAN PLUS, with a normal distribution fitted to the data. Results are shown below:

Table 4-1: Ice Thickness Return Periods

Return period (yrs)	Ice thickness (cm)
100	63
50	60
20	57
10	54
2	44

According to Hydro-Québec's Hydroelectric Works Design Guide (2008), the median stone size D_{50} should be equal to or greater than the ice thickness when water levels fluctuate significantly, as is the case in this tidal inlet. The tidal range between the mean high water and the mean low water is 6.55 m, as shown in Table 4-2. No additional safety factor is included for ice runs, since the upstream

dam makes large ice blocks unlikely. For a 1:50-year return period, this yields D_{50}**≥600 mm** to withstand ice forces.

Table 4-2: Tide Characteristics at Digby station (#00325)

Tide Characteristic	Water Elevation (CD datum)
Highest Astronomical Tide	9.38
Higher High Water Large Tide	9.17
Mean Higher High Water (Higher High Water Mean Tide)	7.94
Mean High Water (High Water Mean Tide)	7.8
Mean Water Level	4.54
Mean Low Water (Low Water Mean Tide)	1.25
Mean Lower Low Water (Lower Low Water Mean Tide)	1.12
Lower Low Water Large Tide	-0.16
Lowest Astronomical Tide	-0.35

5. Wave Conditions

Waves are generated by wind blowing over a distance known as the fetch. Three fetch origins were identified, and radials were drawn every 3° to capture possible wave approach directions from offshore. The analysed fetches are shown in Figure 5-1.

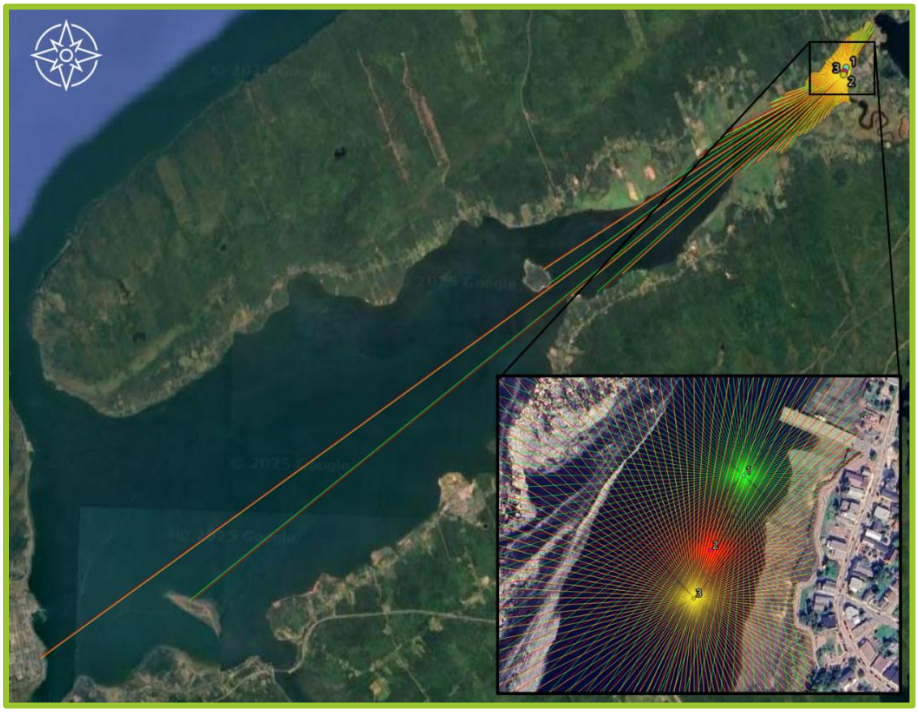


Figure 5-1: Analysed Fetches

Effective fetches were calculated using the mean plus half a standard deviation method. For each of the 16 directions, the maximum effective fetch among the three origins was retained.

Hourly wind speeds from the Environment Canada Greenwood A station (1953–2025) were used. The wind rose for the station is shown in Figure 5-2.

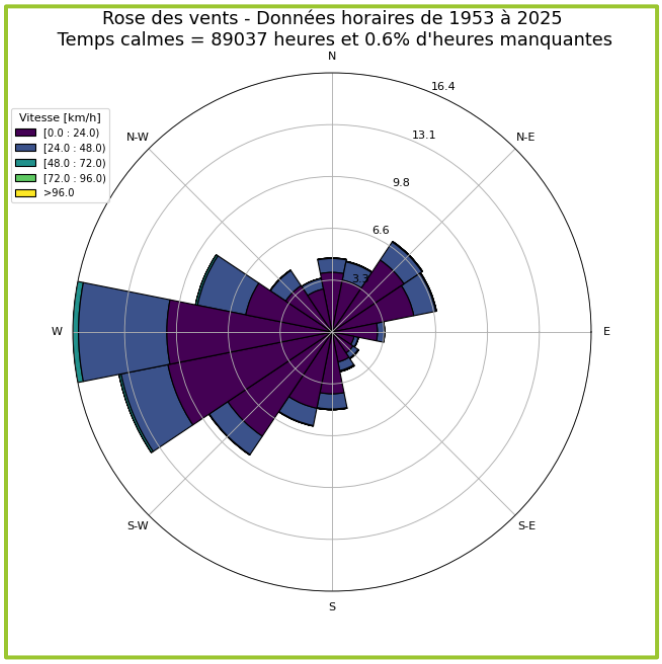


Figure 5-2: Greenwood A Station Wind Rose

A characteristic water depth of 13 m was used for the fetch origins. This corresponds to the future climate 1:100-year water level (4.96 m CGVD2013, feasibility study) minus local bathymetry (~–7 m CGVD2013 from NONNA10 data).

Waves were generated using the GENEREUX model, which applies the equations from the Shore Protection Manual (1977). Annual maximum significant wave heights (H_s) were extracted for each year. A frequency analysis with HYFRAN PLUS was then performed, fitting a Pearson Type III distribution to obtain wave heights for given return periods:

Table 5-1: Characteristic Wave Height Return Periods

Return period (yrs)	H_s (m)
100	1.31
50	1.23
20	1.12
10	1.04
2	0.82

The **Hudson formula** (1974) from the *Coastal Engineering Manual* was applied using the 50-year return period wave height, for a slope of 1V:1.5H.

Table 5-2: Stone Size

Stone type	Size (mm)	Layer Thickness (m)
Armour	600–800	1.2
Filter (1st layer)	200–400	0.7
Filter (2nd layer)	100-200	0.3

The recommended second layer of filter stone can be replaced by a thick nonwoven geotextile underlay (e.g., Texel 7634, 5.8 mm thick) to limit the migration of fine particles found in the embankment.

To prevent scour, a toe berm corresponding to 1xD_{50} of the armour rocks (700 mm) is recommended.

6. Crest Elevation and Width

The Town of Annapolis Royal does not wish to raise the wharf, as this would require a full replacement. However, it is recommended to raise the armour crest relative to the current wharf elevation to provide sufficient freeboard during high tides and storms. This would protect the rip rap integrity itself as well as the wharf infrastructure behind it.

Without detailed water level or overtopping modelling, it is not possible to give a precise crest elevation to limit damage landward of the armour. As a preliminary and conservative measure, an **elevation of 4.9 m CGVD2013** is recommended—slightly below the future climate 1:100-year water level (4.96 m according to the 2024 Flood Risk Assessment). Based on the survey provided by the Town of Annapolis, the current wharf elevation is 4.7 m CGVD2013 (measured at the north-west extremity of the wharf).

The crest width should be **3–4 × D_{50}** of the armour stone. Given that the selected crest elevation allows for some overtopping, a value of 4 × D_{50} is recommended:

$$\boldsymbol{B_{crest}} = 4 \times 0.60\ m = \boldsymbol{2.4\ m}$$

7. Conclusions and Recommendations

- **Stone size:** For wave stability, armour stone should be 600–800 mm. This size also meets the ice-resistance criterion, although ice is not expected to be a critical issue at this site.
- **Crest elevation:** Preliminary recommendation of 4.9 m CGVD2013.
- **Crest width:** 2.4 m (4 × D_{50}).

Further work recommended:

- Evaluate overtopping using a numerical model such as XBeach to refine crest elevation;
- Consult local residents to confirm winter ice conditions;
- Validate flow conditions through field inquiry or a 2D hydrodynamic model, although velocities are expected to be low due to shelter from the main channel.

Prepared by:

Guillaume Morin, Eng., M.Sc.

Verified by:

Pierre-Marc Pelletier, P.Eng, M.A.Sc.

A

Appendix A
Winter Aerial Imagery



Figure 1: 2015-02-28

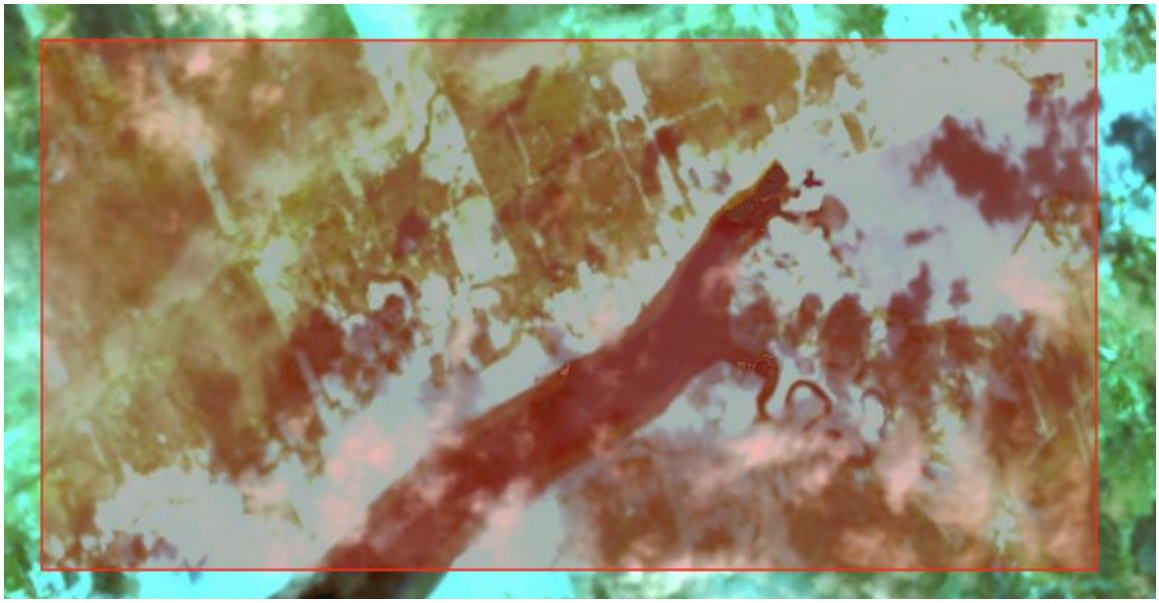


Figure 2: 2016-02-15



Figure 3: 2016-02-23



Figure 4: 2019-02-23



Figure 5: 2020-02-26



Figure 6: 2021-01-11



Figure 7: 2023-01-25

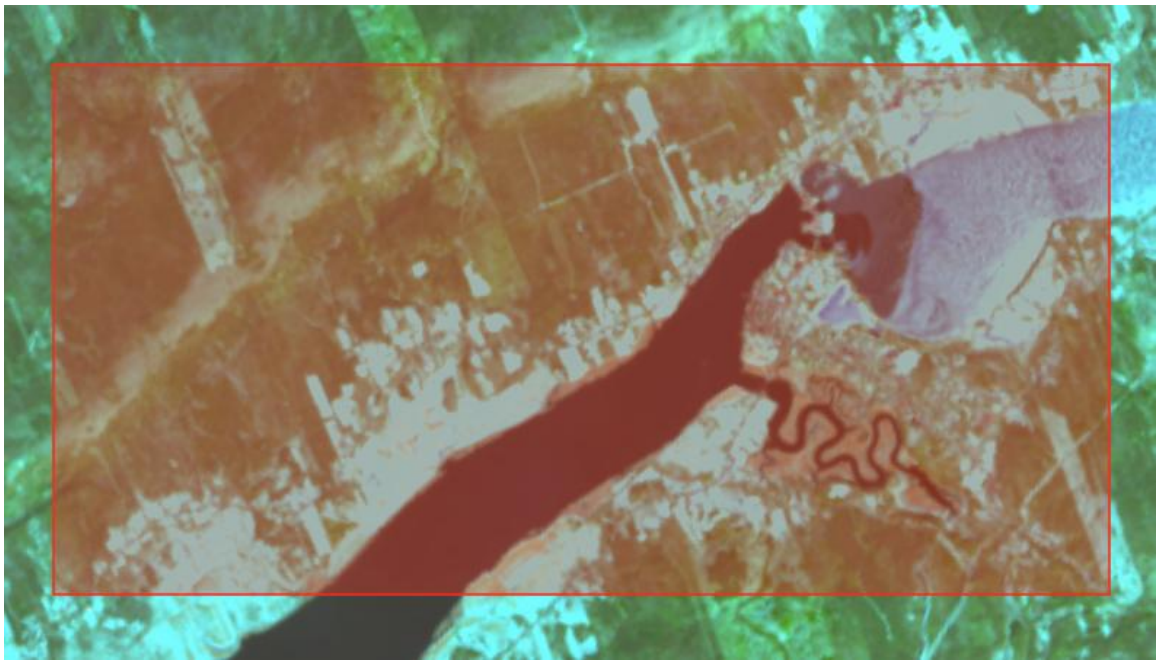


Figure 8: 2023-02-21



Figure 9: 2025-01-22

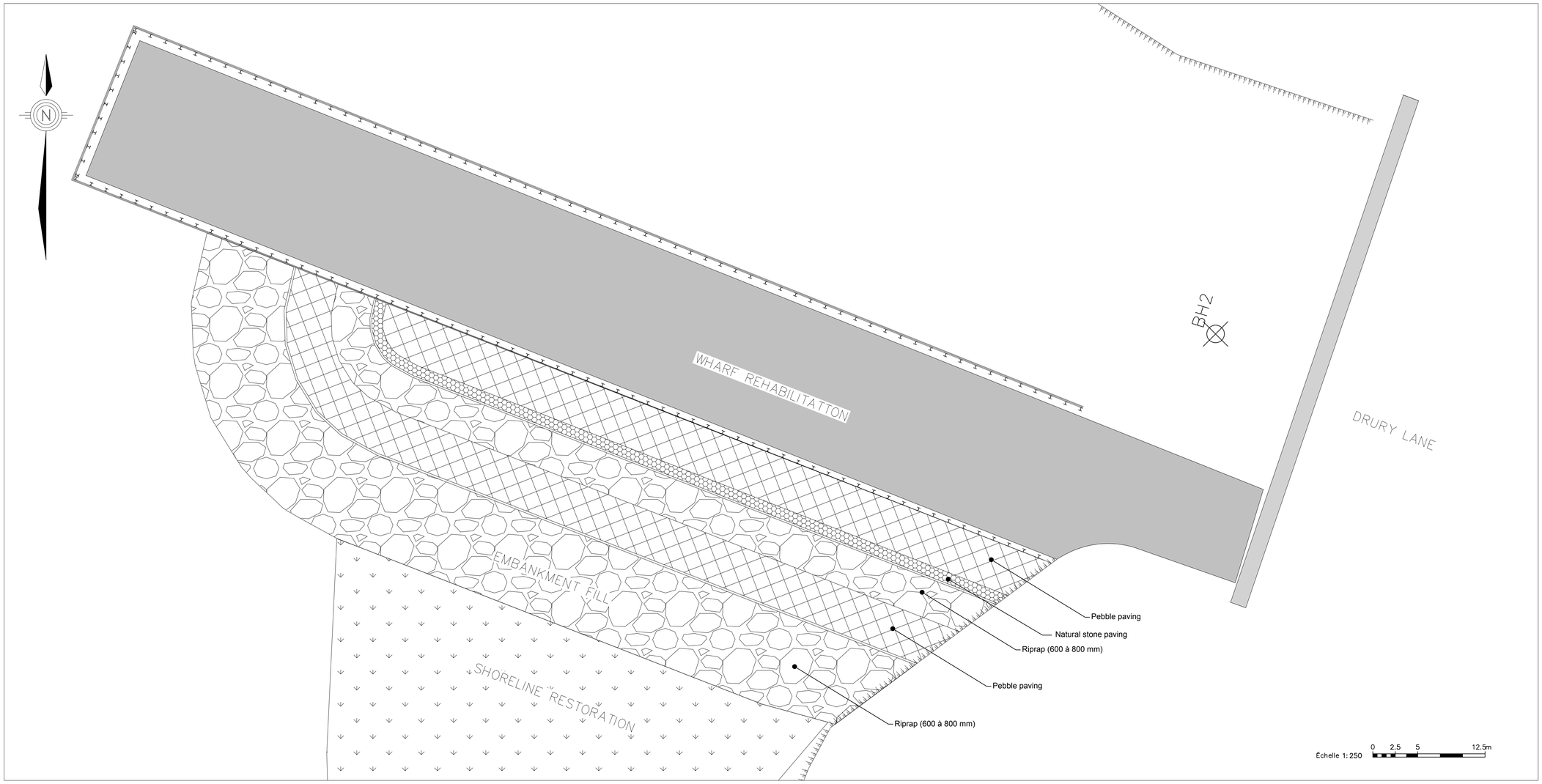


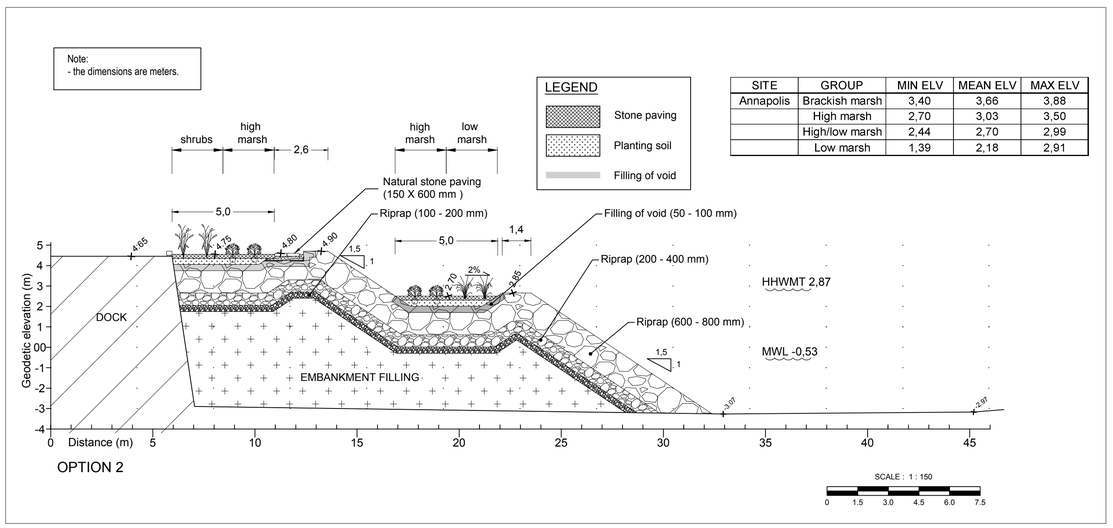
Figure 10: 2025-02-15

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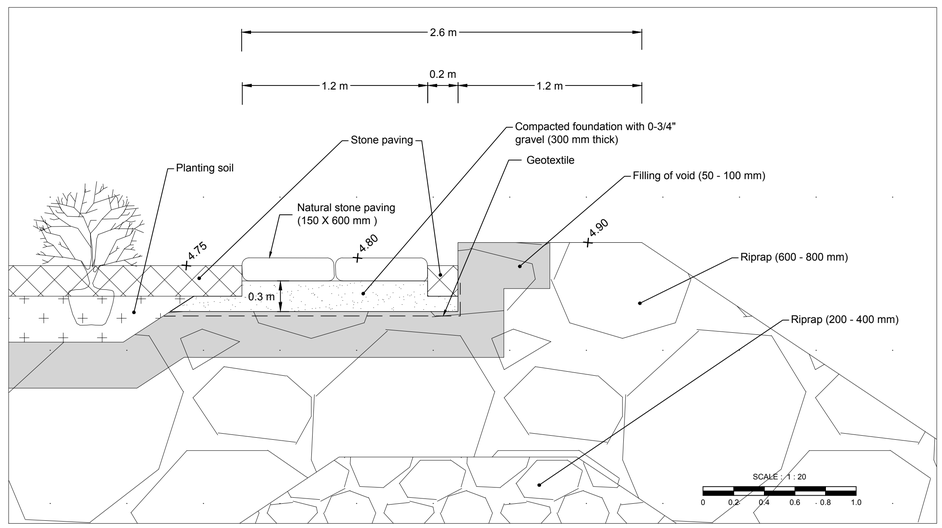
Appendix B
Embankment fill conceptual design

Z0027061–P01





SITE	GROUP	MIN ELV	MEAN ELV	MAX ELV
Annapolis	Brackish marsh	3,40	3,66	3,88
	High marsh	2,70	3,03	3,50
	High/low marsh	2,44	2,70	2,99
	Low marsh	1,39	2,18	2,91



Enlargement

CLIENT:

Annapolis Royal
Nova Scotia

A	M	J	CONCEPTUAL DESING	REV.

SEAL:

CONCEPT PLAN
BEING SUBJECT TO FURTHER CHANGES, THIS PLAN SHOULD BE USED FOR INFORMATION PURPOSES ONLY

prepared by: .....

TECHNICAL TEAM:

CIMA+

1145, Bd Lebourneuf
Québec, QC G2K 2K8

PROJECT:

Wharf Rehabilitation
Terraced Fill Embankment

TITLE:

Embankment Fill
Conceptual desing

SCALE:

PREPARED: François Lambert, tech.
Raphaël Pouliot, ing. f., M.Sc.
DRAWN: Gaétan Couture, tech.
VERIFIED: Charles White, biol., M.Sc.

DATE: 2026–01–09
PLAN: Z0027061–P01
1 / 1

FORMAT ISO A1 V–2382

APPENDIX D – EAGLE BEACH
ANNAPOLIS ROYAL - WHARF REUSE DESIGN - OPTION #1
5 PAGES



Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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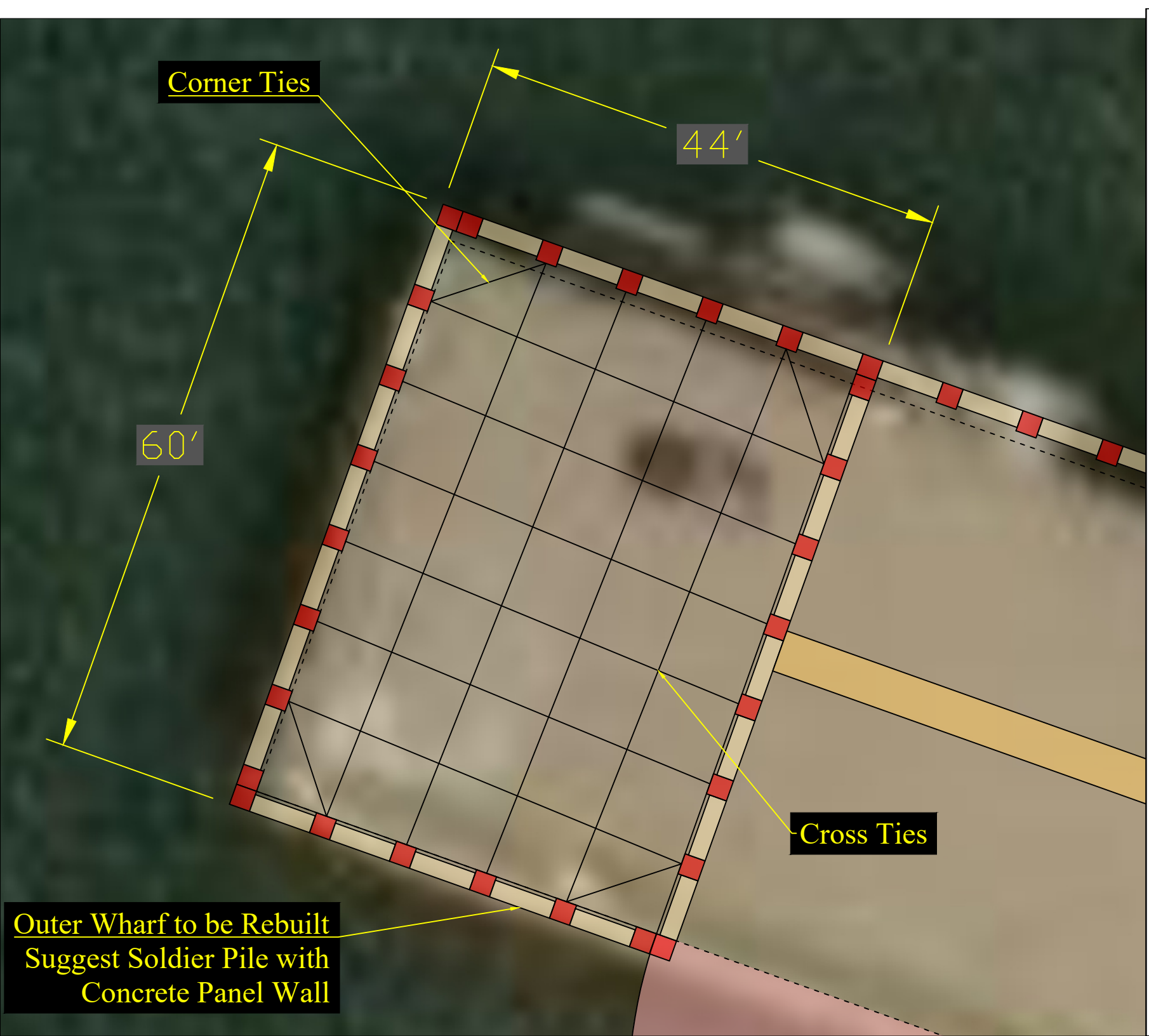
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS



Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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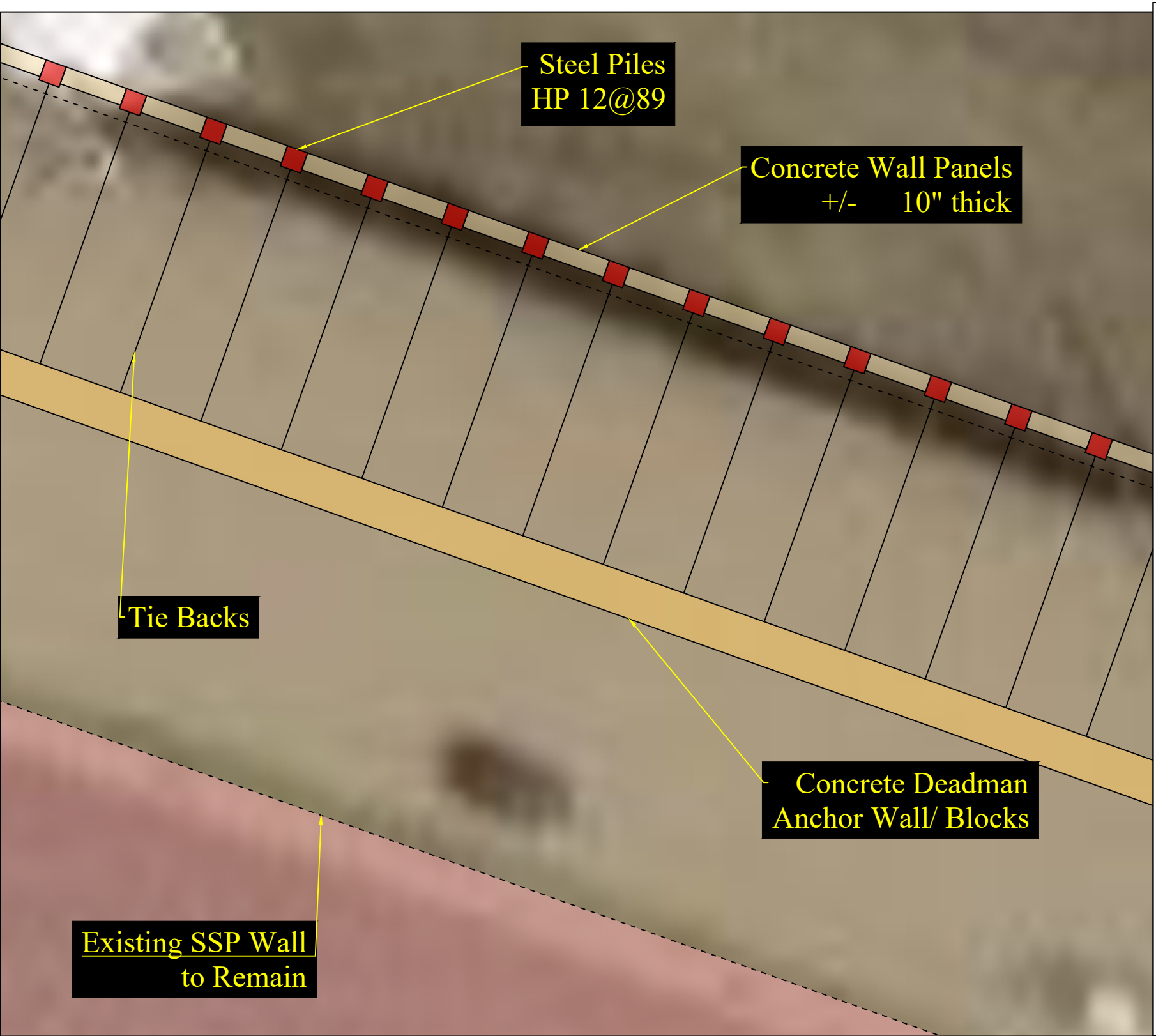
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS



Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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Drawing Number:

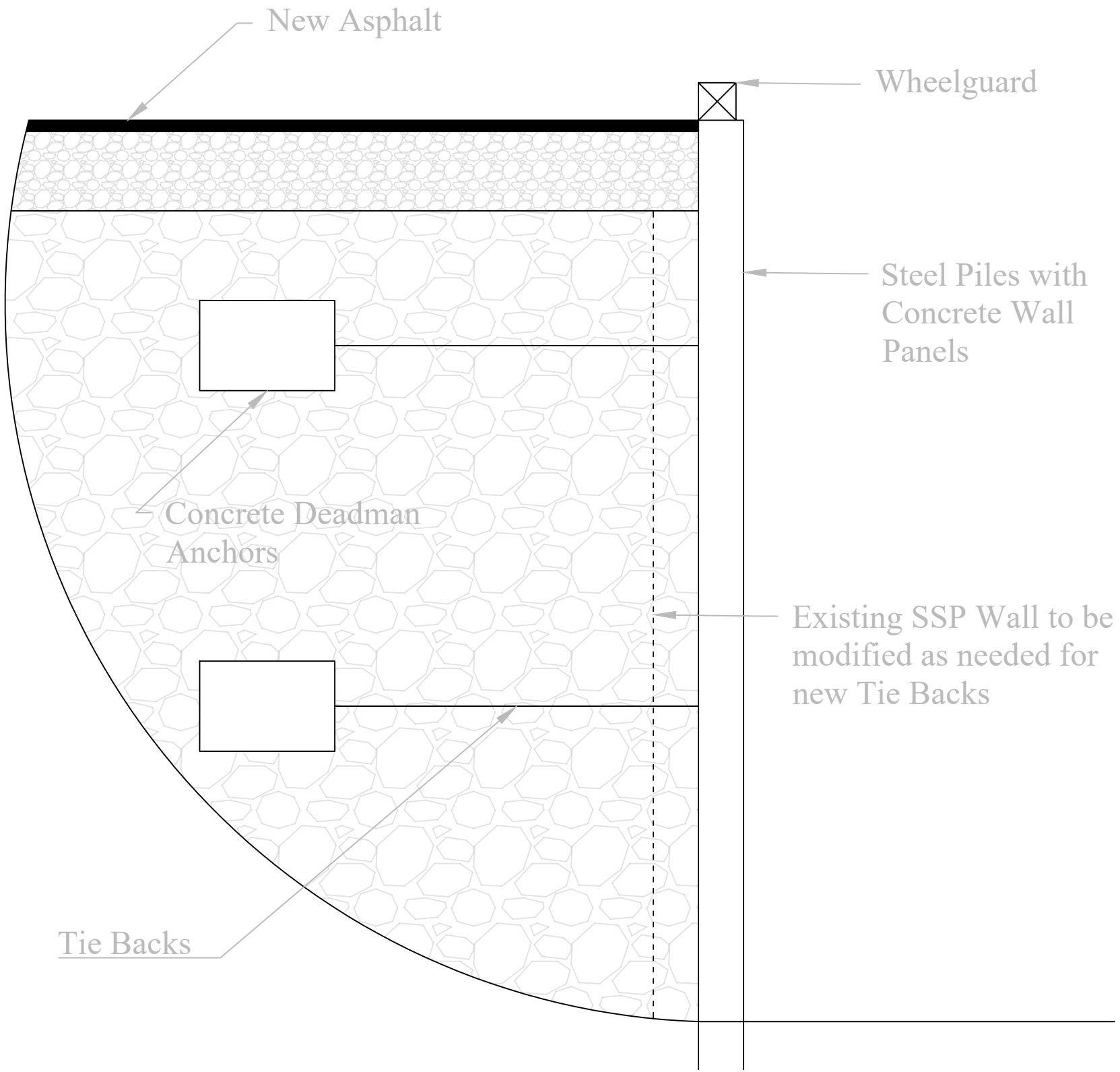
103

Drawn by:
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Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
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Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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Drawing Number:

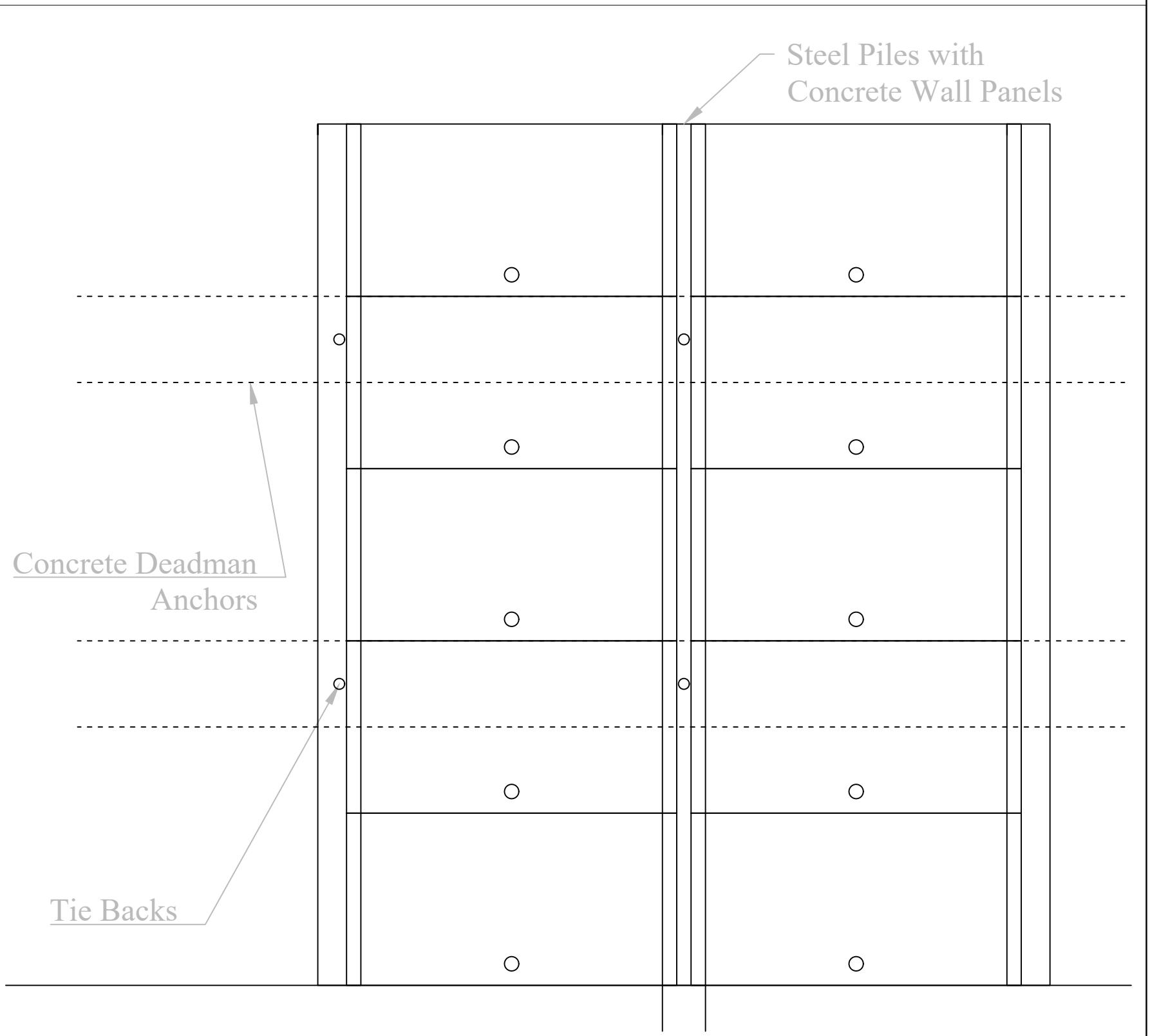
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

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Scale:
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Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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Drawing Number:

105

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS

Annapolis Royal Wharf

CONVERT TO BREAKWATER OPTION

Particulars

50	feet wide	
350	feet long	
27	feet tall at end	
10	feet tall at start	

Cross Section Area

A=	6475	ft^2			

Volume

V=	323750	ft^3			

Density of Soils/ Rocks

p=	100	lbs/ft^3			

Weight of Fill

W=	32375000	lbs	=	16187.5	tons

Steel sheets

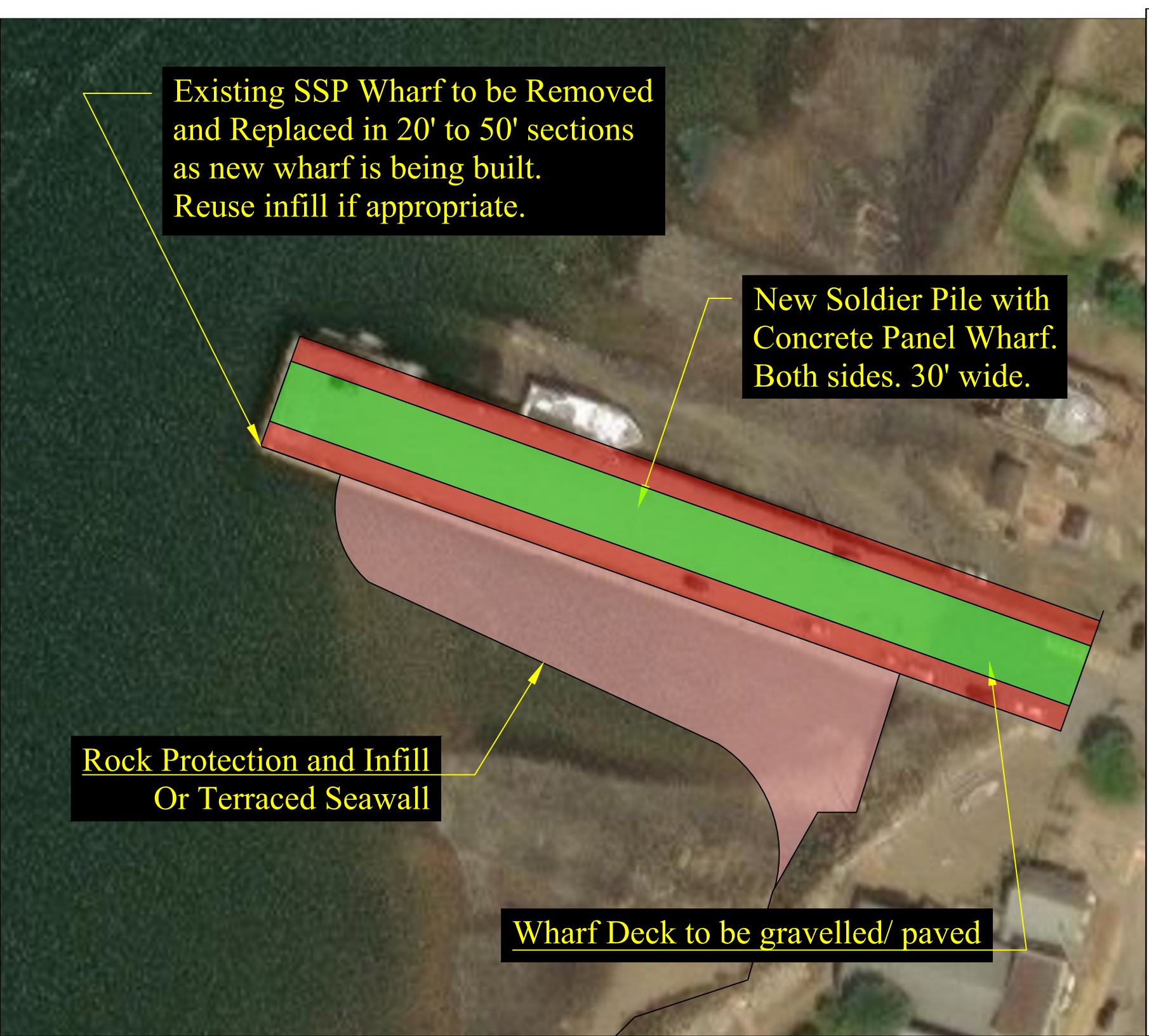
W/ft=	50	lb/ft			
Sheet width=	1.67	ft			
Sheets in wharf=	449.1017964	sheets			
Average length=	20	feet tall			
Lineal feet of sheets=	8982.035928	ft			
Weight of sheets=	449101.7964	lbs	=	224.5509	tons

Excavation=	$	90.00	per ton	
Trucking=	$	40.00	per ton	
Disposal=	$	110.00	per ton	
Unit Cost Removal=	$	240.00	per ton	
Total Cost Removal=	**$**	**1,996,392.22**		Half fill material removed

Assumes NO contaminated materials

Rock Cost=	$	30.00	per ton	
Armour Stone=		5000	tons	
Filter Stone=		4000	tons	
Unit Price Install=	$	160.00		
Breakwater install=	**$**	**1,440,000.00**		
TOTAL COST=	**$**	**3,436,392.22**		+/- $ 500,000.00

APPENDIX E – EAGLE BEACH
ANNAPOLIS ROYAL - WHARF REUSE DESIGN - OPTION #2
5 PAGES



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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Drawing Number:

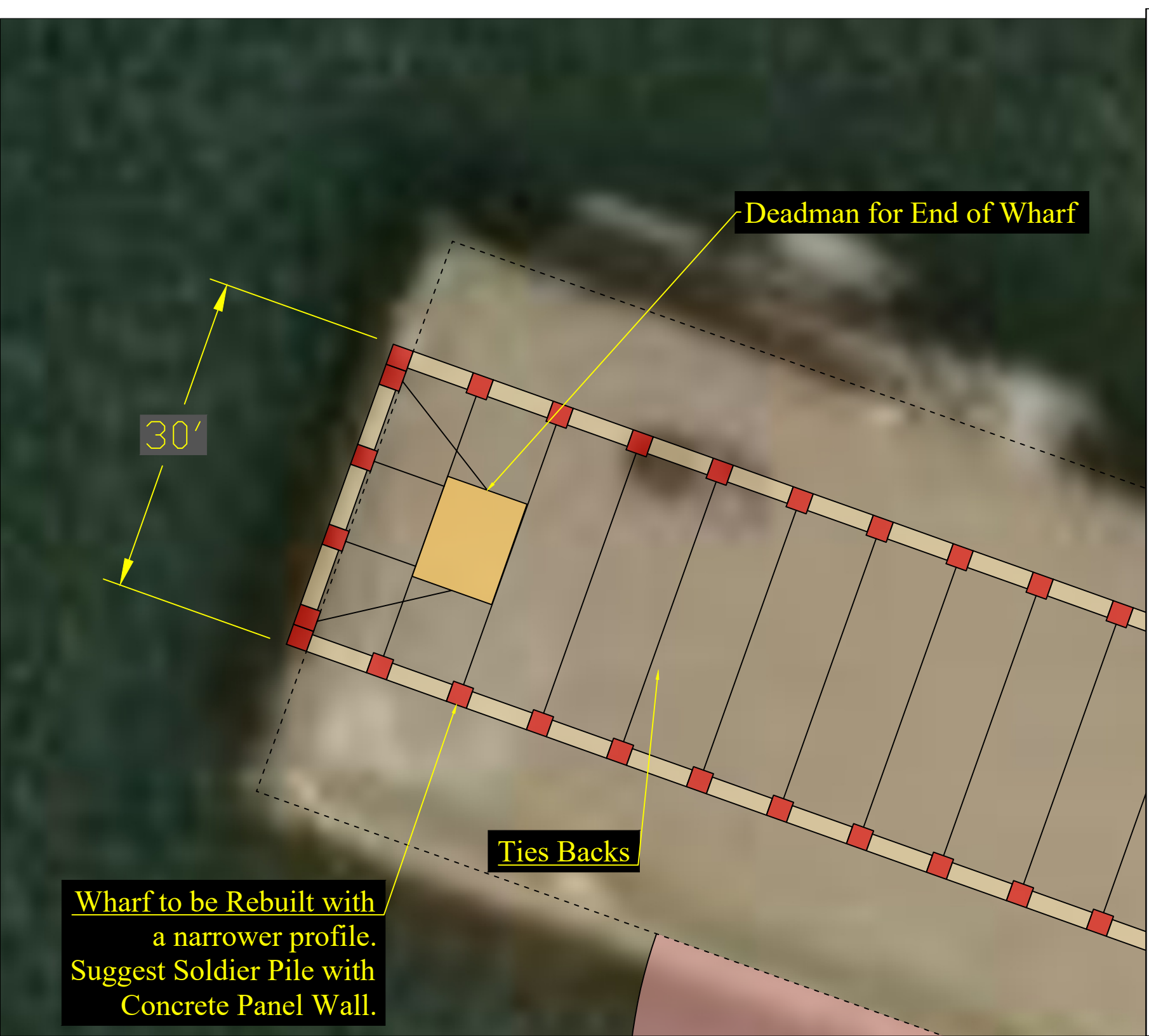
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS



Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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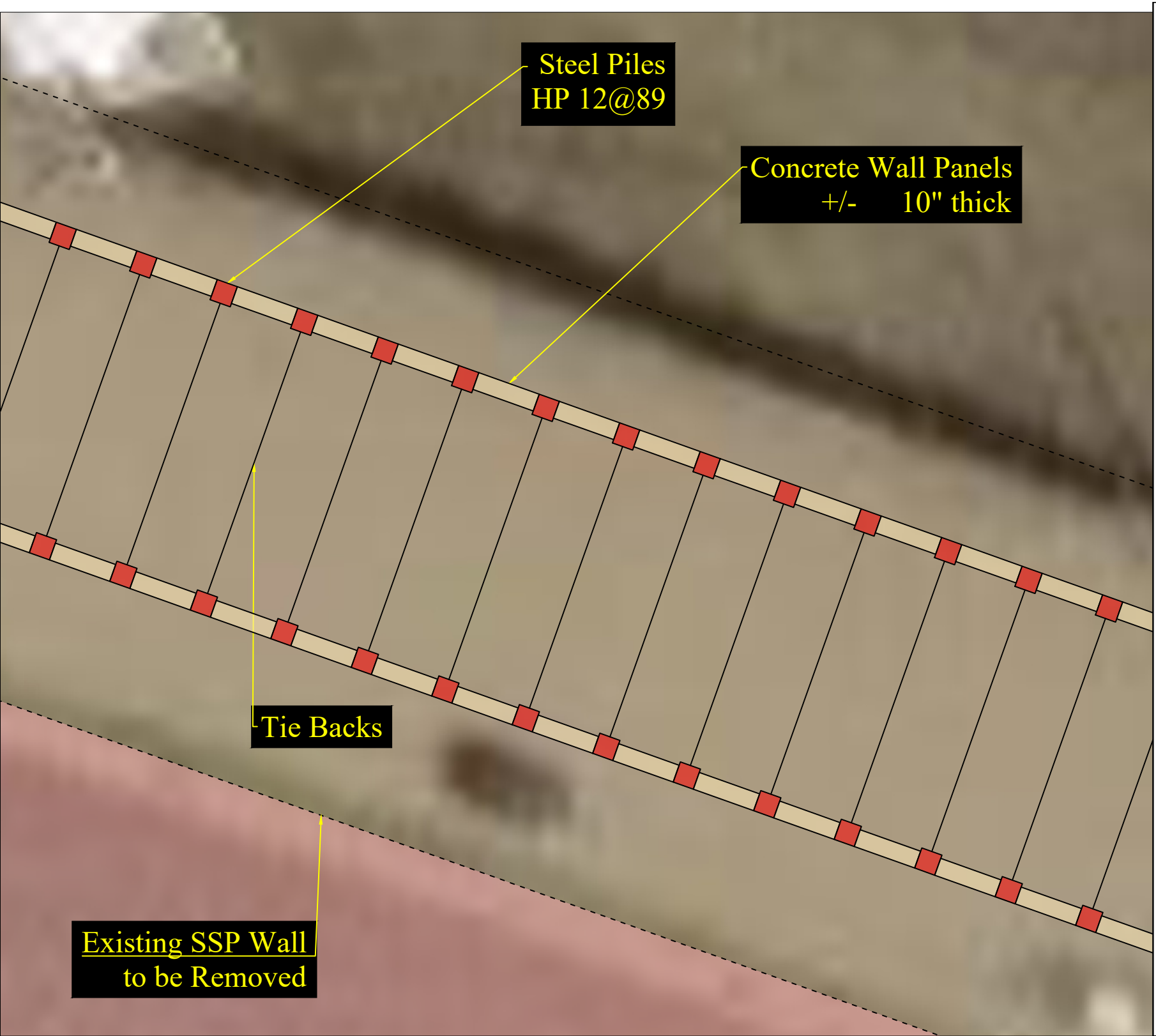
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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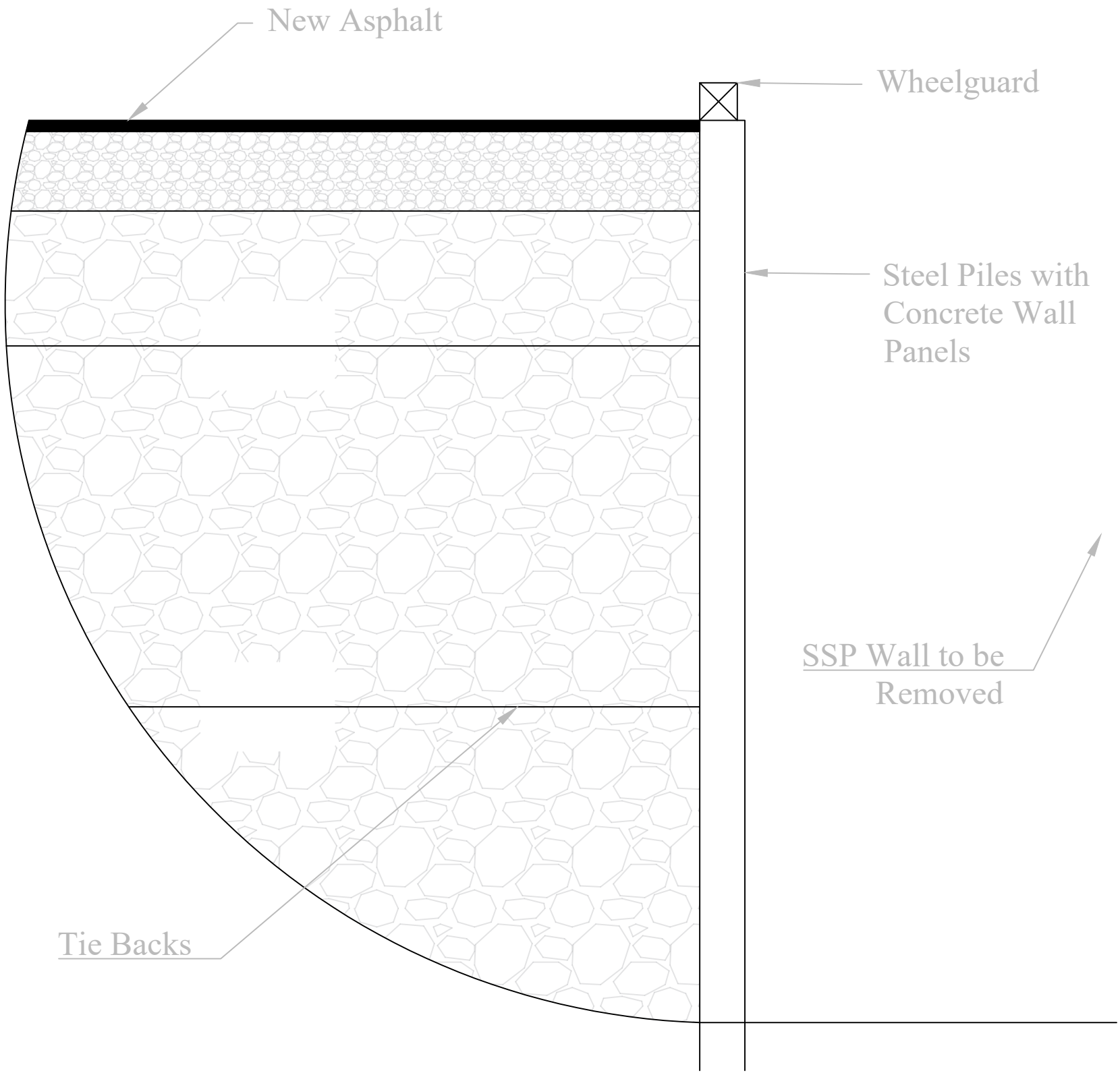
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
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Scale:
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Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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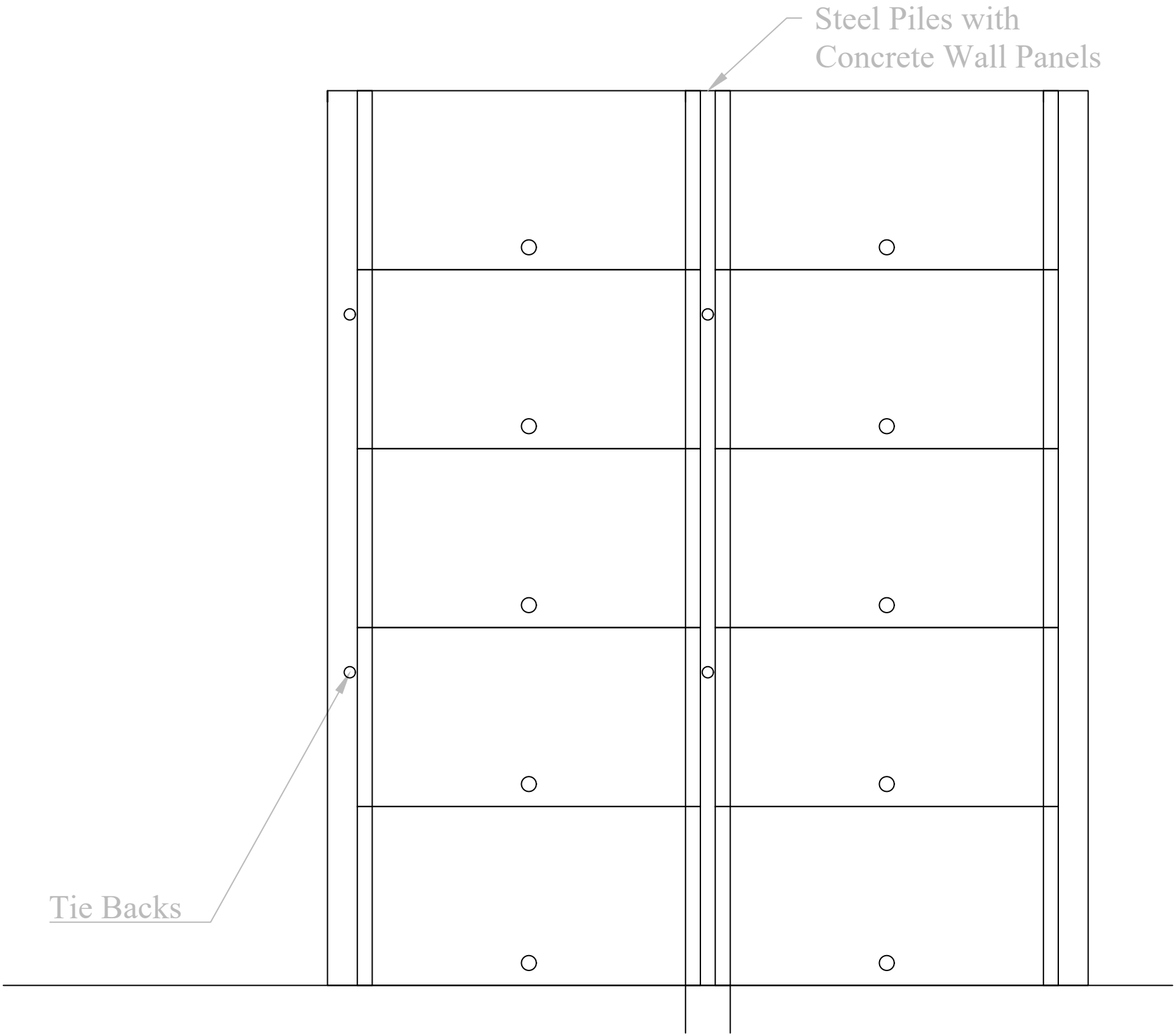
204

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

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Scale:
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Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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Drawing Number:

205

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS

Annapolis Royal Wharf

REBUILD NORTH WALL, BREAKWATER SOUTH WALL

Particulars

50	feet wide	
350	feet long	
27	feet tall at end	
10	feet tall at start	

Lineal Feet

L=		500	ft		
Soldier Pile and Lagging	$	4,500.00	per lineal ft		
Install=	**$**	**2,250,000.00**		+/- $ 400,000.00	

Included tie-backs and deadman anchors

Cross Section Area

A=		6475	ft^2		

Volume

V=		323750	ft^3		

Density of Soils/ Rocks

p=		100	lbs/ft^3		

Weight of Fill

W=		32375000	lbs	=	16187.5	tons

Steel sheets

W/ft=		50	lb/ft			
Sheet width=		1.67	ft			
Sheets in wharf=		449.1017964	sheets			
Average length=		20	feet tall			
Lineal feet of sheets=		8982.035928	ft			
Weight of sheets=		449101.7964	lbs	=	224.5509	tons

Excavation=	$	90.00	per ton		
Trucking=	$	40.00	per ton		
Disposal=	$	110.00	per ton		
Unit Cost Removal=	$	240.00	per ton		
Total Cost Removal=	**$**	**998,196.11**		Quarter fill material removed	
				Half of sheets removed	

Assumes NO contaminated materials

Rock Cost=	$	30.00	per ton	
Armour Stone=		2500	tons	
Filter Stone=		2000	tons	
Unit Cost Install=	$	160.00		
Breakwater install=	**$**	**720,000.00**		

TOTAL COST=	**$**	**3,968,196.11**	+/- $ 500,000.00

APPENDIX F – EAGLE BEACH
ANNAPOLIS ROYAL - WHARF REUSE DESIGN - OPTION #3
5 PAGES



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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Drawing Number:

301

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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Drawing Number:

302

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Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
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Scale:
NTS



Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835–7664

Project Name:

General Notes:

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Drawing Number:

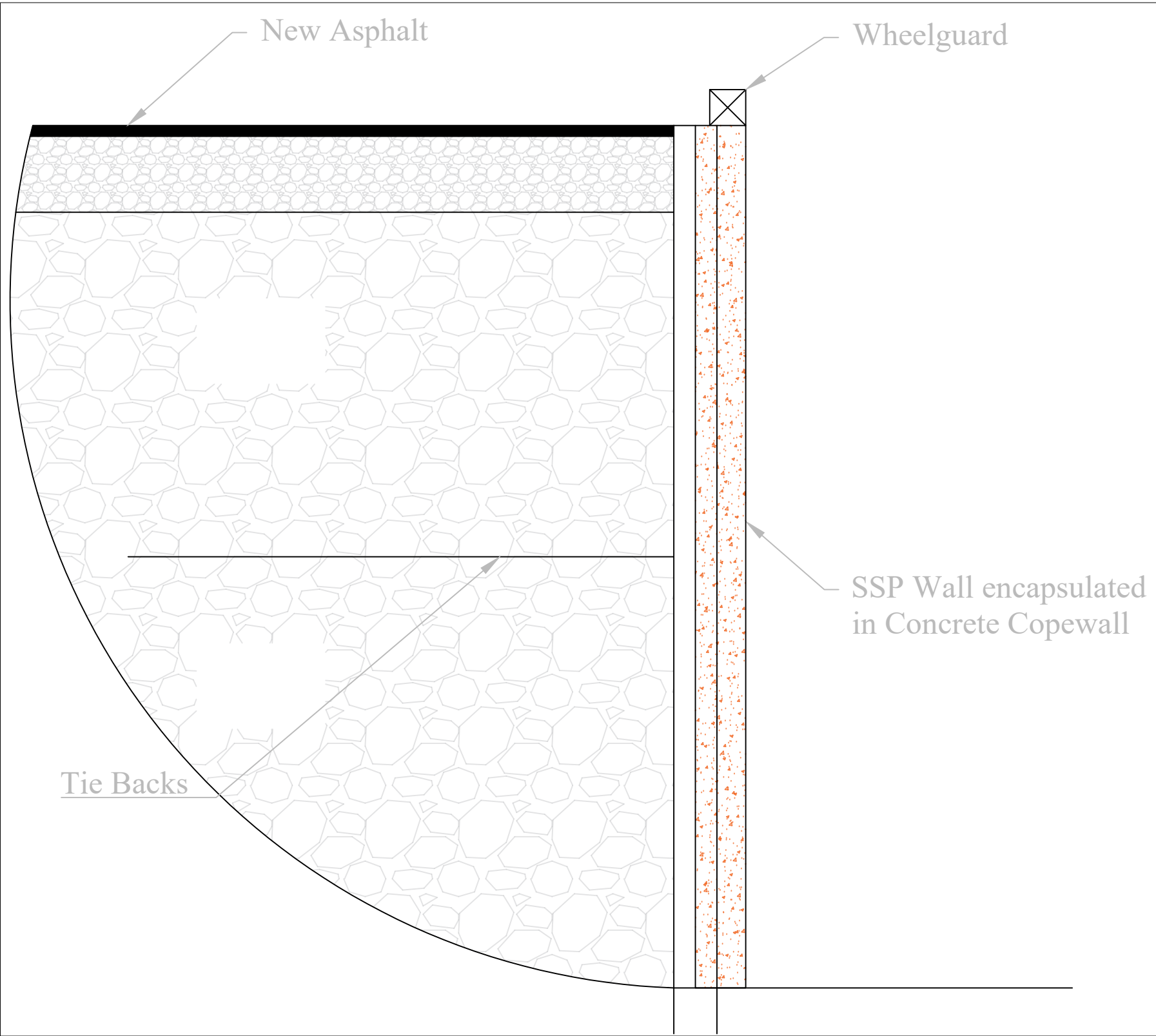
303

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
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Scale:
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Eagle Beach
Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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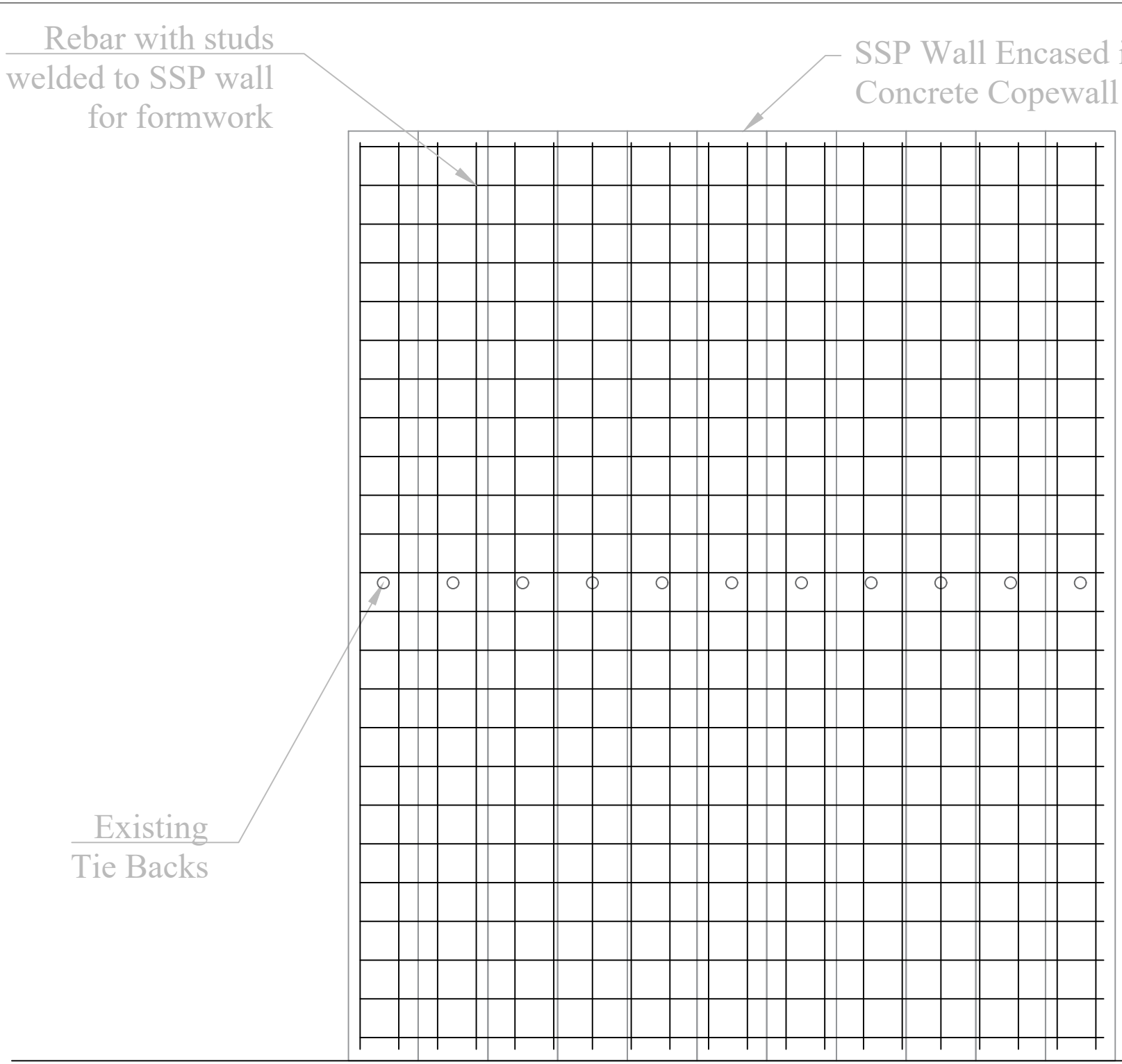
304

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
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Scale:
NTS



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

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Project Name:

General Notes:

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Drawing Number:

305

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS

Annapolis Royal Wharf

ENCASE EXISTING IN CONCRETE OPTION

Particulars

50 feet wide
350 feet long
27 feet tall at end
10 feet tall at start

Surface Area

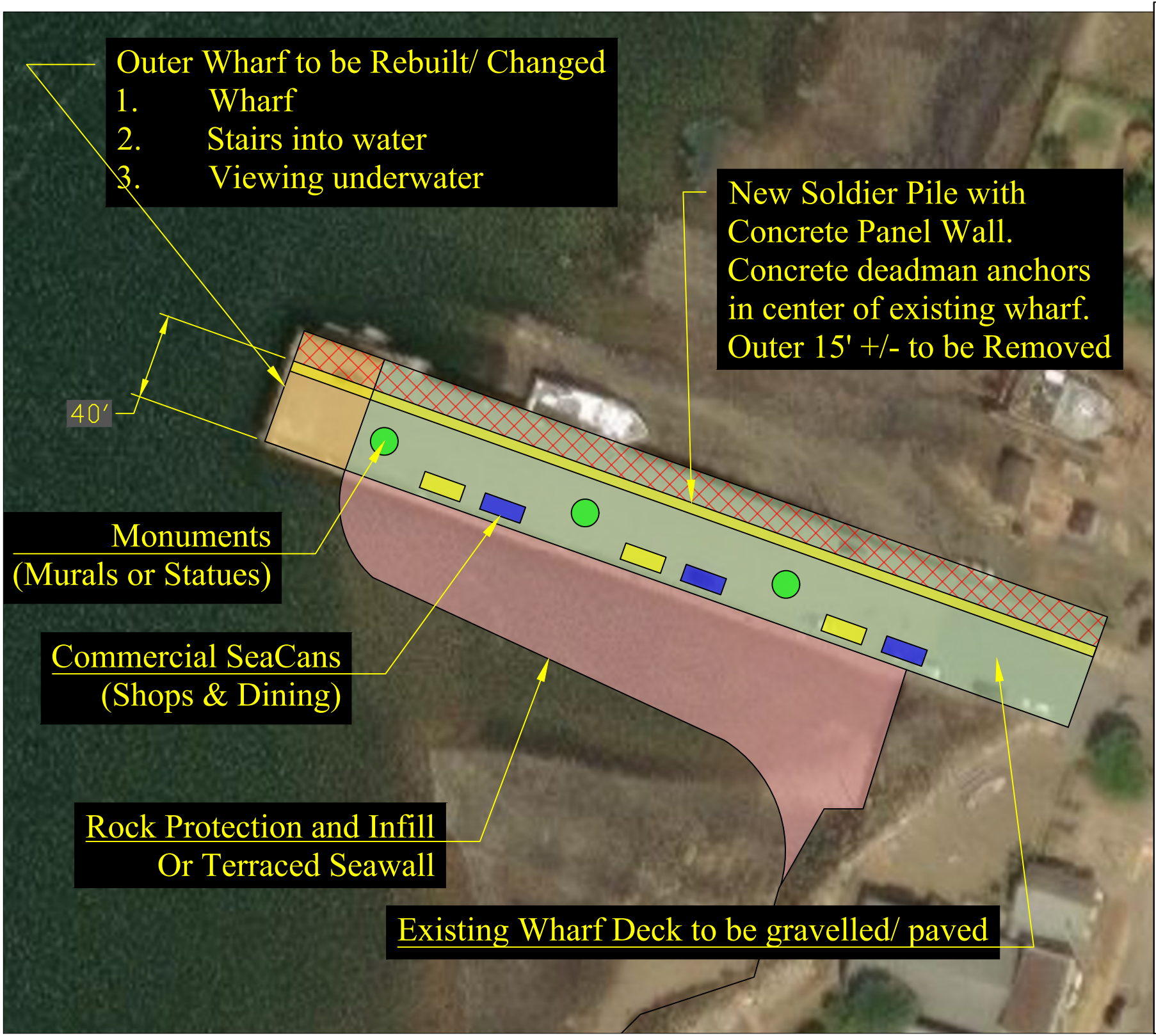
A= 14300 ft^2

Concrete Cope Wall	$	1,600.00	per m^2	=	$ 148.65	per ft^2
Install=	**$ 2,125,623.61**			+/- $ 400,000.00		

Assumes tie-rods are in good condition and can be reused.

Additional tie-rod work would be in the range of **+ $1,000,000.00**

APPENDIX G – EAGLE BEACH
ANNAPOLIS ROYAL - WHARF REUSE DESIGN - OPTION #4
5 PAGES



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835–7664

Project Name:

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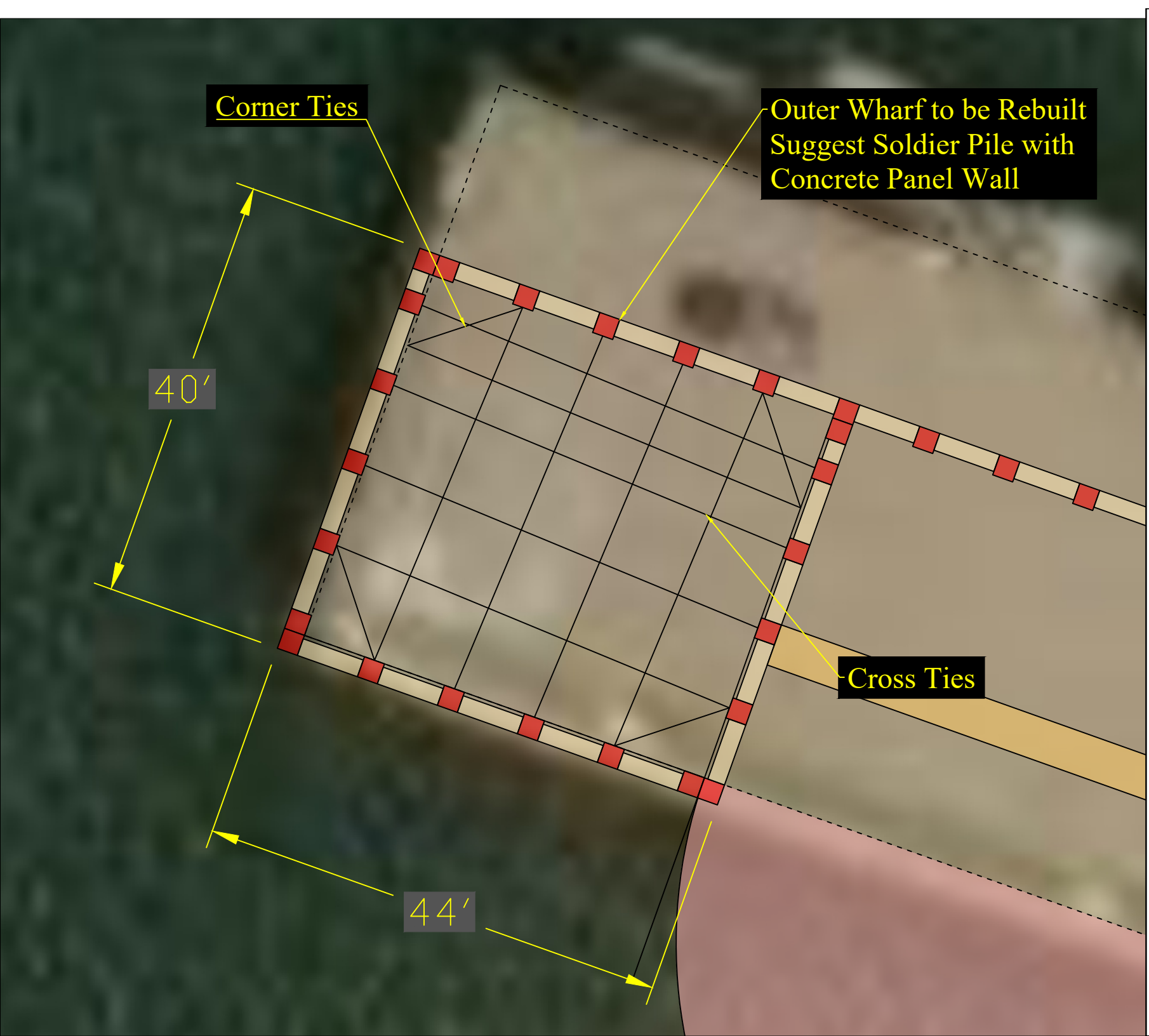
401

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Sc.W., P.Eng

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Eagle Beach
Contractors Ltd.

2033 Hammonds
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(902) 835-7664

Project Name:

General Notes:

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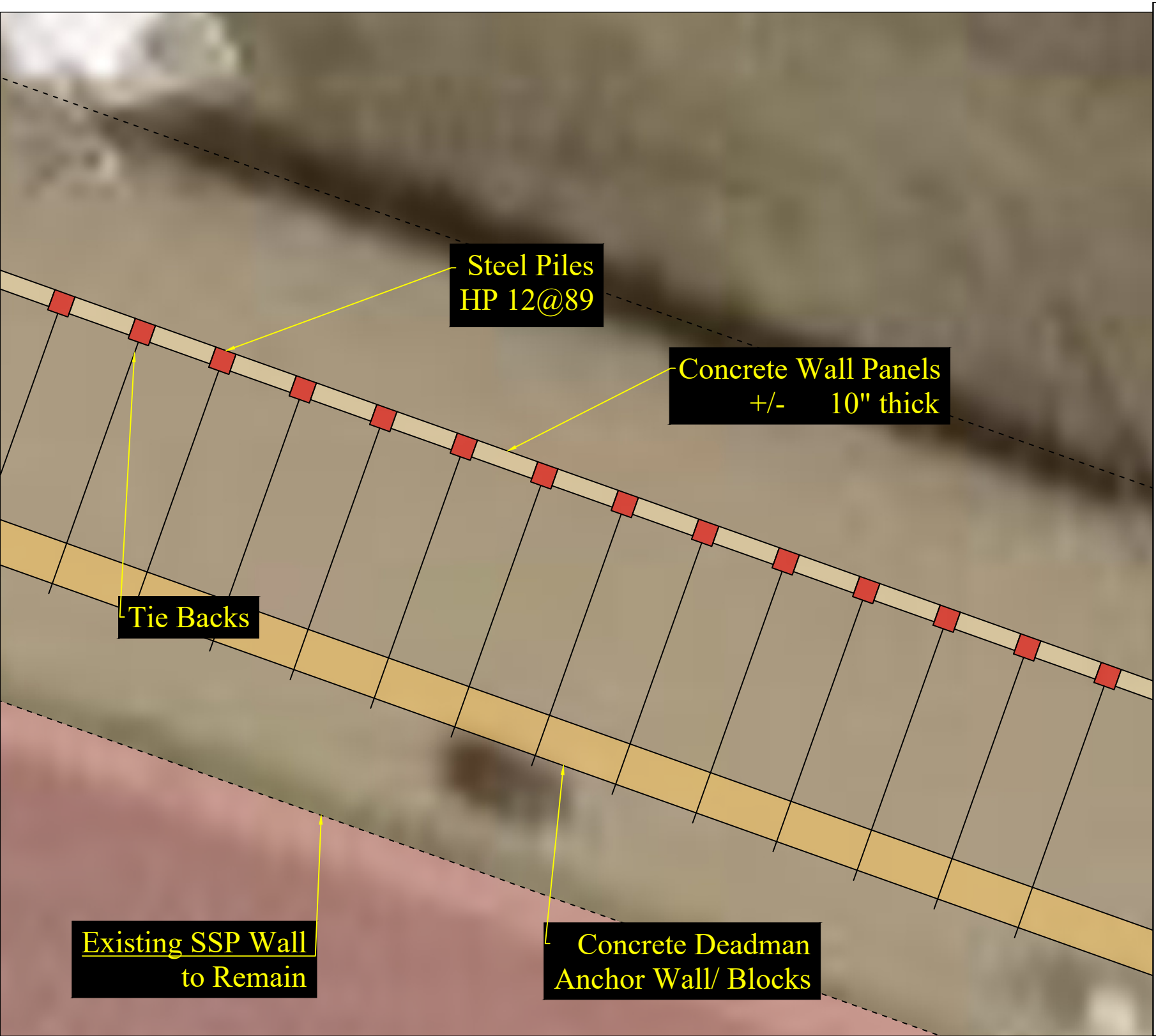
402

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Designed by:
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Contractors Ltd.

2033 Hammonds
Plains Rd., Halifax,
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(902) 835–7664

Project Name:

General Notes:

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Drawing Number:

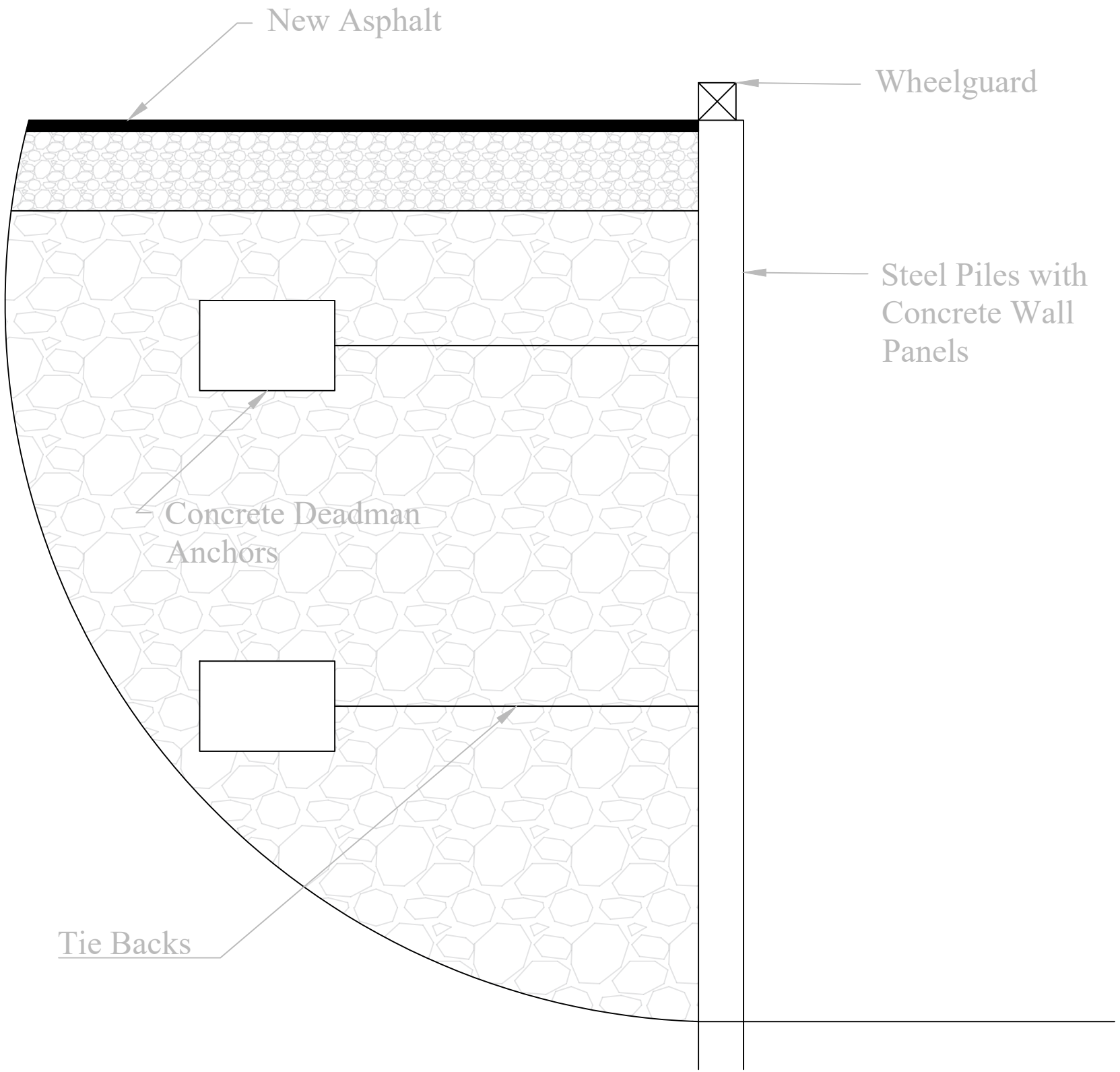
403

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Sc.W., P.Eng

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Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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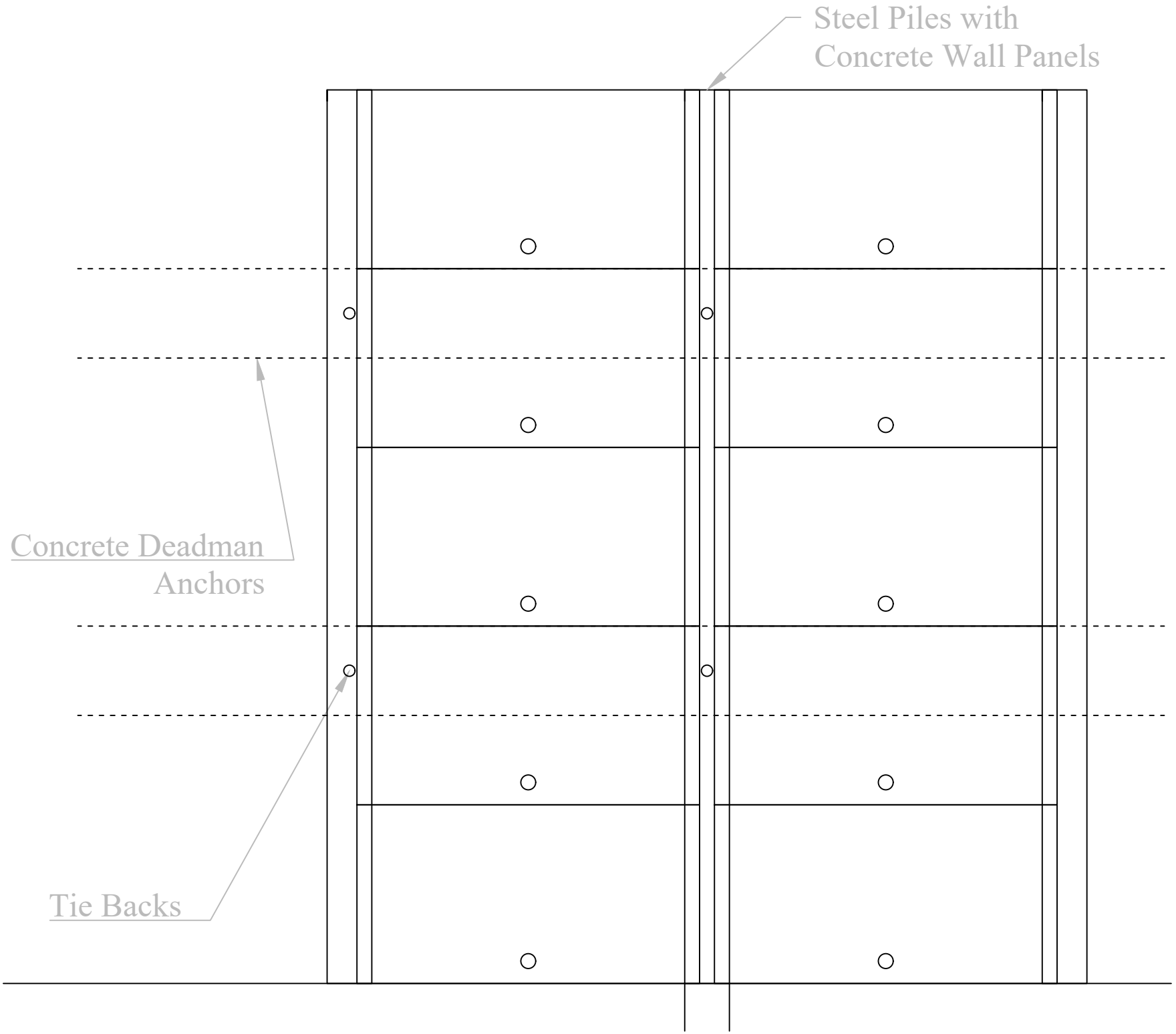
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Sc.W., P.Eng

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Contractors Ltd.

2033 Hammonds
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Project Name:

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Drawing Number:

405

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS

Annapolis Royal Wharf

REBUILD NORTH WALL, BREAKWATER SOUTH WALL
WITH VIEWING SPACE AT END OF WHARF

Particulars

50 feet wide
350 feet long
27 feet tall at end
10 feet tall at start

Lineal Feet
L= 350 ft

Soldier Pile and Lagging $ 4,500.00 per lineal ft

Install= **$ 1,575,000.00** +/- $ 300,000.00

Included tie-backs and deadman anchors

Cross Section Area
A= 6475 ft^2

Volume
V= 323750 ft^3

Density of Soils/ Rocks
p= 100 lbs/ft^3

Weight of Fill
W= 32375000 lbs = 16187.5 tons

Steel sheets
W/ft= 50 lb/ft
Sheet width= 1.67 ft
Sheets in wharf= 449.1017964 sheets
Average length= 20 feet tall
Lineal feet of sheets= 8982.035928 ft
Weight of sheets= 449101.7964 lbs = 224.5509 tons

Excavation= $ 90.00 per ton
Trucking= $ 40.00 per ton
Disposal= $ 110.00 per ton

Unit Cost Removal= $ 240.00 per ton
Total Cost Removal= **$ 1,321,946.11**

Third fill material removed
Half of sheets removed

Assumes NO contaminated materials

Rock Cost= $ 30.00 per ton
Armour Stone= 2500 tons
Filter Stone= 2000 tons

Unit Cost Install= $ 160.00
Breakwater install= **$ 720,000.00**

Concrete Caisson with viewing ports, stairs **$2,000,000**

TOTAL COST= **$ 5,616,946.11** +/- $ 1,000,000.00

APPENDIX H – EAGLE BEACH
ANNAPOLIS ROYAL - WHARF REUSE DESIGN - OPTION #4
5 PAGES



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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Drawing Number:

501

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Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
1:200



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

(902) 835-7664

Project Name:

General Notes:

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Drawing Number:

502

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Designed by:
Sc.W., P.Eng

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Scale:
1:200



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

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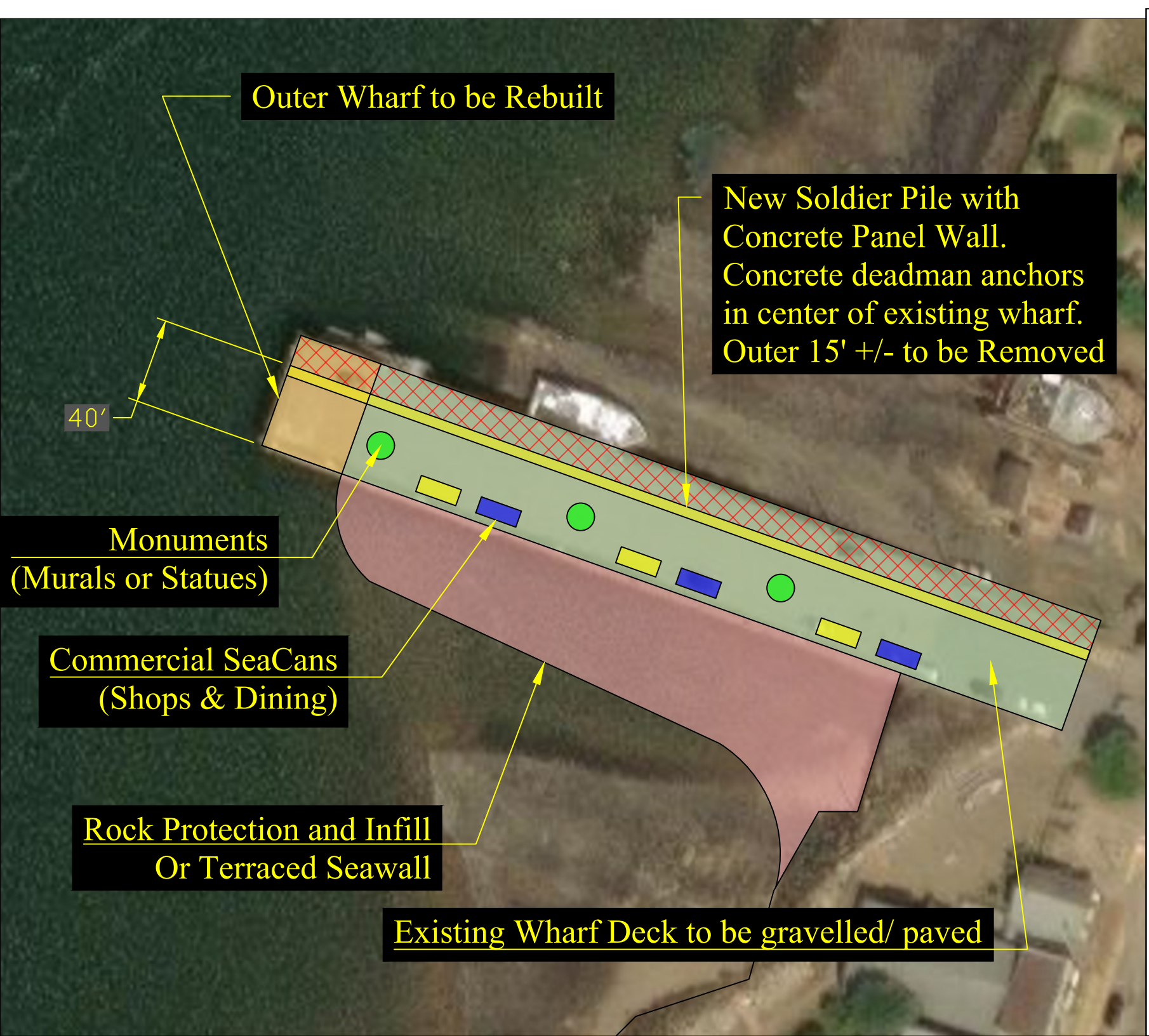
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Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

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04 Feb 2026

Scale:
1:200



Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

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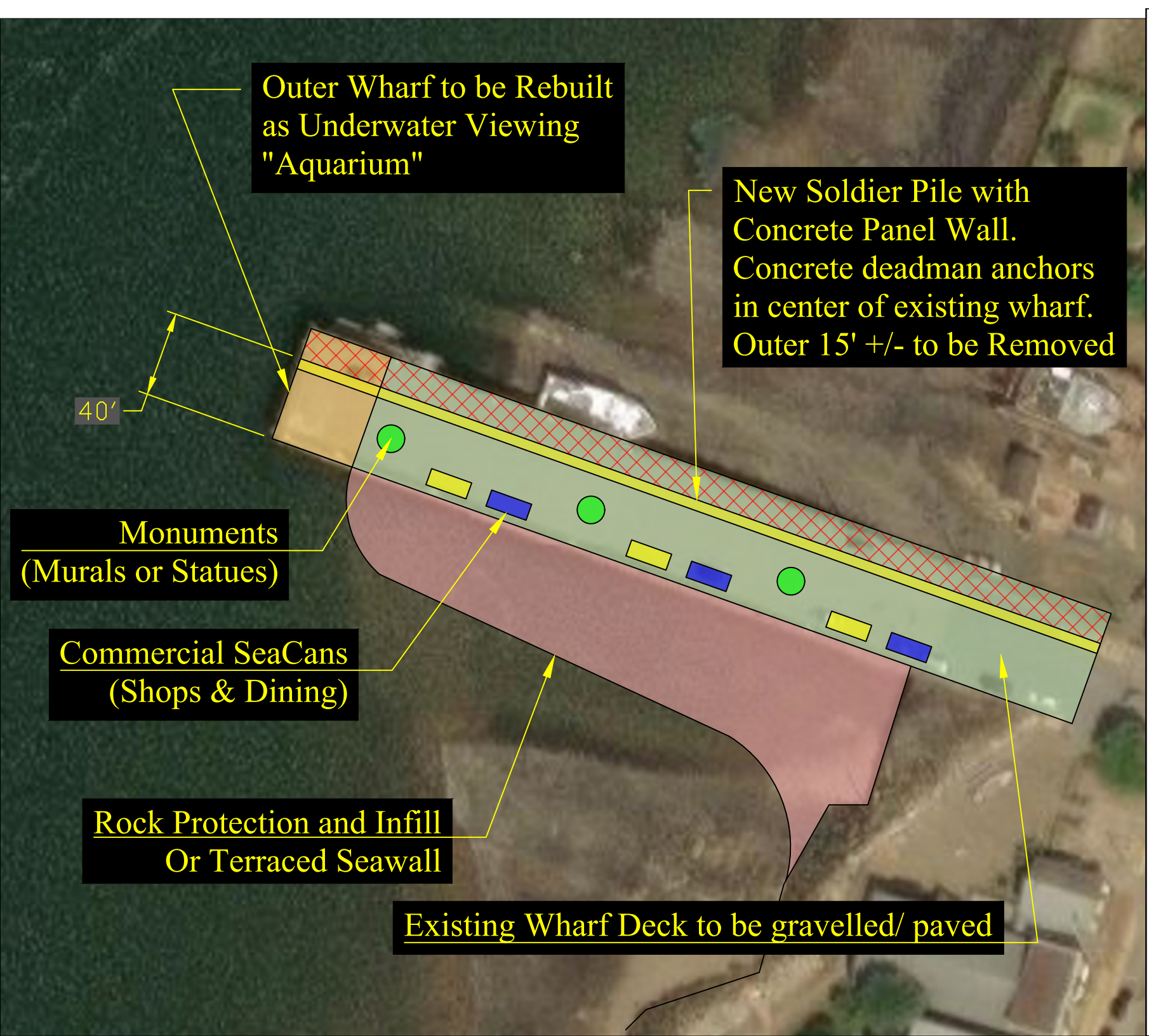
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Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

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Eagle Beach Contractors Ltd.

2033 Hammonds Plains Rd., Halifax, Nova Scotia.

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Project Name:

General Notes:

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Drawing Number:

505

Drawn by:
Sc.W., P.Eng

Designed by:
Sc.W., P.Eng

Date:
04 Feb 2026

Scale:
NTS

Annapolis Royal Wharf

FULL REMOVAL OPTION

Particulars

50	feet wide
350	feet long
27	feet tall at end
10	feet tall at start

Cross Section Area

A=	6475	ft^2

Volume

V=	323750	ft^3

Density of Soils/ Rocks

p=	100	lbs/ft^3

Weight of Fill

W=	32375000	lbs	=	16187.5 tons

Steel sheets

W/ft=	50	lb/ft		
Sheet width=	1.67	ft		
Sheets in wharf=	449.1017964	sheets		
Average length=	20	feet tall		
Lineal feet of sheets=	8982.035928	ft		
Weight of sheets=	449101.7964	lbs	=	224.5509 tons

Excavation=	$	90.00	per ton	
Trucking=	$	40.00	per ton	
Disposal=	$	110.00	per ton	
Unit Cost=	$	240.00	per ton	
Total Cost=	**$**	**3,938,892.22**		+/- $ 500,000.00

Assumes NO contaminated materials